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Comparison of the ruminal degradability of the different components of the maize plant

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Dedicated to

The soul of my late Father and my Mother

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List of Abbreviations

%	percent
°C	degree Celsius
µm	micrometer
A	non degradable fraction of nutrient
a	readily soluble fraction of nutrient
ADF	acid detergent fiber
ADL	acid detergent lignin
b	slowly degradable fraction of nutrient
bm	brown midrib
bm_3	brown midrib hybrid 3
c	constant rate of degradation
CF	crude fiber
cm	centimetre
cm^2	quadric centimetre
CP	crude protein
dl	deciliter
DM	dry matter
ED	effective degradability
EDMD	effective dry matter degradability
EE	ether extract
Exp	experiment
g	gram
h	hour
ha	hectare
HD	harvest date
ISDMD	in situ dry matter disappearance
IVDMD	in vitro dry matter degradability

K	passage rate
Kd	rate of degradation in the rumen (c)
kg	kilogram
Kp	flow (passage) rate in the rumen
L	liter
log	logarithmic
m	meter
m^2	quadric meter
mg	milligram
ml	milliliter
mm	millimeter
mmol	millimole
MSE	Mean of standered error
N	nitrogen
n	number
NDF	neutral detergent fiber
NEL	Net energy for lactation
NH3	ammonia
P	probability
P	rumen disappearance at time t
r^2	coefficient of correlation
SAS	Statistical Analysis System
SD	standard deviation
t	time in h for rumen degradability
t_0	lag time
VFA	volatile fatty acids
vs.	versus
WSC	water soluble carbohydrates

1. Introduction

As an important management target in animal nutrition is to provide optimal nutrient and energy availability for high performing livestock with the lowest feeding costs. In central and northern Europe, maize whole plant silage is important in diets of intensively managed ruminants because it is reliable roughage with high energy content and high level of intake, so it is a major component of diets for dairy cows and beef cattle. Thus for example according to statistics of Deutsches Maiskomitee (2008) Germany produced about 70 million tons of silage corn in 2007 with cultivated area of about 1.5 million hectares which means a multiplication of both the area and the amount produced compared to 1970s (0.52 million tonnes and about 105 000 hectares). Maize whole plant composed of maize grain (highly digestible portion) and maize stover (fibrous portion). In countries like Egypt which suffer from serious shortages in animal feed of the traditional type such as green fodder and cereal grains, maize stover served as an important source of feed for ruminants instead of maize silage.

With increasing demand for livestock products as a result of rapid growth in the economy and human population, understanding of plant factors influencing digestion kinetics of maize silage is important. Therefore, plant breeder and animal nutritionist try to improve digestibility and energy content of maize silage, hence improving the nutritional status of farm animal through increasing energy and feed intake. Improving the nutritional status of farm animals will be translated to improving in their products (milk in high producing dairy cattle and meat in beef cattle).

The effect of maturity stage on the composition of maize plant is unique among forages because it is a mixture of stover and grain. During maturity the nutrients of the grain and the stover as well as the relationship of grain to stover are changing. In general, maize dry matter yield and starch content (grain yield) increase until physiological maturity at the end of the grain filling period. In the same time sugar content in the stover decrease and cell wall maturation and lignification increase. These antagonistic processes lead to a frequent change in the carbohydrate composition of the total dry matter. The dynamics of this change differ from one variety to the other. Therefore, the harvest time has a great influence on assessment the feeding value of maize varieties. Maize varieties have a considerable influence on animal performance proven by laborious and expensive in vivo tests (Barrière et al., 1995) and shown genetic variation in ingestibility and digestibility.

Feed intake and digestibility of maize silage are influenced by both the proportion of grain and the composition of the cell wall fraction of maize stover. Differences in digestibility and energy supply of maize whole plant silage arise from differences in digestibility of maize grain and maize stover. Irlbeck et al. (1993) stated that nearly half the above ground dry matter of maize plant is stover. Thus, it is not surprising that stover digestibility has a large influence on maize plant quality and so it could not be neglected. A similar digestibility of maize silage can be achieved either by a high proportion of grain in combination with low proportion of low digestible maize stover, or by a relatively low proportion of grain and higher proportion of stover with improved digestibility. Therefore, improving digestibility of maize plant entails modifying one or more of the components involved in total digestible dry matter, i.e. dry matter content, yield and digestibility of the grain and stover portion. Improvement of fiber digestibility of maize plant in addition to energy supply could increase feed intake and thus contribute to a better utilization of maize whole plant silage.

Study of maize plant hybrids with faster or more extensive rate of ruminal fermentation has a key research area and maize hybrids that have improved nutritive value will needed to market as branded products. To ensure acceptability and confidence by the consumer, product sales must be supported by independent research and by strong commitment to customer service. Therefore, plant breeder and animal nutritionist need rapid, inexpensive, reliable techniques and equipment to determine and ensure a hybrids nutritional value. In situ technique is considering one of the most important screening tools that used for predicting and determining the relative differences in rumen degradability of forage.

The objective of this work was to study effect of maturity stage at harvest, maize variety and effect of conservation method on the in situ rumen degradability of maize stover, maize cob and maize whole plant. Therefore, in the present study a separate evaluation of stover and grain were done to study the contribution of each component on rumen degradability of maize whole plant as affected by maturity stage, maize variety and conservation method.

2. Materials and Methods

In the present work a total of six experiments (Exp) were done to study the degradability of the dietary components of maize plant (maize stover, maize cob, maize grain and maize whole plant). Dry matter degradability of these components was studied using the in situ method. Maize plants from several varieties harvest at different harvest stages were used. Also two conservation methods (dried in hot air oven and ensiled) in addition to fresh material (freeze dried) were used.

2.1 Experimental site

This work was conducted at Division of Animal Nutrition, Department of Animal Sciences, Center of Life and Food Sciences, Weihenstephan, Technische Universität München, Germany.

2.2 Experimental design

The experimental design of this work was divided into three main principles lines. These lines are:

2.2.1 Rumen degradability of maize stover

2.2.2 Rumen degradability of maize grain

3.2.3 Rumen degradability of maize stover, maize cob and maize whole plant

2.2.1 Rumen degradability of maize stover

2.2.1.1 Effect of maize maturity stage and maize variety on the in situ rumen dry matter degradability of maize stover (Exp 1 – 3)

The aim was to study the effect of maize maturity stage and maize variety on in situ rumen degradability of maize stover. This work achieved by three experiments.

Exp 1: Six varieties namely NK Magitop, EXP99FN, NX1064, NX1494, NX1485 and NX0601 were sampled from maize fields at Hirschau experimental station during September and October 2006. Each variety was harvested from the field at three harvest dates (HD); these harvest dates are presented in Table 1.

Exp 2: Four varieties namely NK Magitop, Winn, NK Lemoro and NX1775 were sampled from maize fields at Hirschau experimental station during September and October 2007. Each variety was harvested at four harvest dates (see Table 1).

Table 1. Harvest dates of maize plant of the different experiments

	harvest dates			
Exp No	***HD1***	***HD2***	***HD3***	***HD4***
Exp1	08.09.06	25.09.06	09.10.06	-
Exp2	03.09.07	18.09.07	02.10.07	17.10.07
Exp3	02.09.08	19.09.08	07.10.08	-
Exp 4 and 5	02.09.08	19.09.08	07.10.08	-
Exp 6	03.09.07	18.09.07	15.10.07	-

Exp 3: Six varieties namely NK Magitop, NX17066, NX10126, NX20026, NX04016 and NX1485 were sampled from maize fields at Hirschau experimental station during September and October 2008. Each variety was harvested from the field at four harvest dates (see Table 1). NK Magitop was used in the three experiments such as a comparative and a control variety.

2.2.1.2 Effect of maturity stage, maize variety and conservation method on rumen dry matter degradability of maize stover (Exp 4)

The aim of this experiment was to study the effect of maturity stage, maize variety and method of conservation (fresh (freeze dried), dried in hot air oven at 60℃ and ensiling) on the in situ dry matter degra dability of maize stover. Two varieties of maize differs in their grain endosperm structure, one flint type (NX1485) and the other from dent type (NX20026) were sampled from maize fields at Hirschau experimental station during September and October 2008. Each variety was harvested from the field at three harvest dates (see Table 1).

2.2.2 Rumen degradability of maize grain (Exp 5)

The aim of this experiment was to study the effect of maturity stage, maize variety (flint or dent endosperm) and method of conservation (fresh (freeze dried), dried in hot air oven at 85 ℃ and ensiling) on the in situ dry matter degradability of maize grain. The grains of the two maize varieties were harvested from the field at three harvest dates (see Table 1).

2.2.3 Rumen degradability of maize stover, maize cob, maize whole plant and maize whole plant silage (Exp 6)

The aim of this experiment was to study the effect of maturity stage and maize variety on rumen dry matter degradability of maize stover, maize cob, maize whole plant and maize whole plant silage. Two varieties from maize namely NK Magitop and NX1485 were sampled from the maize fields at Hirschau experimental station during September and October 2007. Each variety was harvested from the field at three harvest dates (see Table 1).

2.3 Maize planting

Table 2 show the sowing date, sowing rate, fertilization and chemical pesticide of the maize variety. Maize varieties of the different experiments were planted in Hirschau experimental station of Technische Universität München. All maize varieties were under the same conditions of sowing date, sowing rate and the same rate of fertilization.

Table 2. Sowing date, sowing rate, fertilization and chemical pesticide for maize varieties

		2006	***2007***	***2008***
Sowing date		04/05/2006	25/04/2007	06/05/2008
Sowing rate		10 seeds/m²	10 seeds/m²	10 seeds/m²
Seeds treatment		Mesurol	Mesurol	Mesurol
Organic fertilizer	date	02/05/2006	02/04/2007	05/05/2008
	form	Dairy cattle slurry	Beef cattle slurry	Dairy cattle slurry
	rate	25 m³/ha	30 m³/ha	35 m³/ha
Commertial fertilizer	date	03/05/2006	24/04/2007	06/05/2008
	form	Urea (46% N)	Urea (46% N)	Urea (46% N)
	fertilization rate	2.0 dt/ha	2.5 dt/ha	2.5 dt/ha
Chemical pesticides	date	14/06/2006	21/05/2007	27/05/2008
	form and rate	Zintan-Gold-Pack which contain Callisto 0.9 l/ha + Gardo Gold 3.5 l/ha	Zintan-Gold-Pack which contain Callisto 0.9 l/ha + Gardo Gold 3.5 l/ha	Zintan-Platin-Pack which contain Calaris 1.2 l/ha + Dual Gold 1.0 l/ha

2.4 Maize plant sampling

Sampling of maize plant was done after starting of cob drying (about 50% DM). At sampling plants were cut at about 10 cm from the ground surface. In Exp 1, Exp 2, and Exp 3 thirty plants from each variety at each maturity stage were cut and the whole plants were weighted and then separated into stalks and husks (maize stover) and cobs followed by weighed each of them. After that maize stover was chopped to be 2-3 cm and thoroughly mixed in order to obtain a uniform material then maize stover was stored in the freezing room at -18 ℃ un til it prepared for the in situ study.
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For Exp 4 and Exp 5 sampling occur by cutting 60 plants from each variety at each maturity stage and weighed. After that the plants were separated into stalks and husks (maize stover) and cobs and weighed each of them. Maize stover of each variety at each maturity stage was chopped to be 2-3 cm and thoroughly mixed in order to obtain a uniform material. As well maize grain was removed from the cob. Afterwards maize stover and maize grain were stored in freezing room at -18 ℃ until prepared them for the in situ studies. During the in situ study each of maize stover and maize grain were divided into three portions. The first portion used as fresh (dried at freeze drying machine for 72 h), the second portion dried in hot air oven and the third portion used as ensiling. Then maize stover was used in Exp 4 and maize grain was used in Exp 5.

For Exp 6 sampling occur by cutting 60 plants from each variety at each maturity stage and weighed. Then plants were divided into three portions. The first portion was used as fresh whole plants, in which chopped to be 2-3 cm, thoroughly mixed in order to obtain a uniform material and stored in freezing room at -18 ℃ until it prepared for the in situ study as fresh whole plant. The second portion was prepared to be used as whole plants silage, in which chopped to be 2-3 cm, thoroughly mixed in order to obtain a uniform material then ensiled. The third portion was separated into stalks and husks (maize stover) and cobs and weighed each of them. Afterwards maize stover was chopped to be 2-3 cm, thoroughly mixed in order to obtain a uniform material then maize stover and maize cob were stored at the freezing room at -18 ℃ until prepared them for the in situ study.

2.5 Silage making and sample preparation

For making silage from maize stover for Exp 4, from maize grain for Exp 5 and from maize whole maize plant silage for Exp 6, the samples were send to Bavarian State Research Center for Agriculture at Grub to be ensiling there. Samples were taken out from the freezing room and left until thawed to be ensiling. For maize grain it was necessary to crash the grain before ensiling. To simulate the ensilage process, sample from each variety at each maturity stage was packed and ensiling in two glasses (ca. 1400 ml volume each). Then the glasses were stored at the ensiling room in controlled environmental condition for 90 days. The temperature inside the ensiling room was 25 ℃. At the end of the ensilage process sample from the different silage were taken to evaluate silage quality such as pH, acetic acid, butyric acid and lactic acid to be sure that they are suitable for the experimental study. Data of silage quality of the different components are presented in Table 3.

Table 3. Silage quality of the different materials at the different experiments

Treatment	Variety	Harvest dates	DM %	pH value	Acetic acid %	Butyric acid %	Lactic acid %	Ammonia nitrogen %
Ensiled maize stover Exp 4	NX1485	HD1	17.5	3.4	0.92	-	nd	0.03
		HD2	26.3	3.6	0.19	-	nd	0.07
		HD3	26.0	3.8	0.78	-	nd	0.07
	NX20026	HD1	18.8	3.5	0.27	-	nd	0.08
		HD2	18.7	3.7	0.34	-	nd	0.07
		HD3	25.1	3.8	0.24	-	nd	0.06
Ensiled maize grain Exp 5	NX1485	HD1	52.7	3.8	1.00	-	nd	0.07
		HD2	59.7	3.8	0.37	-	nd	0.07
		HD3	63.5	4.3	0.68	0.31	nd	0.09
	NX20026	HD1	46.5	3.7	0.5	-	nd	0.06
		HD2	58.6	3.7	0.2	-	nd	0.07
		HD3	62.0	4.1	0.7	0.15	nd	0.03
Ensiled maize whole plant Exp 6	NK Magitop	HD1	28.5	3.8	1.19	0.27	1.68	0.11
		HD2	34.9	3.8	0.43	0.01	2.07	0.06
		HD3	45.3	3.9	0.75	-	2.34	0.06
	NX1485	HD1	26.7	3.7	0.89	0.02	2.10	0.10
		HD2	31.4	3.8	0.35	-	1.65	0.06
		HD3	42.5	3.8	0.4	-	1.57	0.06

nd=not determined

For preparing the different materials for using at the in situ study, those materials were dried at first then ground. The different components which will be used such as fresh materials (maize stover, maize cob, maize grain and maize whole plant) and ensiled materials (ensiled maize stover, ensiled maize grain and ensiled maize whole plant) were freeze dried at freeze drying machine for 72 h. Samples which will be used such as oven dried materials were dried for 24 hrs in hot air oven at 60 ℃ for maize stover in Exp 4 and at 85 ℃ for maize grain in Exp 5. Finally all these dried materials were ground in the grinding machine (Nelles&Co., Braunschweig) to be 3.0 mm and packed until used for the in situ study.

2.6 In situ degradability method

2.6.1 Animals and feeding

Six ruminally fistulated, non lactating Friesian dairy cows (live body weight about 750 kg) were used in those experiments. Cows were fitted with cannula (Bar Diamond Inc., Parma, Idaho, USA with 10 cm internal width) at the dorsal sac of the rumen. Cows were individually penned in clean and full automatic aerated stall (temperature 20 ℃). Clean fresh water and salts bl ocks were offered for free choice. Daily dry matter intake was about 6.00 kg and the animals were given the ration in two equal portions at 07.00 am and at 04.00 pm, each portion as fresh basis was 4.00 kg maize silage, 0.22 kg soybean meal, 1.60 kg hay and 0.05 kg vitamin mixture’s. The maize silage, the soybean meal and the vitamin mixture’s were mixed together and offered to cattle at first, followed by hay after 10 minutes. Table 4 shows the chemical composition of the used ration. This ration contains energy of 36.0 MJ NEL and crude protein of 12.0% (maintenance requirements). Ration was given for 10 days before start of the experiment for adaptation and extended throughout the experimental period.

Table 4. Chemical composition of the used ration

Feed	***DM%***	***On DM basis***			
		Crude ash	***Crude protein***	***Crude fat***	***Crude fiber***
Maize silage	35.7	3.82	8.34	2.53	19.2
Soybean meal	90.3	6.59	46.2	1.53	5.58
Hay	88.3	6.83	8.03	1.47	25.0

2.6.2 Rumen physiological parameters of the experimental cattle

Usually at beginning of each experiment the experimental ration was given for 10 days followed by the incubation period. Ruminal juice samples were taken from the experimental cattle just the day before or after the incubation period for controlling the rumen physiological parameters (pH values and ammonia nitrogen as well as volatile fatty acids (VFA)). Table 5 shows the different dates of sampling the ruminal juice before or after the incubation time at the different experiments.

Table 5. The different dates of ruminal juice sampling

Experiment period	*Ruminal juice sampling*	
	before start of incubation period	*after end of incubation period*
Exp 1 (28.12.06-23.01.07)	-/-	23.01.07
Exp 2 (05.11.07-29.11.07)	29.11.07	-/-
Exp 3 (24.11.08-18.12.08)	04.12.08	-/-
Exp 4 (09.03.09-26.03.09)	-/-	26.03.09
Exp 5 (26.03.09-09.03.09)	26.03.09	-/-
Exp 6 (17.05.08-10.06.08)	27.05.08	-/-

Rumen fluid samples (about 200 ml) were collected from each cattle through the ruminal cannula just before feeding time at 07:00 (zero time), 07:30, 08:00, 08:30, 09:30, 10:30 and 11:30 am to determine the concentration of rumen pH value and ammonia nitrogen (Figure 1) as well as VFA (Figure 2).

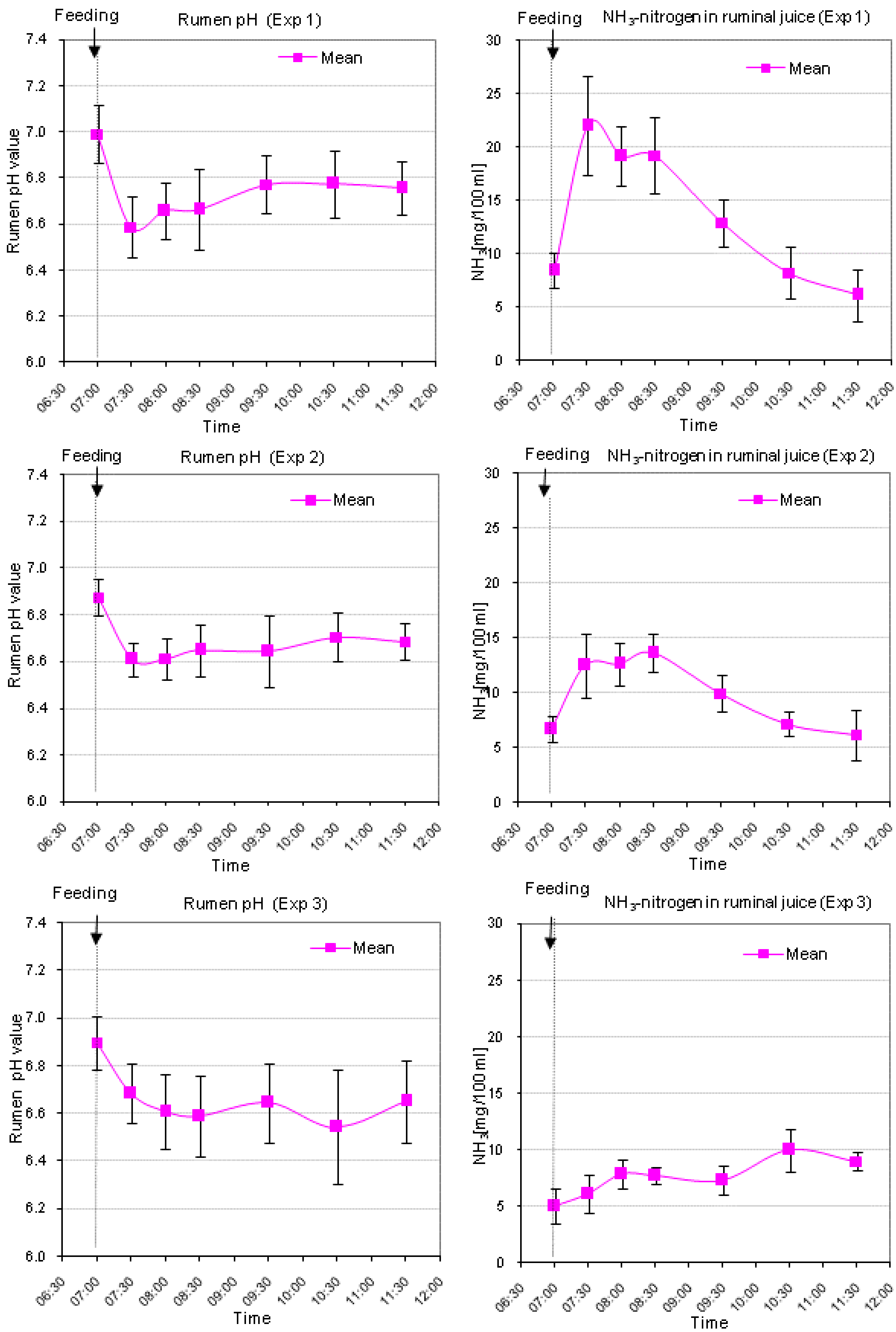
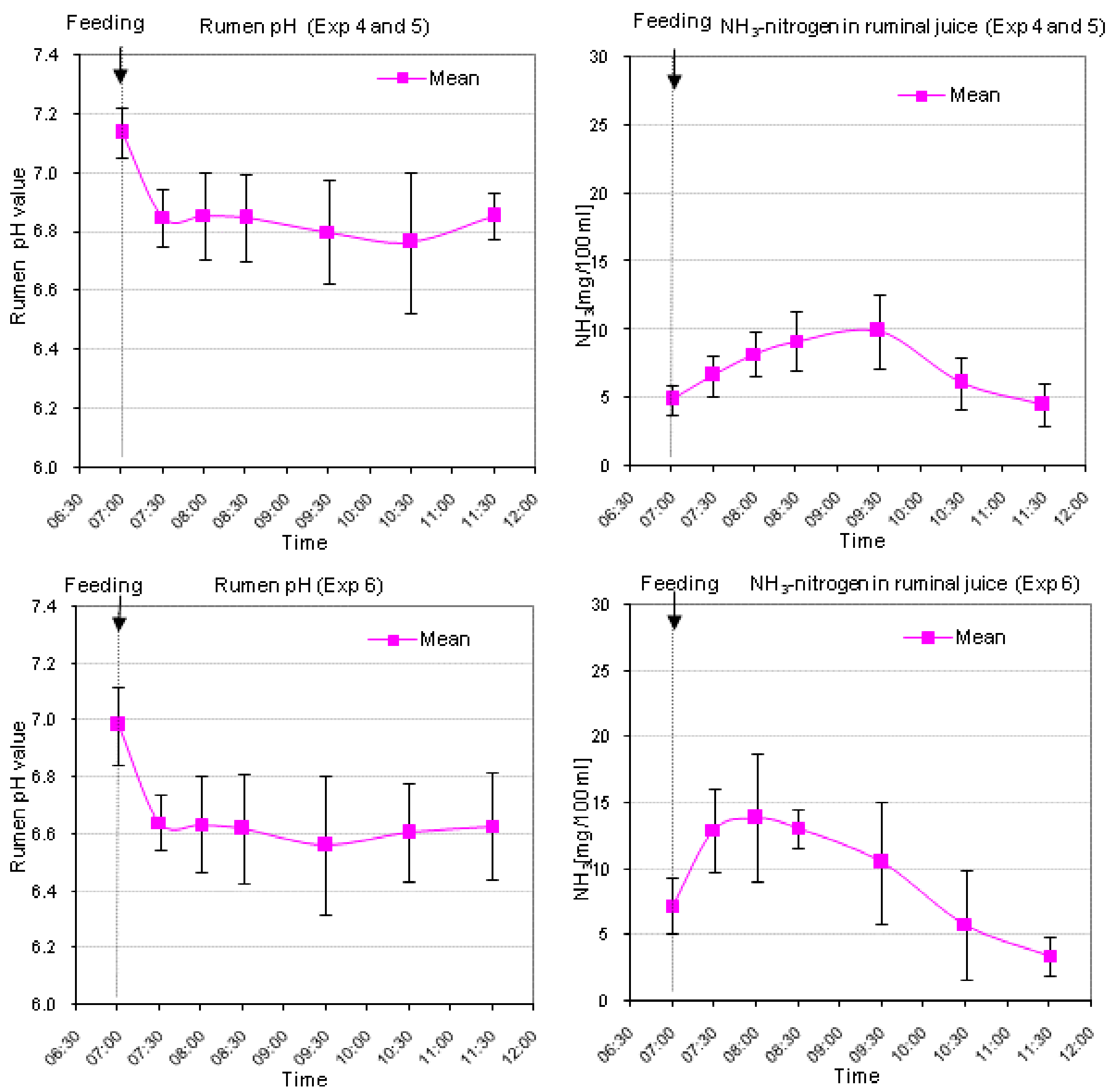


Figure 1. Rumen pH value and ammonia nitrogen of the used animals for the different experiments

Continue Figure 1



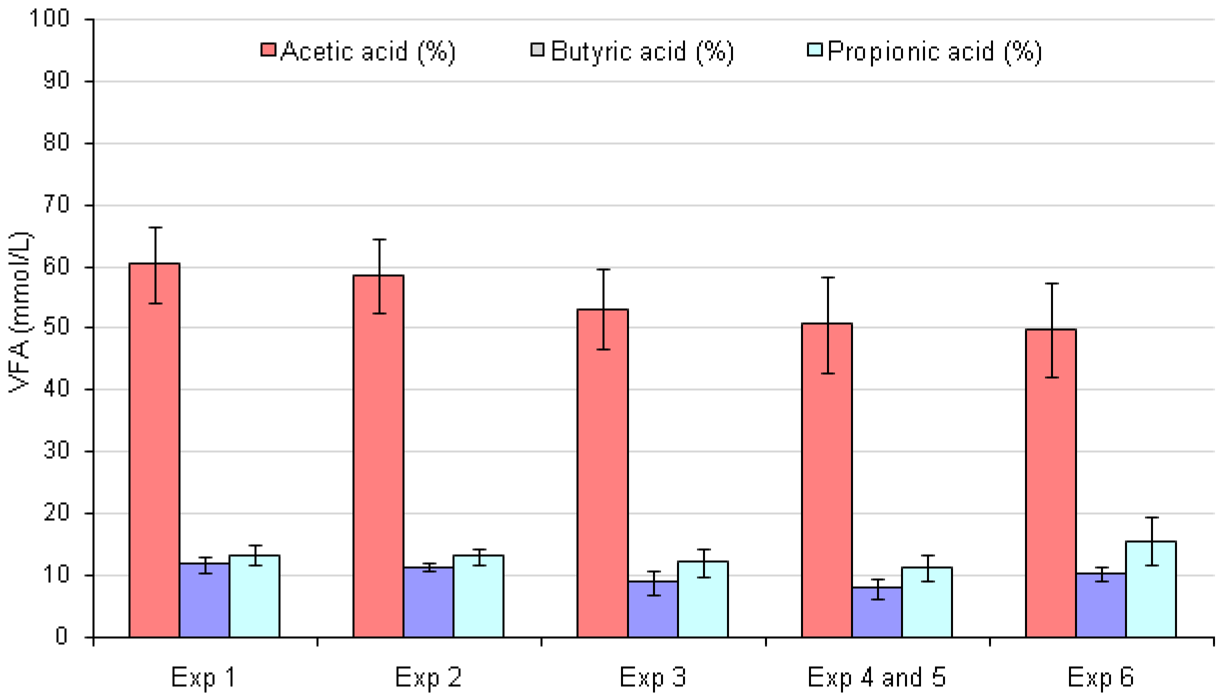


Figure 2. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at the different experiments

2.6.3 In situ method

Dry matter disappearances in the rumen were estimated using the nylon bag technique (Ørskov and McDonald 1979).The bags (10 x 20 cm) with a pore size of 53 µm (R1020, Dohod Technology, Fairport, NY, USA). Four grams of the dried ground materials were weighed to the nearest 3 decimal points. The weighed materials were placed into previously labelled, dried (at 60 ℃ fo r 48 h) and weighed bags, which was incubated in the rumen of the fistulated cows. The prepared bags were fixed on an elastic wire about 55 cm lengths. This wire contains from 9-16 points at which it is possible to fix two or three bags at each point. During fixing the bags the replicates of one treatment must be fixed at different levels at the wire, because the degradability inside the rumen different between the dorsal sac (less degradable) and the ventral sac (high degradable). All samples were prepared in duplicate or triplicate and incubated in the rumen of three or six cows just before the morning feeding at 07.00 am for 2, 4, 8, 16, 24, 48, 72 and 96 h for Exp 1, Exp.2, Exp 3 Exp 4 and Exp 6 and for 2, 4, 8, 16, 24 and 48 h for Exp 5. Table 6 contains summary which describe materials and design of the different experiments. The bags were removed from the rumen (all in and all out system) and were immediately put in ice water to stop the microbial activity. Then the bags were put in washing tank with about 40 liter cold water and washed for about 5 minutes and finally washing in washing machine (QUELLE WVA BASIC 74) for 19 minutes. Afterwards the bags were frozen and then dried in freeze drying machine for 72 h till complete dryness then weighed again to determine the in situ dry matter degradability. Zero hour bags were done by washing three bags by cold water as before then washing in the washing machine (QUELLE WVA BASIC 74) for 19 minutes to measure the fraction that disappears during washing in washing machine.

Table 6. Summary describe materials and design of the different experiments

Period	Exp. No.	Varieties (n)	Harvest dates (n)	Conservation method	Animals (n)	Bags per animal (n)	Incubation time
28.12.06-23.01.07	1	6	3	fresh	3	2	0 – 96 h
05.11.07-29.11.07	2	4	2	fresh	3	3	0 – 96 h
24.11.08-18.12.08	3	6	3	fresh	3	3	0 – 96 h
17.05.08-10.06.08	4	2	3	fresh, oven dried and ensiled	6	2	0 – 96 h
27.03.09-09.03.09	5	2	3	fresh, oven dried and ensiled	3	3	0 – 48 h
17.05.08-10.06.08	6	2	3	fresh and ensiled	6	2	0 – 96 h

Calculation of the in situ dry matter disappearance (ISDMD) from the nylon bag after incubation were done by calculation the difference between the weight of bag and the material inside before and after the incubation then dry matter disappearance calculated as a percentage of initial weight before incubation.

$$ISDMD\ (\%) = \frac{\text{Weight before incubation (g) - Weight after incubation (g)}}{\text{Weight before incubation (g)}} \times 100$$

Rumen dry matter degradation data were fitted to the exponential equation of Ørskov and McDonald (1979).

[1] $$p = a + b(1 - e^{-c(t-t_0)}) \quad \text{for } t = t_0$$

where

P = DM degradation (%) at time t

a = rapidly soluble fraction

b = insoluble but ruminally degradable fraction (slowly degradable fraction)

c = constant rate of degradation of b (%/h)

t_0 = lag time, defined as the time from beginning of incubation until beginning of degradation (delay time).

Sum of the soluble fraction (a) and the insoluble but ruminally degradable fraction (b) represents the potential total degradable fraction of material which under search. From the sum of (a) and (b) fractions we can calculate the non degradable fraction (A). Therefore, A = 100 - (a + b)

Effective rumen dry matter degradability (EDMD) were calculated following the equation of McDonald (1981)

[2] $$P = a + \left[(b \times c)/(c + k)\right] \times e^{-k \times t_0}$$

where

a, b, c and (t_0) are the same as in [1]

K ($\%h^{-1}$) is the estimate rate of passage of the digesta from the rumen per hours. The effective dry matter rumen degradability was calculated for a passage rate of $2\%h^{-1}$, $4\%h^{-1}$, $6\%h^{-1}$ and $8\%h^{-1}$. The passage rate of k = $2\%h^{-1}$ represent the low level of feed intake, the passage rates of k = $4\%h^{-1}$, and k = $6\%h^{-1}$ represent the medium level of feed intake and the passage rate of k = $8\%h^{-1}$ represent the high level of feed intake (Agricultural Research Council, 1984).

2.7 Chemical analysis

2.7.1 Chemical analysis of maize materials

2.7.1.1 Determination of dry matter of maize materials

For determination of dry matter (DM) of the cobs, 7 cobs from each variety at each maturity stage were dried in hot air oven at 60 ℃ for 72 h. For the other materials they dried at freeze drying machine for 72 h.

2.7.1.2 Determination of chemical composition of maize materials

For determination of the chemical composition (crude ash, crude protein, crude fat and crude fiber), samples from maize materials were ground in grinding machine **(**Nelles&Co., Braunschweig) to be 1.0 mm to used for chemical analysis. Chemical analysis of the collected samples was carried out by weender analysis according to the standard procedures of VDLUFA methods (VDLUFA, 2004).

2.7.1.3 Determination of fiber fractions (NDF, ADF and ADL)

The freeze dried materials of maize stover (Exp 1, 2, 3 and 4), maize whole plant and maize whole plant silage (Exp 6) were analysed for fiber fractions in form of organic neutral detergent fiber (NDF), organic acid detergent fiber (ADF) and acid detergent lignin (ADL). The analysis was performed according to the standard procedures of VDLUFA method. The principle of fiber analysis (Van Soest, 1963; Van Soest and Wine, 1967; Goering and Van Soest 1970) is based on the ability of detergent solution to dissolve non-fibrous components and separate the fiber by filtration, as particulate material. One gram of the sample material was boiled and digested in the detergent solution (neutral detergent solution for NDF and acid detergent solution for ADF) for 60 minutes. After digestion the samples were filtrated. Afterwards the filtrates was first dried in the air and then complete drying in hot air oven at 105 ℃ for 3 hours then reweighed. The amou nt of dry matter of the residuals represents of NDF content of the sample and respectively ADF content of the sample.

The ADL content was determined from the filtrate which was previously used for ADF analysis. For this purpose, residuals of ADF analysis were covered with 72% H_2SO_4 for three hours in 50 ml beaker and agitation every 60 minutes. Afterwards the sample was then rinsed with distilled hot water to remove the acid and oven dried at 130 ℃ for 3 hours before reweighed. After ashing t he sample in muffle furnace, the residual organic matter was weight which represents ADL content of the sample.

2.7.1.4 Starch analysis

Starch analysis of the different maize grain (Exp 5), maize cob, maize whole plant and maize whole plant silage (Exp 6) was performed after the polarimetric method of VDLUFA (2004). This method is based on two determinations. In the first determination the sample was boiled in dilute hydrochloric acid. After clarification and filtration, the optical rotation of the solution was measured with the polarimeter (S). In the second determination extraction of the sample with ethanol (40%) was made. After treatment the filtrate with hydrochloric acid the solution was clarified, filtered, and the optical rotation was measured under the same conditions as in the first determination (blank S'). The difference between the two measurements (S - S'), multiplied by a known factor, gives the starch content of the sample.

For determination of the sample value (S) 2.5 g of the ground sample (0.5 mm) were weighed into a 100 ml flask and 25.0 ml of hydrochloric acid were added. The flask was shaken, and then another 25.0 ml of acid salt were added. Finally, the flask was placed in a bath of boiling water and shaken vigorously during the first 3 minutes. After 15 minutes, the flask was removed from the bath and 30.0 ml of cold water were added and immediately cooled to 20 ℃. S ubsequently, 5.0 ml of Carrez solution I was added and shaken for 1 minute. Then the process was repeated with Carrez solution II. Afterwards the flask was filled with water until the mark, shaken and filtered. Subsequently the optical rotation of the solution was measured in the filtrate.

For determination of the blank value (S') 5.0 g of sample were weighed in 100 ml volumetric flask and 80 ml of ethanol were added. The flask was allowed to stand for 1 h at room temperature, and shaken vigorously 6 times during this hour. Then the flask was filled with ethanol until the mark, shaken and filtered. Fifty ml of the filtrate were pipette into a 250 ml Erlenmeyer flask and 2.1 ml of sulphuric acid were added, and then the flask was shaken vigorously, connected to a reflux condenser and placed into a boiling water bath. After 15 minutes, the flask was removed from the bath and 30.0 ml of cold water were added and immediately cooled to 20 ℃. Subsequently, 5.0 ml of Carrez solution I were added and shaken for 1 minute. Afterwards, the process was repeated with Carrez solution II and the flask was filled with water until the mark, shaken and filtered. Subsequently, the optical rotation of the solution was measured in the filtrate. The calibration of the polarimeter was carried out by 4.875 g of sucrose in 250 ml water (set point 13).

Calculation:

$$\text{Starch \%} = \frac{2000}{(a)_D^{20^\circ}} * \frac{(2N*0{,}655*(S-S'))}{100}$$

S = optical rotation of the sample

S' = optical rotation of the sample in ethanol solution (40%)

N = content of sucrose (in gram) in 100 ml of water which has an optical rotation of 100 degrees at a thickness of 200 mm (depending on the polarimeter type)

$(a)_D^{20^\circ}$ = specific optical rotation of pure starch

2.7.2 Determination of silage quality

For determination of silage quality samples from the different silage materials (ensiled maize stover, ensiled maize whole plant and ensiled maize grain) were taken and send to the Central Institute of Nutrition and Food Sciences in Freising Weihenstephan (ZIEL) to determine the silage quality. One hundred gram of each silage sample was homogenized with 1000 ml distilled water. Afterwards the homogenized mass was allowed to stand for 20 h with occasional shaking then strained through four layers of cheese cloth. The filtrate was used for the determination of pH and the concentration of lactic, acetic, butyric acids and ammonia nitrogen. This was performed according to the methods of VDLUFA, III, 18.1 for pH and VDLUFA, III, GC-FID for lactic, acetic, and butyric acids and VDLUFA, III, 4.8.1 for ammonia nitrogen (VDLUF, 2004).

2.7.3 Determination of ruminal physiological parameters

2.7.3.1 Determination of rumen pH

Rumen fluid samples were collected through the ruminal cannula just before the feeding time (zero time), 30, 60, 90, 150, 210 and 270 minutes post feeding. Rumen pH was immediately measured using a pH-meter (Schott, CG 842).

2.7.3.2 Determination of rumen ammonia nitrogen

For determination of rumen juice ammonia nitrogen, a sample from ruminal juice was immediately taken after collection through the ruminal cannula and centrifuged with a centrifugal force of 1,132 x g for 15 minutes. The clear supernatant was taken and frozen at -18. Then the frozen sample has been send to the central institute of nutrition and food sciences in Freising Weihenstephan (ZIEL) for ammonia nitrogen analysis. Analysis of ammonia nitrogen was conducted by a modified method of Conway (VDLUFA, 1976). In which 10.0 g of the centrifuged ruminal juice were extracted with water, clarified and filtered. The volatile ammonia containing base was release in Conway unit after addition of potassium carbonate solution by micro diffusion. Then the volatile ammonia was caught in a boric acid solution and, titrated against 0.02N sulphuric acids until the indicator colour changed. Following the same procedure a blank test was carried out. The calculation of the results is based on the relationship that 1.00 ml of 0.02N sulphuric acid corresponds to 0.34 mg of ammonia in the sample. The result was calculated as a mean of two repetitions and expressed as a percentage of the initial sample.

2.7.3.3 Determination of rumen volatile fatty acids

For determination of rumen juice volatile fatty acids a sample from rumen juice was taken from rumen though rumen cannula after 210 minutes from the morning feeding. According to the method of Geissler et al. (1976) rumen juice sample was centrifuged with a centrifugal force of 1,132 x g for 5 minutes then the following amounts were pipette in a clean centrifuge tube

1) 10.0 ml from the clear supernatant of rumen juice
2) 1.50 ml from 25% meta phosphoric acid
3) 0.50 ml formic acid

Afterwards the tube was closed and centrifuged with a centrifugal force of 1,398 x g for 20 minutes. The clear supernatant was taken and pipette in a clean tube. Then one drop of saturated quick silver chloride ($HgCl_2$) was added and the sample frozen at -18. Afterwards the frozen sample has been send to the Central Institute of Nutrition and Food Sciences in Freising Weihenstephan (ZIEL) for volatile fatty acids analysis by gas chromatography. For VFA analysis the sample was centrifuged again with 2% meta phosphoric acid solution and shaken for one hour. Afterwards the supernatant solution clarified, and the clear filtered sample solution was injected into gas liquid chromatography with FID (Dani) analyses. Nitrogen was used as a carrier gas, the column temperature was 180 ℃, and the inj ection temperature was 250 ℃. Flieg acids standard was used as a comparison.

2.8 Statistic analysis

The nutrients (DM, crude ash, crude protein, crude fat, crude fiber and starch), DM lost from bags at the different incubation hours and the degradability parameters (a, b, c, t_0 and A) were subjected to analysis of variance with GLM procedures of SAS (SAS Institute Inc., Vers. 8.2; 1989) using Duncan test (P<0.05).

To compare the mean value the following model was used:

$Y_{ij} = \mu + \text{variety}_i + \text{harvest stage}_j + e_{ij}$

Where

Y_{ij}	= observation value of the dependant variable
μ	= overall mean
Variety_i	= fixed effect of maize variety variety
Harvest stage_j	= fixed effect of harvest stage k
e_{ij}	= residual error

3. Results

3.1 Rumen degradability of maize stover

3.1.1 Effect of maturity stage and maize variety on stover DM degradability

The aim of this work was to study the effect of maturity stage and variety on rumen DM degradability of maize stover. Three experiments (Exp 1, Exp 2 and Exp 3) were done over a period of three seasons of cultivation (2006, 2007 and 2008) to evaluate the maximal number of maize variety. However six, four and six varieties were used in Exp 1, Exp 2 and Exp 3, respectively. Variety NK Magitop which characterized with good rumen DM degradability was used as a comparative and a control variety in the three experiments.

3.1.1.1 Exp 1, 2006

The aim of this experiment was to study the effect of maturity stage and maize variety on the in situ rumen DM degradability of maize stover. Six varieties of maize (NK Magitop, EXP99FN, NX1064, NX1494, NX1485 and NX0601) were used. Those six varieties cultivated in 2006 and harvested at three harvest dates (period between HD1 and HD3 was about one month, starting from beginning of September until beginning of October, as this period covers the practical harvest time).

3.1.1.1.1 Dry matter and chemical composition of maize stover

Data illustrated in Table 7 and 8 showed DM and the chemical composition of maize stover of the six varieties at the three harvest dates. Regarding to maize stover DM it increased with increasing plant maturity and the mean of the harvest date significantly increased from 19.7% at HD1 to 28.3% at HD3 with an increase of 8.60%. On the other hand there was no significant difference in stover DM between the means of the varieties. It ranged from 21.9% for variety NX1485 to 25.9% for variety NX1064. Stover DM in all varieties regularly increased from HD1 to HD3 except variety NX1064 which jumped from 23.3% at HD2 to 34.3% at HD3 with an increase of 11%; and in turn it had the highest mean among the varieties.

Concerning to stover crude ash content there was no significant differece between the means of the three harvest dates (5.30%, 5.59% and 5.26% for HD1, HD2 and HD3 respectively). On the other hand, the mean of variety NX1064 (5.84%)

was significantly higher in stover crude ash content than that of varieties NK Magitop and NX1485 (5.05 and 5.13% respectively).

Table 7. Dry matter and chemical composition of maize stover for the six varieties at the three harvest dates

Nutrient	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety
DM (%)	NK Magitop	21.8	25.3	28.3	**25.1**
	EXP99FN	20.2	23.3	28.8	**24.1**
	NX1064	20.0	23.3	34.3	**25.9**
	NX1494	19.3	22.3	27.3	**23.0**
	NX1485	18.5	21.7	25.5	**21.9**
	NX0601	18.4	23.7	25.5	**22.0**
	Mean HD	**19.7^{c}**	**23.3^{b}**	**28.3^{a}**	
Crude ash (%)	NK Magitop	5.11	5.20	4.84	**5.05^{B}**
	EXP99FN	5.86	5.48	5.36	**5.57^{AB}**
	NX1064	5.32	6.56	5.64	**5.84^{A}**
	NX1494	5.35	5.37	5.31	**5.34^{AB}**
	NX1485	5.23	5.41	4.75	**5.13^{B}**
	NX0601	4.91	5.49	5.65	**5.35^{AB}**
	Mean HD	**5.30**	**5.59**	**5.26**	
CP (%)	NK Magitop	4.89	3.68	3.44	**4.00**
	EXP99FN	5.74	4.24	4.37	**4.78**
	NX1064	5.54	4.32	4.55	**4.81**
	NX1494	5.81	4.92	4.04	**4.92**
	NX1485	5.42	4.36	3.65	**4.48**
	NX0601	4.73	4.89	3.76	**4.46**
	Mean HD	**5.36**	**4.40**	**3.96**	
EE (%)	NK Magitop	1.02	1.00	0.95	**0.99**
	EXP99FN	1.11	0.88	1.02	**1.00**
	NX1064	1.04	0.94	0.72	**0.90**
	NX1494	1.05	1.03	0.98	**1.02**
	NX1485	1.34	1.10	0.88	**1.11**
	NX0601	0.85	1.17	0.83	**0.95**
	Mean HD	**1.07^{a}**	**1.02^{ab}**	**0.90^{b}**	

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Regarding to stover CP content it decreased with increasing plant maturity and the mean of the harvest date decreased with increasing plant maturity but it was not significantly different. The means of HD1, HD2 and HD3 are 5.36%, 4.40% and 3.96% respectively. No significant difference in stover CP content between the means of the six varieties was noticed. It ranged from 4.00% for variety NK Magitop to 4.92% for variety NX1494.

Stover EE content decreased with increasing plant maturity from 1.07% at HD1 to 0.90% at HD3. There was no significant difference in stover EE content between the means of varieties as it ranged from 0.90% for variety NX1064 to 1.11% for variety NX1485.

Table 8. Crude fiber and crude fiber fractions of maize stover for the six varieties at the three harvest dates

Nutrient	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety
CF (%)	NK Magitop	31.7	32.5	33.9	**32.7^{AB}**
	EXP99FN	34.3	33.6	33.8	**33.9^{A}**
	NX1064	32.0	32.8	35.8	**33.5^{A}**
	NX1494	29.3	29.6	31.1	**30.0^{C}**
	NX1485	29.6	31.6	31.5	**30.9^{BC}**
	NX0601	32.3	31.7	33.6	**32.5^{AB}**
	Mean HD	**31.5**	**32.0**	**33.3**	
NDF (%)	NK Magitop	59.5	61.8	62.1	**61.1^{AB}**
	EXP99FN	67.4	61.4	67.9	**65.6^{AB}**
	NX1064	60.3	68.6	69.5	**66.1^{A}**
	NX1494	58.6	60.3	60.8	**59.9^{B}**
	NX1485	57.7	63.8	62.2	**61.2^{AB}**
	NX0601	63.5	63.1	66.1	**64.2^{AB}**
	Mean HD	**61.2**	**63.2**	**64.8**	
ADF (%)	NK Magitop	35.2	39.1	42.5	**38.9**
	EXP99FN	39.2	30.9	31.5	**33.9**
	NX1064	36.6	42.0	42.3	**40.3**
	NX1494	32.0	34.4	35.5	**34.0**
	NX1485	33.1	35.3	37.6	**35.3**
	NX0601	36.8	31.6	42.1	**36.8**
	Mean HD	**35.5**	**35.6**	**38.6**	
ADL (%)	NK Magitop	3.50	4.60	4.8	**4.30**
	EXP99FN	5.80	4.60	3.50	**4.63**
	NX1064	4.70	4.70	4.00	**4.47**
	NX1494	4.50	3.90	4.00	**4.13**
	NX1485	4.10	3.90	4.60	**4.20**
	NX0601	4.70	4.90	5.00	**4.87**
	Mean HD	**4.60**	**4.40**	**4.30**	

Means along the same column bearing different capital letters are significantly different

For stover CF content it increased with increasing plant maturity and the mean of harvest date increased non-significantly from 31.5% at HD1 to 33.3% at HD3 Means of stover CF for varieties NX1064 and EXP99FN (33.5 and 33.9% respectively) were significantly higher than those for varieties NX1494 and NX1485 (30.0 and 30.9% respectively). Stover CF content increased with increasing plant maturity from HD1 to HD3 in all varieties except variety EXP99FN in which it was nearly equal at the three harvest date with high CF level (34.3, 33.6 and 33.8% for HD1, HD2 and HD3 respectively).

Regarding to stover NDF content it increased with increasing plant maturity and the mean of harvest date increased non-significantly from 61.2% at HD1 to 64.8% at HD3 with an increase of 3.60%. Means of stover NDF for variety NX1064 (66.1%) was significantly higher than that for variety NX1485 (59.9%).

Belong to stover ADF content it increased with increasing plant maturity and the mean of harvest date increased non-significantly from 35.5% at HD1 to 38.6% at HD3 with an increase of 3.10%. There was no significant differences in stover ADF between means of the different varieties. It ranged from 33.9% for variety EXP99FN to 40.3% for variety NX1064.

Stover ADL content was nearly equal at the three harvest dates (4.60, 4.40 and 4.30% for HD1, HD2 and HD3 respectively). There was no significant difference in stover ADL content between the means of varieties as it ranged from 4.13% for variety NX1494 to 4.87% for variety NX0601.

3.1.1.1.2 In situ rumen dry matter degradability of maize stover

Table 9 illustrate the results of DM degradability of maize stover of the six varieties at the three harvest dates, after various incubation times. DM degradability increased with increasing the incubation times. Means of stover DM degradability were 31.0, 33.0, 36.0, 44.0, 52.0, 59.0, 65.0, 69.0 and 72.0% at 0, 2, 4, 8, 16, 24, 48, 72 and 96 h of incubation, respectively.

Dry matter washing losses (0 h) decreased with increasing plant maturity and the mean of the harvest date significantly decreased from 32.7% at HD1 to 29.7% at HD3. There was a significant difference in DM washing losses between the means of the varieties and it ranged from 24.7% for variety NX1064 to 34.5% for variety NX1494. Also there was a significant decrease in DM washing losses with increasing plant maturity for the various varieties except variety EXP99FN in which HD2 (32.2%) was the highest. The decrease in DM washing losses between HD1 and HD3 was different between varieties. Variety NX1064 showed a decrease of 8.70% from 29.7% at HD1 to 21.0% at HD3, but for variety NX1485 showed a decrease of 2.2% from 35.6% at HD1 to 33.4% at HD3.

Regarding to the other incubation times (2, 4, 8, 16, 24, 48, 72 and 96 h) they have the same direction in DM degradability like 0 h, as there was a significant decreased in DM degradability with increasing plant maturity. And there was a significant difference between the means of the varieties. It is important to note that the difference in DM degradability between the harvest dates and between the varieties decreased with increasing the incubation time. For example, the difference in DM washing losses (0 h) between HD1 and HD3 for variety NX1064 was 8.70%, but at 96 h of incubation this difference decreased to be 3.60% (from 73.0% at HD1 to 69.4% at HD3). On the other hand, this difference for variety NX1485 at 0 h was 2.2%, but at 96 h this difference decreased to be 1.30% (from 75.7% at HD1 to 74.4% at HD3). Also the difference in DM washing losses between mean of variety NX1485 (34.1%) and mean of variety NX1064 (24.7%) was 9.40%, but at 96 h of incubation this difference in DM degradability between mean of variety NX1485 (74.6%) and mean of variety NX1064 (70.4%) became 4.2%.

Table 9. Dry matter degradability (%) of maize stover of the six varieties at the three harvest dates after various incubation times

Time	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety	MSE HD	P-Value
	NK Magitop	36.3^{Aa} ± 0.21	34.7^{Ab} ± 0.78	33.7^{Ac} ± 0.46	**34.9^{A}**	0.53	0.0027
	EXP99FN	27.9^{Ec} ± 0.68	32.2^{Ca} ± 0.77	30.0^{Bb} ± 0.50	**30.0^{B}**	0.66	0.0007
	NX1064	29.7^{Da} ± 0.21	23.4^{Eb} ± 0.29	21.0^{Dc} ± 0.26	**24.7^{C}**	0.26	0.0001
	NX1494	35.2^{Ba} ± 0.49	35.1^{Aa} ± 0.24	33.2^{Ab} ± 0.38	**34.5^{A}**	0.38	0.0010
0 h	**NX1485**	35.6^{ABa} ± 0.45	33.3^{Bb} ± 0.38	33.4^{Ab} ± 0.47	**34.1^{A}**	0.45	0.0013
	NX0601	31.3^{Ca} ± 0.43	28.1^{Db} ± 0.22	26.9^{Cc} ± 0.32	**28.8^{B}**	0.35	0.0001
	Mean HD	**32.7^{a}**	**31.1^{ab}**	**29.7^{b}**			
	MSE variety	0.43	0.52	0.41			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	38.0^{Aa} ± 1.01	35.6^{Ab} ± 0.30	33.1^{Bc} ± 0.67	**35.6^{A}**	0.66	0.0003
	EXP99FN	30.6^{Cc} ± 0.44	34.4^{Ba} ± 0.38	31.0^{Cb} ± 0.21	**32.0^{B}**	0.23	0.0001
	NX1064	33.1^{Ba} ± 0.30	23.8^{Db} ± 0.86	21.9^{Ec} ± 0.91	**26.3^{C}**	0.72	0.0001
	NX1494	37.5^{Aa} ± 1.14	35.0^{ABb} ± 0.76	34.1^{ABb} ± 0.77	**35.5^{A}**	0.81	0.0051
2 h	**NX1485**	37.5^{Aa} ± 0.19	35.1^{ABb} ± 0.68	34.8^{Ab} ± 0.47	**35.8^{A}**	0.47	0.0007
	NX0601	33.7^{Ba} ± 0.74	30.0^{Cb} ± 0.46	29.8^{Db} ± 1.04	**31.2^{B}**	0.76	0.0012
	Mean HD	**35.1^{a}**	**32.3^{b}**	**30.8^{b}**			
	MSE variety	0.71	0.54	0.66			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	40.9^{Aa} ± 1.50	38.7^{ABb} ± 0.75	36.1^{Ac} ± 0.79	**38.6^{A}**	1.05	0.0041
	EXP99FN	33.7^{Cb} ± 0.40	37.7^{Ba} ± 0.64	34.0^{Bb} ± 0.54	**35.1^{B}**	0.47	0.0001
	NX1064	34.9^{BCa} ± 0.69	27.0^{Db} ± 0.52	23.8^{Dc} ± 0.50	**28.6^{C}**	0.62	0.0001
	NX1494	40.3^{Aa} ± 1.31	39.5^{Aa} ± 0.69	37.1^{Ab} ± 0.71	**39.0^{A}**	0.95	0.0156
4 h	**NX1485**	41.5^{Aa} ± 1.39	37.4^{Bb} ± 1.15	37.0^{Ab} ± 0.83	**38.7^{A}**	1.16	0.0058
	NX0601	36.3^{Ba} ± 1.30	31.7^{Cb} ± 0.84	31.3^{Cb} ± 0.95	**33.1^{B}**	1.13	0.003
	Mean HD	**37.9^{a}**	**35.3^{ab}**	**33.2^{b}**			
	MSE variety	1.2	0.84	0.7			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	48.8^{ABa} ± 2.97	46.2^{Bab} ± 1.28	43.1^{Ab} ± 1.03	**46.0^{AB}**	2.09	0.0431
	EXP99FN	43.3^{Ca} ± 2.67	44.1^{Ca} ± 0.51	41.7^{ABa} ± 0.99	**43.0^{B}**	1.70	0.297
	NX1064	46.7^{BCa} ± 1.40	37.3^{Eb} ± 1.16	33.0^{Cc} ± 1.18	**39.0^{C}**	1.25	0.0001
	NX1494	49.8^{ABa} ± 1.56	48.4^{Aa} ± 1.45	43.7^{Ab} ± 2.03	**47.3^{A}**	0.78	0.0138
8 h	**NX1485**	51.8^{Aa} ± 1.01	46.2^{Bb} ± 0.31	44.6^{Ab} ± 2.14	**47.5^{A}**	1.23	0.0009
	NX0601	46.7^{BCa} ± 2.28	41.5^{Db} ± 1.57	38.5^{Bb} ± 2.61	**42.2^{BC}**	2.30	0.0133
	Mean HD	**47.8^{a}**	**44.0^{b}**	**40.8^{c}**			
	MSE variety	2.14	1.16	1.87			
	P-Value	0.0061	0.0001	0.0001			
	NK Magitop	58.0^{ABa} ± 0.71	54.3^{Aa} ± 0.87	48.8^{Bb} ± 3.74	**53.7^{AB}**	2.50	0.0114
	EXP99FN	52.0^{Ca} ± 0.66	51.3^{ABa} ± 1.00	51.0^{ABa} ± 1.14	**51.4^{B}**	0.66	0.2204
	NX1064	51.7^{Ca} ± 5.62	45.1^{Ba} ± 2.90	43.8^{Ca} ± 1.77	**46.9^{C}**	4.17	0.1228
	NX1494	58.1^{ABa} ± 1.45	54.2^{Aa} ± 3.96	52.9^{ABa} ± 1.01	**55.1^{AB}**	2.70	0.114
16 h	**NX1485**	59.9^{Aa} ± 0.44	53.8^{Aa} ± 4.65	55.0^{Aa} ± 1.99	**56.2^{A}**	3.11	0.111
	NX0601	53.5^{BCa} ± 2.93	50.4^{ABa} ± 5.01	49.8^{Ba} ± 1.36	**51.2^{B}**	3.76	0.4731
	Mean HD	**55.5^{a}**	**51.5^{b}**	**50.2^{b}**			
	MSE variety	2.94	3.77	2.16			
	P-Value	0.0169	0.0797	0.0008			

Continued Table 9

Time	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety	MSE HD	P-Value
24 h	**NK Magitop**	62.7^{ABa} ± 2.10	59.8^{Bab} ± 1.52	58.0^{Bb} ± 1.08	**60.2^{B}**	1.60	0.0302
	EXP99FN	56.4^{Ca} ± 1.10	53.6^{Ca} ± 2.66	55.8^{Ca} ± 0.60	**55.3^{C}**	1.82	0.234
	NX1064	62.1^{ABa} ± 1.13	54.8^{Cb} ± 1.49	54.8^{CDb} ± 1.32	**57.2^{C}**	1.13	0.0003
	NX1494	63.9^{Aa} ± 2.18	63.3^{Aa} ± 1.63	60.9^{Aa} ± 0.96	**62.7^{A}**	1.69	0.1488
	NX1485	61.0^{Ba} ± 1.05	60.9^{ABa} ± 1.52	59.7^{ABa} ± 1.75	**60.5^{AB}**	1.47	0.5473
	NX0601	57.0^{Ca} ± 0.98	55.6^{Ca} ± 0.75	53.2^{Db} ± 1.46	**55.3^{C}**	1.07	0.0138
	Mean HD	**60.5^{a}**	**58.0^{b}**	**57.1^{b}**			
	MSE variety	1.53	1.72	1.16			
	P-Value	0.0002	0.0001	0.0001			
48 h	**NK Magitop**	68.9^{Aa} ± 0.46	66.7^{ABb} ± 0.52	65.1^{ABCc} ± 0.44	**66.9^{A}**	0.42	0.0001
	EXP99FN	62.2^{Ba} ± 2.57	61.9^{Ca} ± 2.11	62.6^{BCDa} ± 1.61	**62.2^{B}**	2.28	0.932
	NX1064	67.0^{Aa} ± 1.51	61.1^{Cb} ± 1.71	62.4^{CDb} ± 1.02	**63.5^{B}**	1.52	0.0076
	NX1494	69.0^{Aa} ± 1.38	68.2^{Aab} ± 1.37	66.4^{Ab} ± 0.79	**67.9^{A}**	1.07	0.0602
	NX1485	69.0^{Aa} ± 0.89	66.1^{ABa} ± 2.41	66.2^{ABa} ± 3.03	**67.1^{A}**	2.49	0.3417
	NX0601	61.9^{Ba} ± 4.20	63.3^{BCa} ± 3.03	59.7^{Da} ± 2.54	**61.6^{B}**	3.62	0.5113
	Mean HD	**66.3^{a}**	**64.6^{ab}**	**63.7^{b}**			
	MSE variety	2.35	2.17	1.95			
	P-Value	0.0042	0.0089	0.008			
72 h	**NK Magitop**	72.0^{Aa} ± 0.55	70.3^{ABb} ± 0.60	68.6^{BCc} ± 0.54	**70.3^{A}**	0.51	0.0005
	EXP99FN	66.9^{Ba} ± 2.28	66.1^{Ca} ± 1.91	66.6^{CDa} ± 1.83	**66.5^{B}**	2.17	0.9027
	NX1064	71.0^{Aa} ± 0.85	65.5^{Cb} ± 0.97	66.8^{CDb} ± 1.78	**67.7^{B}**	1.23	0.0037
	NX1494	71.6^{Aa} ± 0.47	72.2^{Aa} ± 0.92	69.7^{Bb} ± 0.43	**71.2^{A}**	0.67	0.0087
	NX1485	73.0^{Aa} ± 1.72	70.6^{Aa} ± 1.76	71.3^{Aa} ± 2.15	**71.6^{A}**	2.06	0.3965
	NX0601	66.9^{Ba} ± 2.15	67.3^{BCa} ± 2.44	65.9^{Da} ± 2.03	**66.7^{B}**	2.44	0.7891
	Mean HD	**70.2^{a}**	**68.7^{a}**	**68.1^{b}**			
	MSE variety	1.63	1.70	1.73			
	P-Value	0.0015	0.0018	0.0177			
96 h	**NK Magitop**	74.8^{ABa} ± 0.48	73.0^{ABb} ± 0.29	71.2^{BCc} ± 0.56	**73.0^{A}**	0.36	0.0001
	EXP99FN	70.1^{Ca} ± 1.22	68.9^{Ca} ± 0.73	69.5^{CDa} ± 1.03	**69.5^{B}**	1.12	0.4336
	NX1064	73.0^{Ba} ± 0.53	68.8^{Cb} ± 0.25	69.4^{CDb} ± 0.26	**70.4^{B}**	0.40	0.0001
	NX1494	74.6^{ABa} ± 0.22	74.1^{Aa} ± 0.43	72.3^{Bb} ± 0.64	**73.7^{A}**	0.48	0.0021
	NX1485	75.7^{Aa} ± 0.66	73.6^{Aa} ± 1.98	74.4^{Aa} ± 0.99	**74.6^{A}**	1.47	0.2942
	NX0601	70.2^{Ca} ± 2.19	71.2^{Ba} ± 1.31	68.4^{Da} ± 1.39	**69.9^{B}**	1.58	0.252
	Mean HD	**73.1^{a}**	**71.6^{ab}**	**70.9^{b}**			
	MSE variety	1.23	1.13	0.95			
	P-Value	0.0003	0.0002	0.0001			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.1.1.1.3 Parameters of rumen dry matter degradability of maize stover

Table 10 illustrate the parameters of rumen DM degradability of maize stover of the six varieties at the three harvest dates. For maize stover rapidly soluble fraction (a) it decreased with increasing plant maturity and the mean of the harvest date significantly decreased from 32.7% at HD1 to 29.7% at HD3. Means of the rapidly soluble fraction for the varieties NX1494 (34.5%), NK Magitop (34.8%) and NX1485 (34.1%) were significantly higher than those for varieties NX1064 (24.8%), NX0601

(28.8%) and EXP99FN (30.2%). There was a significant decrease in the rapidly soluble fraction with increasing plant maturity for the various varieties except for variety EXP99FN in which HD1 (27.9%) was significantly lower than HD2 (32.7%) and HD3 (30.0%). The rapidly soluble fraction for variety NX1064 had dramatically progressive decrease with increasing plant maturity, in which it decreased from 29.7% at HD1 to 23.4% at HD2 to 21.2% at HD3.

Regarding to maize stover slowly degradable fraction (b) it increased with increasing plant maturity and the mean of the harvest date increased not-significantly from 38.6% at HD1 to 40.3% at HD3. On the other hand there was a significant difference between the means of the varieties and it ranged from 37.3% for variety NK Magitop to 44.6% for variety NX1064. It is obvious that there is a relationship between the rapidly soluble fraction and the slowly degradable fraction, as the rapidly soluble fraction decreased when the slowly degradable fraction increased and vice versa.

For maize stover non degradable fraction (A) there was no significant difference between the means of the harvest dates (28.8%, 29.4% and 30.0% for HD1, HD2 and HD3 respectively), but there was only slight increased from HD1 to HD3. Means of the non degradable fraction for varieties NX1064 (30.6%), NX0601 (31.7%) and EXP99FN (31.8%) were significantly higher than those for varieties NX1494 (27.6%), NK Magitop (27.9%) and NX1485 (26.8%).

Concerning to maize stover rate of degradation (c) it decreased with increasing plant maturity and the mean of HD1 (5.77%h^{-1}) was significantly higher than that of HD2 (4.95%h^{-1}) and HD3 (4.86%h^{-1}). There was no significant difference in the degradation rate between the means of the varieties and it ranged from 4.90%h^{-1} for variety EXP99FN to 5.72%h^{-1} for variety NX1494. For variety NK Magitop the rate of degradation at HD3 (4.44%h^{-1}) was significantly lower than that at HD1 (5.64%h^{-1}) and for variety EXP99FN the rate of degradation at HD2 (4.11%h^{-1}) was significantly lower than that at HD1 (5.51%h^{-1}) and at HD3 (5.09%h^{-1}).

Table 10. Parameters of rumen dry matter degradability (% ± SD) of fresh maize stover of the six varieties at the three harvest dates

Parameters	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	36.3^{Aa} ± 0.21	34.7^{Ab} ± 0.78	33.5^{Ac} ± 0.34	**34.8^{A}**	0.5	0.0015
	EXP99FN	27.9^{Ec} ± 0.68	32.7^{Ba} ± 0.76	30.0^{Bb} ± 0.50	**30.2^{B}**	0.66	0.0004
	NX1064	29.7^{Da} ± 0.21	23.4^{Db} ± 0.29	21.2^{Dc} ± 0.46	**24.8^{C}**	0.34	0.0001
	NX1494	35.2^{Ba} ± 0.49	35.1^{Aa} ± 0.24	33.1^{Ab} ± 0.38	**34.5^{A}**	0.38	0.001
	NX1485	35.5^{ABa} ± 0.45	33.3^{Bb} ± 0.39	33.5^{Ab} ± 0.47	**34.1^{A}**	0.46	0.0015
	NX0601	31.3^{Ca} ± 0.43	28.1^{Cb} ± 0.21	26.9^{Cc} ± 0.32	**28.8^{B}**	0.35	0.0001
	Mean HD	**32.7^{a}**	**31.2^{ab}**	**29.7^{b}**			
	MSE variety	0.45	0.51	0.43			
	P-Value	0.0001	0.0001	0.0001			
b (%)	**NK Magitop**	37.0^{Ca} ± 0.77	37.3^{CDa} ± 0.74	37.5^{Ca} ± 0.77	**37.3^{C}**	0.77	0.7563
	EXP99FN	40.1^{ABa} ± 1.78	35.7^{Db} ± 1.56	38.2^{BCab} ± 2.02	**38.0^{BC}**	1.78	0.0614
	NX1064	42.3^{Ab} ± 1.55	44.0^{Ab} ± 1.66	47.5^{Aa} ± 0.70	**44.6^{A}**	1.38	0.0096
	NX1494	37.7^{BCa} ± 0.45	38.1^{CDa} ± 1.35	38.2^{BCa} ± 0.68	**38.0^{BC}**	0.91	0.765
	NX1485	37.8^{BCa} ± 1.44	39.9^{BCa} ± 1.89	39.8^{BCa} ± 1.12	**39.2^{BC}**	1.53	0.2623
	NX0601	36.4^{Cb} ± 2.60	41.6^{ABa} ± 1.27	40.5^{Bab} ± 2.20	**39.5^{B}**	2.1	0.0524
	Mean HD	**38.6^{a}**	**39.4^{a}**	**40.3^{a}**			
	MSE variety	1.6	1.46	1.39			
	P-Value	0.0062	0.0002	0.0001			
A (%)	**NK Magitop**	26.7^{Bb} ± 0.57	28.0^{BCa} ± 0.08	29.0^{Ba} ± 0.75	**27.9^{B}**	0.54	0.0056
	EXP99FN	32.0^{Aa} ± 2.22	31.6^{Aa} ± 0.95	31.8^{Aa} ± 2.03	**31.8^{A}**	1.81	0.975
	NX1064	28.0^{Bb} ± 1.35	32.7^{Aa} ± 1.52	31.3^{Aa} ± 0.26	**30.6^{A}**	1.18	0.0073
	NX1494	27.2^{Bb} ± 0.21	26.8^{Cb} ± 1.15	28.7^{Ba} ± 0.41	**27.6^{B}**	0.72	0.0425
	NX1485	26.6^{Ba} ± 1.01	26.9^{Ca} ± 1.98	26.9^{Ba} ± 0.67	**26.8^{B}**	1.35	0.9706
	NX0601	32.2^{Aa} ± 2.56	30.3^{ABa} ± 1.47	32.6^{Aa} ± 1.88	**31.7^{A}**	2.03	0.3811
	Mean HD	**28.8^{a}**	**29.4^{a}**	**30.0^{a}**			
	MSE variety	1.56	1.34	1.22			
	P-Value	0.0013	0.0005	0.0006			
c (%)	**NK Magitop**	5.64^{Aa} ± 0.81	4.91^{Aab} ± 0.29	4.44^{Ab} ± 0.58	**4.98^{A}**	0.60	0.1067
	EXP99FN	5.51^{Aa} ± 0.39	4.11^{Ab} ± 0.51	5.09^{Aa} ± 0.55	**4.90^{A}**	0.49	0.0318
	NX1064	5.67^{Aa} ± 1.19	5.20^{Aa} ± 0.58	5.14^{Aa} ± 0.46	**5.33^{A}**	0.81	0.6928
	NX1494	6.27^{Aa} ± 0.53	5.65^{Aa} ± 1.30	5.23^{Aa} ± 0.23	**5.72^{A}**	0.85	0.3855
	NX1485	5.97^{Aa} ± 0.24	4.98^{Aa} ± 1.59	4.73^{Aa} ± 0.55	**5.23^{A}**	0.98	0.3311
	NX0601	5.56^{Aa} ± 0.40	4.84^{Aa} ± 0.91	4.55^{Aa} ± 0.17	**4.98^{A}**	0.58	0.1721
	Mean HD	**5.77^{a}**	**4.95^{b}**	**4.86^{b}**			
	MSE variety	0.67	0.98	0.48			
	P-Value	0.7282	0.573	0.2446			
t_0 (h)	**NK Magitop**	1.14^{Ab} ± 0.43	1.31^{ABb} ± 0.46	2.23^{ABa} ± 0.39	**1.56^{A}**	0.43	0.0419
	EXP99FN	0.55^{ABb} ± 0.42	0.25^{Cb} ± 0.43	1.36^{CDa} ± 0.12	**0.72^{B}**	0.35	0.0206
	NX1064	0.34^{Bb} ± 0.40	1.79^{Aa} ± 0.30	2.56^{Aa} ± 0.53	**1.56^{A}**	0.42	0.0018
	NX1494	1.02^{ABa} ± 0.35	1.68^{ABa} ± 0.58	1.69^{BCa} ± 0.30	**1.46^{A}**	0.43	0.1745
	NX1485	0.49^{ABb} ± 0.33	0.96^{BCab} ± 0.40	1.33^{CDa} ± 0.28	**0.93^{AB}**	0.34	0.0623
	NX0601	0.46^{ABa} ± 0.37	1.12^{ABa} ± 0.20	0.59^{Da} ± 0.78	**0.72^{B}**	0.51	0.3183
	Mean HD	**0.67^{c}**	**1.19^{b}**	**1.63^{a}**			
	MSE variety	0.38	0.41	0.45			
	P-Value	0.1225	0.0075	0.0023			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Belong to maize stover lag time (t_0) it increased with increasing plant maturity and the mean of the harvest date significantly increased from 0.67 h at HD1 to 1.63 h at HD3. Also there was a significant difference between the means of the varieties and it ranged from 0.72 h for varieties EXP99FN and NX0601 to 1.56 h for varieties NX1064 and NK Magitop.

3.1.1.1.4 Effective rumen dry matter degradability of maize stover

Table 11 shows the effective rumen dry matter degradability of maize stover of the six varieties at the three harvest dates by passage rate of 6%h^{-1}. It is conspicuous that harvest date and maize variety influenced the effective rumen dry matter degradability. The effective rumen DM degradability of maize stover decreased with increasing plant maturity and the mean of harvest date at HD1 (50.8%) was significantly higher than that at HD2 (47.6%) and HD3 (46.0%). Also there was a significant difference between the means of the varieties, as means of varieties NX1494, NX1485 and NK Magitop (51.3, 51.1 and 50.2% respectively) were significantly higher than those of varieties EXP99FN, NX 0601 and NX1064 (46.5, 45.9 and 43.8% respectively). Also there was a significant decreased in the effective rumen DM degradability with increasing plant maturity for the various varieties except for variety EXP99FN in which there was no significant difference between the three harvest dates with low level of degradability (46.5, 47.0 and 46.1% for HD1, HD2 and HD3 respectively). On the other hand, variety NX1064 had dramatically progressive decrease in EDMD with increasing plant maturity, in which it decreased from 49.7% at HD1 to 41.7% at HD2 to 40.0% at HD3, and this wide range indicates the deterioration of DM degradability with increasing plant maturity. But the EDMD for varieties NX1485 and NX1494 was high and there was only slight decrease in EDMD from HD1 (53.9 and 53.2% for NX1485 and 1494 respectively) to HD3 (49.6 and 49.2% for NX1485 and 1494 respectively) with a decrease of 4.30 and 4.00% for NX1485 and 1494 respectively, which indicate a wide window for harvesting this variety without deterioration of their DM degradability.

Table 11. Effective rumen dry matter degradability (% ± SD) of maize stover of the six varieties at the three harvest dates by passage rate of 6%h^{-1}

Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety	MSE HD	P-Value
NK Magitop	53.0^{Aa} ± 0.95	50.2^{Ab} ± 0.65	47.3^{Bc} ± 0.49	**50.2^{A}**	0.72	0.0002
EXP99FN	46.5^{Ca} ± 0.89	47.0^{Ba} ± 0.88	46.1^{Ba} ± 0.06	**46.5^{B}**	0.74	0.361
NX1064	49.7^{Ba} ± 1.72	41.7^{Cb} ± 0.47	40.0^{Db} ± 0.57	**43.8^{C}**	1.08	0.0001
NX1494	53.2^{Aa} ± 0.76	51.6^{Ab} ± 1.01	49.2^{Ac} ± 0.58	**51.3^{A}**	0.80	0.0025
NX1485	53.9^{Aa} ± 0.94	49.9^{Ab} ± 2.05	49.6^{Ab} ± 1.29	**51.1^{A}**	1.50	0.022
NX0601	48.4^{BCa} ± 2.06	45.4^{Bab} ± 2.12	43.8^{Cb} ± 1.54	**45.9^{BC}**	1.93	0.0652
Mean HD	**50.8^{a}**	**47.6^{b}**	**46.0^{b}**			
MSE variety	1.32	1.36	0.92			
P-Value	0.0001	0.0001	0.0001			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

It is obvious that DM degradability of maize stover strongly affected by both stage of maize maturity and variety. The chemical composition is the prime cause which affects the DM degradability of maize stover, as stover CF content increases with increasing plant maturity and in turn decreases DM degradability. The decrease in the DM degradability between HD1 and HD3 is different between varieties. In NX1064 variety this decrease has wide range which indicates the deterioration of DM degradability with increasing plant maturity. But on the other hand this range is small for NX1494, NX1485 and NK Magitop varieties which indicates a wide window for harvesting those varieties without deterioration of degradability. Varieties here can be classified according to DM degradability into three categories, in which varieties NX1494, NK Magitop and NX1485 are high in degradability, varieties NX0601 and EXP99FN are intermediate degradability and variety NX1064 is low in degradability.

3.1.1.2 Exp 2, 2007

The aim of this experiment was to study the effect of maturity stage and maize variety on the in situ rumen degradability of maize stover. Three new varieties (Winn, NK Lemoro and NX1775) in addition to NK Magitop were used. Those four varieties cultivated in 2007 and harvested at four maturity dates instead of three maturity dates for Exp1 (the period between HD1 and HD4 extended to one and half month, starting from beginning of September until middle of October, as this period covers the practical harvest time).

3.1.1.2.1 Dry matter and chemical composition of maize stover

Table 12 and 13 show DM and chemical compositions of the maize stover for the four varieties at the four harvest date. Regarding to maize stover DM, it increased with increasing plant maturity and the mean of the harvest date significantly increased from 20.3 at HD1 to 40.4% at HD4 with an increase of 20.0%. There was no significant difference between the means of the varieties and it ranged from 27.1% for variety NX1775 to 29.6% for variety Winn. Stover DM content of the different varieties had progressive increase from HD3 to HD4 especially variety Winn which increased from 30.9% at HD3 to 43.1% at HD4 with an increase of 12.2%.

For stover crude ash content it decreased with increasing plant maturity, and the means of the harvest date at HD1 (5.31%) and HD2 (5.40%) were significantly higher than those at HD3 (4.67%) and HD4 (4.76%). But on the other hand there was no significant difference in stover crude ash content between the means of the varieties. The mean of variety NK Magitop (4.63%) was the lowest while that of variety NK Lemro (5.29%) was the highest in stover crude ash content.

Concerning to CP content it decreased with increasing plant maturity and the mean of the harvest date at HD1 (6.07%) was significantly higher than those at HD2 (4.55%), HD3 (4.42%) and HD4 (4.53%). On the other hand, there was no significant difference in stover CP content between the means of the varieties. It ranged from 4.60% for variety Winn to 5.37% for variety NK Lemro.

Belong to stover EE it decreased with increasing plant maturity. Also the mean of the harvest date significantly decreased from 1.00% at HD1 to 0.64% at HD4. But there was no significant difference in stover EE between the means of the varieties, and it had a small range from 0.75% for variety Winn to 0.89% for variety NK Lemro.

Table 12. Dry matter and chemical composition of maize stover for the four varieties at the four harvest dates

Nutrient	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety
DM (%)	NK Magitop	21.9	23.8	30.0	39.9	**28.9**
	Winn	20.5	23.8	30.9	43.1	**29.6**
	NK Lemoro	19.5	24.1	27.2	39.2	**27.5**
	NX1775	19.3	22.1	27.5	39.3	**27.1**
	Mean HD	**20.3**[c]	**23.5**[c]	**28.9**[b]	**40.4**[a]	
Crude ash (%)	NK Magitop	4.78	4.85	4.36	4.54	**4.63**
	Winn	5.45	5.47	4.90	4.39	**5.05**
	NK Lemoro	5.43	5.86	4.73	5.14	**5.29**
	NX1775	5.56	5.40	4.68	4.98	**5.16**
	Mean HD	**5.31**[a]	**5.40**[a]	**4.67**[b]	**4.76**[b]	
CP (%)	NK Magitop	6.78	4.08	4.53	4.36	**4.94**
	Winn	5.71	4.50	4.38	3.81	**4.60**
	NK Lemoro	6.53	5.24	4.53	5.18	**5.37**
	NX1775	5.27	4.36	4.23	4.76	**4.65**
	Mean HD	**6.07**[a]	**4.55**[b]	**4.42**[b]	**4.53**[b]	
EE (%)	NK Magitop	0.90	0.95	0.79	0.71	**0.84**
	Winn	0.94	0.76	0.75	0.55	**0.75**
	NK Lemoro	1.09	1.03	0.88	0.57	**0.89**
	NX1775	1.06	0.83	0.83	0.73	**0.86**
	Mean HD	**1.00**[a]	**0.89**[ab]	**0.81**[b]	**0.64**[c]	

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Regarding to stover CF content the direction of most varieties indicates that it increased with increasing plant maturity. The mean of the harvest date showed an increase of 3.50% from 34.3% at HD1 to 37.8% at HD4, but this increase was not significantly. On the other hand there was a significant difference in stover CF content between the means of the varieties with variety Winn (38.1%) was significantly higher than varieties NX1775 (33.5%) and NK Magitop (34.5%).

Regarding to stover NDF content it increased with increasing plant maturity and the mean of harvest date increased significantly from 62.4% at HD1 to 70.1% at HD4 with an increase of 7.70%. There wasno significant differences in stover NDF between means of the different varieties. It ranged from 61.9% for variety NK Magitop to 68.7% for variety Winn.

Belong to stover ADF content it increased with increasing plant maturity and the mean of harvest date increased non-significantly from 34.2% at HD1 to 40.7% at HD4 with an increase of 6.50%. Means of stover ADF for variety Winn (44.4%) was significantly higher than that for variety NX1775 (34.2%).

Stover ADL content was nearly equal at the four harvest dates (4.10, 4.40, 4.50 and 4.50% for HD1, HD2, HD3 and HD4 respectively). There was no significant difference in stover ADL content between the means of varieties as it ranged from 4.00% for variety NX1775 to 4.55% for variety NK Magitop.

Table 13. Crude fiber and crude fiber fractions of maize stover for the four varieties at the four harvest dates

Nutrient	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety
CF (%)	NK Magitop	34.1	33.3	34.8	35.6	**34.5**^{B}
	Winn	34.1	39.5	38.3	40.5	**38.1**^{A}
	NK Lemoro	34.8	35.7	36.0	40.4	**36.7**^{AB}
	NX1775	34.3	31.2	33.8	34.5	**33.5**^{B}
	Mean HD	**34.3**	**34.9**	**35.7**	**37.8**	
NDF (%)	NK Magitop	59.6	59.7	61.9	66.4	**61.9**
	Winn	62.5	68.8	69.2	74.3	**68.7**
	NK Lemoro	63.1	69.1	67.3	73.3	**68.2**
	NX1775	64.3	56.8	64.9	66.4	**63.1**
	Mean HD	**62.4**^{b}	**63.6**^{ab}	**65.8**^{ab}	**70.1**^{a}	
ADF (%)	NK Magitop	34.2	37.4	35.7	37.8	**36.3**^{AB}
	Winn	35.8	41.7	57.3	42.6	**44.4**^{A}
	NK Lemoro	36.4	37.7	37.6	44.9	**39.2**^{AB}
	NX1775	30.5	32.4	36.6	37.3	**34.2**^{B}
	Mean HD	**34.2**	**37.3**	**41.8**	**40.7**	
ADL (%)	NK Magitop	4.70	4.30	4.80	4.40	**4.55**
	Winn	3.70	4.60	4.60	5.00	**4.48**
	NK Lemoro	4.00	4.20	4.40	4.60	**4.30**
	NX1775	3.80	4.30	4.00	3.90	**4.00**
	Mean HD	**4.10**	**4.40**	**4.50**	**4.50**	

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.1.1.2.2 In situ rumen dry matter degradability of maize stover

Table 14 illustrate the results of the DM degradability of fresh maize stover of the four varieties at the four harvest dates after the various incubation times. It is clear from this table that DM degradability of maize stover is affected by both stage of maize maturity and variety. About the dry matter degradation course, it is obvious that dry matter degradability increased with increasing the incubation times. Means of DM degradability were 26.0, 28.0, 30.0, 36.0, 45.0, 52.0, 63.0, 67.0 and 72.0% at 0, 2, 4, 8, 16, 24, 48, 72 and 96 h of incubation, respectively.

Regarding to DM washing losses (0 h) it decreased with increasing plant maturity and the mean of the harvest date at HD1 (28.8%) and HD2 (28.6%) was significantly higher than that at HD4 (21.2%). Furthermore, the means of varieties NK Magitop (30.1%) and NX1775 (29.6%) were significantly higher in DM washing losses than those of varieties Winn (22.0%) and NK Lemoro (21.8%). Variety NX1775 showed its highest DM washing losses at HD2 (36.8%). The decrease in the DM washing losses between HD1 and HD4 was different between varieties. In -variety Winn it showed a decrease of 12.3% (from 28.4% at HD1 to 16.1% at HD4), while variety NK Magitop showed a decrease of 5.80% (from 32.0% at HD1 to 26.2% at HD4).

Concerning to the dry matter degradability after 2, 4, 8, 16, 24, 48 and 72 h of incubation it follows the same trend such as 0 h as DM degradability decreased with increasing plant maturity. Also varieties NK Magitop and NX1775 were significantly higher in DM degradability than varieties Winn and NK Lemoro.

For DM degradability after 96 h of incubation there was no significant difference between the means of the harvest dates (72.9, 71.4, 71.9 and 70.0% for HD1, HD2, HD3 and HD4 respectively), but it had the tendency to decrease with increasing plant maturity. Furthermore, means of varieties NK Magitop (75.2%) and NX1775 (73.9%) were significantly higher than those for varieties Winn (69.9%) and NK Lemoro (67.4%). Here also the difference in DM degradability between the harvest dates and between the varieties decreased with increasing the incubation time.

Table 14. In situ rumen dry matter degradability (% ± SD) of maize stover of the four varieties at the four harvest dates after the various incubation times

Time	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety	MSE HD	P-Value
0 h	**NK Magitop**	32.0^{Aa} ± 1.69	32.2^{Ba} ± 2.19	30.1^{Aa} ± 1.78	26.2^{Ab} ± 0.63	**30.1^{A}**	1.67	0.0077
	Winn	28.4^{Ba} ± 1.09	22.1^{Cb} ± 0.18	21.4^{Cb} ± 1.37	16.1^{Bc} ± 0.24	**22.0^{B}**	0.89	0.0001
	NK Lemoro	25.8^{Ca} ± 0.27	23.3^{Cb} ± 0.70	21.5^{Cc} ± 0.62	16.6^{Bd} ± 0.31	**21.8^{B}**	0.51	0.0001
	NX1775	29.1^{Bb} ± 0.44	36.8^{Aa} ± 0.35	26.5^{Bc} ± 0.60	25.9^{Ac} ± 0.37	**29.6^{A}**	0.45	0.0001
	Mean HD	**28.8^{a}**	**28.6^{a}**	**24.9^{ab}**	**21.2^{b}**			
	MSE variety	1.38	1.17	1.20	0.42			
	P-Value	0.0007	0.0001	0.0001	0.0001			
2 h	**NK Magitop**	33.2^{Ab} ± 0.34	34.0^{Ba} ± 0.51	32.4^{Ac} ± 0.41	29.3^{Ad} ± 0.79	**32.2^{A}**	0.26	0.0001
	Winn	30.2^{Ba} ± 0.86	24.9^{Cb} ± 0.53	23.0^{Cc} ± 0.83	19.0^{Bd} ± 0.44	**24.3^{B}**	0.40	0.0001
	NK Lemoro	27.7^{Ca} ± 0.70	25.2^{Cb} ± 1.14	23.1^{Cc} ± 0.54	18.6^{Bd} ± 0.42	**23.7^{B}**	0.70	0.0001
	NX1775	28.6^{Cb} ± 0.87	37.7^{Aa} ± 1.34	28.5^{Bc} ± 0.67	28.9^{Abc} ± 1.42	**30.9^{A}**	0.85	0.0001
	Mean HD	**29.9^{a}**	**30.5^{a}**	**26.8^{ab}**	**23.9^{b}**			
	MSE variety	0.54	0.90	0.42	0.41			
	P-Value	0.0001	0.0001	0.0001	0.0001			
4 h	**NK Magitop**	35.5^{Aa} ± 0.94	35.3^{Ba} ± 0.42	33.5^{Ab} ± 0.59	30.9^{Ac} ± 0.94	**33.8^{A}**	0.71	0.0001
	Winn	33.9^{Ba} ± 1.19	26.6^{Db} ± 0.61	25.4^{Cc} ± 0.63	20.9^{Bd} ± 0.47	**26.7^{B}**	0.58	0.0001
	NK Lemoro	32.0^{Ca} ± 0.56	28.6^{Cb} ± 1.09	26.1^{Cc} ± 1.21	19.8^{Bd} ± 0.68	**26.6^{B}**	0.91	0.0001
	NX1775	31.2^{Cb} ± 0.85	39.4^{Aa} ± 0.83	29.4^{Bc} ± 0.49	29.9^{Abc} ± 1.17	**32.5^{A}**	0.75	0.0001
	Mean HD	**32.2^{a}**	**32.5^{a}**	**28.6^{b}**	**25.4^{b}**			
	MSE variety	0.84	0.68	0.75	0.72			
	P-Value	0.001	0.0001	0.0001	0.0001			
8 h	**NK Magitop**	42.0^{Aa} ± 2.23	43.0^{Aa} ± 1.99	40.3^{Aab} ± 1.70	37.6^{Ab} ± 1.79	**40.7^{A}**	1.79	0.0255
	Winn	40.6^{Aa} ± 2.84	32.1^{Bb} ± 2.45	30.5^{Bb} ± 1.70	25.7^{Cc} ± 1.40	**32.2^{B}**	2.31	0.0003
	NK Lemoro	38.5^{Aa} ± 1.65	32.1^{Bb} ± 3.59	30.7^{Bb} ± 2.79	24.7^{Cc} ± 2.24	**31.5^{B}**	2.96	0.0033
	NX1775	38.1^{Ab} ± 3.33	45.9^{Aa} ± 2.01	34.0^{Bb} ± 2.19	34.1^{Bb} ± 1.48	**38.0^{A}**	2.53	0.0013
	Mean HD	**39.8^{a}**	**38.3^{a}**	**33.9^{b}**	**30.5^{b}**			
	MSE variety	2.62	2.88	2.30	1.78			
	P-Value	0.2987	0.0005	0.0025	0.0001			
16 h	**NK Magitop**	51.2^{Aa} ± 2.03	50.4^{Aa} ± 2.36	48.9^{Aab} ± 2.13	46.2^{Ab} ± 1.46	**49.2^{A}**	1.89	0.0521
	Winn	48.3^{Aa} ± 2.74	39.3^{Bb} ± 2.43	37.3^{Cbc} ± 3.20	32.4^{Bc} ± 3.09	**39.3^{B}**	3.09	0.0016
	NK Lemoro	47.0^{Aa} ± 2.91	40.4^{Bb} ± 2.41	39.9^{BCb} ± 3,84	34.3^{Bc} ± 1.91	**40.4^{B}**	2.97	0.0055
	NX1775	48.7^{Aab} ± 1.85	51.3^{Aa} ± 4.20	45.3^{ABb} ± 1.68	45.7^{Ab} ± 0.65	**47.8^{A}**	2.55	0.0634
	Mean HD	**48.8^{a}**	**45.4^{ab}**	**42.9^{bc}**	**39.7^{c}**			
	MSE variety	2.27	3.21	3.00	2.00			
	P-Value	0.2316	0.0025	0.0057	0.0001			

Continued Table 14

Time	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety	MSE HD	P-Value
	NK Magitop	56.5^{Aa} ± 3.39	57.7^{Aa} ± 1.42	54.2^{Aa} ± 1.46	53.9^{Aa} ± 1.27	**55.6^{A}**	1.93	0.1171
	Winn	54.9^{Aa} ± 4.10	47.0^{Bab} ± 2.86	48.0^{Aab} ± 5.37	44.9^{Bb} ± 6.29	**48.7^{B}**	4.74	0.1314
	NK Lemoro	50.2^{Aa} ± 8.62	49.4^{Ba} ± 2.02	49.9^{Aa} ± 2.44	44.5^{Ba} ± 0.88	**48.5^{B}**	5.20	0.5333
24 h	**NX1775**	54.2^{Aa} ± 1.81	57.4^{Aa} ± 1.80	52.5^{Aa} ± 3.34	52.9^{Aa} ± 3.27	**54.3^{A}**	2.79	0.206
	Mean HD	**54.0^{a}**	**52.9^{ab}**	**51.2^{ab}**	**49.1^{b}**			
	MSE variety	5.58	2.26	3.61	3.43			
	P-Value	0.5786	0.0007	0.2365	0.0156			
	NK Magitop	66.4^{Aab} ± 0.62	67.9^{Aa} ± 1.30	65.9^{Ab} ± 1.16	65.4^{Ab} ± 0.78	**66.4^{A}**	0.98	0.0623
	Winn	65.2^{Aa} ± 4.06	57.6^{Ba} ± 3.79	61.6^{Ba} ±2.82	57.2^{Ba} ± 5.35	**60.4^{B}**	4.42	0.168
	NK Lemoro	62.4^{Aa} ± 4.28	61.5^{Bab} ± 1.30	60.8^{Bab} ± 2.19	56.9^{Bb} ± 1.14	**60.4^{B}**	2.74	0.1186
48 h	**NX1775**	64.8^{Ab} ± 1.19	67.1^{Aa} ± 0.63	64.2^{ABb} ± 0.98	64.3^{Ab} ± 0.60	**65.1^{A}**	0.89	0.0134
	Mean HD	**64.7^{a}**	**63.5^{ab}**	**63.1^{ab}**	**61.0^{ab}**			
	MSE variety	3.27	3.38	1.90	2.98			
	P-Value	0.551	0.0022	0.0378	0.0132			
	NK Magitop	71.6^{Aa} ± 0.71	71.8^{Aa} ± 0.82	71.0^{Aa} ± 0.52	70.8^{Aa} ± 0.82	**71.3^{A}**	0.53	0.1732
	Winn	71.7^{Aa} ± 1.26	64.3^{Bb} ± 1.25	66.1^{Bab} ± 3.49	63.3^{Bb} ± 5.08	**66.4^{B}**	3.58	0.0801
	NK Lemoro	67.5^{Ca} ± 1.25	65.8^{Ba} ± 1.82	66.3^{Ba} ± 1.65	61.5^{Bb} ± 0.45	**65.3^{B}**	1.38	0.0036
72 h	**NX1775**	69.5^{Bc} ± 0.51	71.2^{Aa} ± 0.32	70.2^{Ab} ± 0.34	69.1^{Ac} ± 0.50	**70.0^{A}**	0.27	0.0001
	Mean HD	**70.1^{a}**	**68.3^{ab}**	**68.4^{ab}**	**66.2^{b}**			
	MSE variety	1.02	1.15	2.06	2.91			
	P-Value	0.003	0.0001	0.0361	0.0119			
	NK Magitop	75.3^{Aa} ± 1.1	75.5^{Aa} ± 0.8	75.1^{Aa} ± 0.70	74.9^{Aa} ± 0.5	**75.2^{A}**	0.84	0.8764
	Winn	73.8^{Aa} ± 1.53	66.9^{Ba} ± 2.53	70.3^{BCab} ± 2.40	68.4^{Bb} ± 2,95	**69.9^{B}**	2.67	0.0609
	NK Lemoro	69.0^{Ba} ± 0.8	68.4^{Ba} ± 2.57	68.7^{Ca} ± 2.13	63.5^{Cb} ± 1.16	**67.4^{C}**	2.58	0.093
96 h	**NX1775**	73.6^{Aa} ± 1.06	75.0^{Aa} ± 0.91	73.5^{ABa} ± 0.98	73.3^{Aa} ± 0.79	**73.9^{A}**	1.00	0.2118
	Mean HD	**72.9^{a}**	**71.4^{a}**	**71.9^{a}**	**70.0^{a}**			
	MSE variety	1.98	2.15	1.92	1.81			
	P-Value	0.0222	0.002	0.0124	0.0002			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

For example, the difference in DM washing losses between HD1 and HD4 for variety Winn was 12.3%, but at 96 h of incubation this difference decreased to be 5.40% (from 73.8% at HD1 to 68.4% at HD4). On the other hand, this difference for variety NK Magitop at 0 h (washing losses) was 5.80%, but at 96 h of incubation this difference decreased to be 0.40% (from 75.3% at HD1 to 74.9% at HD3). Also the difference in DM washing losses (0 h) between mean of variety NK Magitop (30.1%) and mean of variety Winn (22.0%) was 8.10%, but at 96h this difference in DM degradability between mean of variety NK Magitop (75.2%) and mean of variety Winn (69.9%) became 5.30%.

3.1.1.2.3 Parameters of rumen dry matter degradability of maize stover

Table 15 illustrate the parameters of rumen dry matter degradability of maize stover of the four varieties at the four harvest dates. For the rapidly soluble fraction (a) it decreased with increasing plant maturity and the mean of the harvest date at HD1 (29.0%) and at HD2 (28.7%) was significantly higher than that at HD3 (25.0%) and HD4 (21.6%). Means of the rapidly soluble fraction of varieties NX1775 (29.6%) and NK Magitop (30.1%) were significantly higher than those for varieties Winn and NK Lemoro (both 22.3%). Variety NX1775 showed its highest rapidly soluble fraction at HD2 (36.8%).

Concerning to the slowly degradable fraction (b) it increased with increasing plant maturity and the mean of the harvest date at HD3 (49.1%) and at HD4 (50.8%) was significantly higher than that at HD1 (45.0%) and HD2 (44.4%). Mean of the slowly degradable fraction of variety Winn (50.9%) was significantly higher than that of the other varieties (46.0, 45.5 and 47.1% for NK Magitop, NX1775 and NK Lemoro respectively). Variety NX1775 showed its lowest slowly degradable fraction at HD2 (39.5%). It is obvious that there is a relationship between the rapidly soluble fraction and the slowly degradable fraction, as when the rapidly soluble fraction decreased the slowly degradable fraction increased and vice versa.

For the non degradable fraction (A) mean of the harvest date of HD1 (26.1%), HD2 (26.8%) and HD3 (25.9%) was nearly the same but the mean of the harvest stage increased at HD4 to be 27.7%. There was a significant difference in the non degradable fraction between the means of the varieties as it ranged from 23.9% for variety NK Magitop to 30.7% for variety NK Lemoro.

Belong to the rate of degradation (c) it is obvious that there wasn't any significant between the means of the harvest dates (3.76, 3.35, 3.25 and 3.33$\%h^{-1}$ for HD1, HD2, HD3 and HD4 respectively). Contrarily there was a significant difference in the rate of degradation between the mean varieties, and mean of variety NK Lemoro (3.70$\%h^{-1}$) was significantly higher than that of variety Winn (3.08$\%h^{-1}$).

Table 15. Parameters of rumen dry matter degradability (% ± SD) of maize stover of the four varieties at the four harvest dates

Parameters	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	32.0^{Ab} ± 0.00	32.2^{Ba} ± 0.00	30.1^{Ac} ± 0.00	26.2^{Ad} ± 0.00	**30.1^{A}**	0.00	0.0001
	Winn	28.5^{Ba} ± 0.24	22.2^{Db} ± 0.17	21.6^{Cb} ± 0.40	16.7^{Bc} ± 0.71	**22.3^{B}**	0.43	0.0001
	NK Lemoro	26.3^{Ca} ± 0.81	23.7^{Cb} ± 0.30	21.7^{Cc} ± 0.31	17.4^{Bd} ± 0.87	**22.3^{B}**	0.63	0.0001
	NX1775	29.0^{Bb} ± 0.17	36.8^{Aa} ± 0.00	26.5^{Bc} ± 0.00	25.9^{Ad} ± 0.00	**29.6^{A}**	0.08	0.0001
	Mean HD	**29.0^{a}**	**28.7^{a}**	**25.0^{b}**	**21.6^{b}**			
	MSE variety	0.43	0.18	0.25	0.56			
	P-Value	0.0001	0.0001	0.0001	0.0001			
b (%)	**NK Magitop**	43.7^{Cc} ± 0.27	43.7^{Ac} ± 0.97	46.5^{Cb} ± 0.72	50.2^{Ba} ± 0.64	**46.0^{B}**	0.70	0.0001
	Winn	47.1^{Ac} ± 0.70	47.8^{Ac} ± 0.90	52.1^{Ab} ± 0.87	56.5^{Aa} ± 0.75	**50.9^{A}**	0.81	0.0001
	NK Lemoro	45.0^{Ba} ± 0.75	47.0^{Aa} ± 3.25	48.8^{Ba} ± 1.21	47.6^{Ba} ± 3.03	**47.1^{B}**	2.33	0.3289
	NX1775	44.2^{BCb} ± 0.28	39.5^{Bc} ± 2.37	49.2^{Ba} ± 1.27	48.9^{Ba} ± 0.34	**45.5^{B}**	1.36	0.0001
	Mean HD	**45.0^{b}**	**44.4^{b}**	**49.1^{a}**	**50.8^{a}**			
	MSE variety	0.55	2.12	1.04	1.60			
	P-Value	0.0003	0.0052	0.0013	0.0006			
A (%)	**NK Magitop**	24.3^{Ca} ± 0.27	24.2^{Ba} ± 0.97	23.4^{Ca} ± 0.72	23.6^{Ca} ± 0.64	**23.9^{C}**	0.70	0.4165
	Winn	24.4^{Cc} ± 0.92	30.0^{Aa} ± 0.75	26.3^{Ab} ± 0.57	26.8^{Bb} ± 0.41	**26.9^{B}**	0.69	0.0001
	NK Lemoro	28.7^{Ab} ± 1.50	29.4^{Ab} ± 3.12	29.5^{Bb} ± 0.94	35.0^{Aa} ± 2.17	**30.7^{A}**	2.10	0.0206
	NX1775	26.8^{Ba} ± 0.45	23.7^{Bb} ± 2.37	24.3^{Cab} ± 1.27	25.1^{BCab} ± 0.34	**25.0^{C}**	1.37	0.1042
	Mean HD	**26.1**	**26.8**	**25.9**	**27.7**			
	MSE variety	0.92	2.05	0.91	1.16			
	P-Value	0.001	0.0085	0.0002	0.0001			
c (%)	**NK Magitop**	3.60^{Aa} ± 0.43	3.74^{Aa} ± 0.30	3.20^{Aa} ± 0.18	3.27^{ABa} ± 0.06	**3.45^{AB}**	0.28	0.1147
	Winn	3.57^{Aa} ± 0.95	2.97^{Aa} ± 0.57	3.02^{Aa} ± 0.68	2.75^{Ba} ± 0.80	**3.08^{B}**	0.76	0.6188
	NK Lemoro	3.86^{Aa} ± 1.55	3.39^{Aa} ± 0.44	3.57^{Aa} ± 0.48	3.98^{Aa} ± 0.68	**3.70^{A}**	0.91	0.8514
	NX1775	4.00^{Aa} ± 0.38	3.30^{Aa} ± 0.75	3.23^{Aa} ± 0.43	3.31^{ABa} ± 0.34	**3.46^{AB}**	0.50	0.2769
	Mean HD	**3.76**	**3.35**	**3.25**	**3.33**			
	MSE variety	0.95	0.54	0.48	0.55			
	P-Value	0.9329	0.4297	0.5775	0.1334			
t_0 (h)	**NK Magitop**	1.12^{Ba} ± 0.36	1.16^{Aa} ± 0.36	0.69^{Aa} ± 0.45	0.36^{Ba} ± 0.50	**0.83**	0.42	0.1409
	Winn	0.50^{Ba} ± 0.52	0.37^{Aa} ± 0.42	1.71^{Aa} ± 1.22	1.25^{ABa} ± 1.52	**0.96**	1.03	0.3882
	NK Lemoro	0.58^{Ba} ± 0.64	1.47^{Aa} ± 1.61	1.75^{Aa} ± 0.97	3.63^{Aa} ± 2.63	**1.86^{A}**	1.65	0.2214
	NX1775	2.55^{Aa} ± 0.98	1.32^{Aab} ± 0.40	1.60^{Aab} ± 0.21	0.96^{ABb} ± 0.75	**1.61**	0.66	0.0812
	Mean HD	**1.19**	**1.08**	**1.44**	**1.55**			
	MSE variety	0.67	0.78	0.82	1.58			
	P-Value	0.0182	0.4622	0.3909	0.1360			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Concerning to the lag time (t_0) there was no significant difference between the means of the harvest dates (1.19, 1.08, 1.44 and 1.55 h for HD1, HD2, HD3 and HD4 respectively). Also there was no significant in the lag time between means of the varieties, and it ranged from 0.83 h for variety NK Magitop to 1.86 h for variety NK-Lemoro.

3.1.1.2.4 Effective rumen dry matter degradability of maize stover

Table 16 shows the effective rumen DM degradability of maize stover of the four varieties at the four harvest dates by passage rate of 6%h^{-1}. It is conspicuous that harvest date and maize variety influenced the effective rumen DM degradability. There was a significant decrease in the effective rumen DM degradability with increasing plant maturity and the mean of harvest date at HD1 (44.9%) and at HD2 (43.6%) was significantly higher than that at HD4 (37.8%). Furthermore the means of the effective DM degradability of the variety NX1775 (44.6%) and variety NK Magitop (46.1%) were significantly higher than those of varieties Winn and NK Lemoro (both 38.2%). Variety NX1775 showed its highest effective rumen DM degradability at HD2 (49.2%). The EDMD did not changed from HD2 (37.6 and 39.2% for varieties Winn and NK Lemoro respectively) to HD3 (37.2 and 38.1% for varieties Winn and NK Lemoro respectively), and the same for variety NK Magitop as it did not changed from HD1 (47.3%) to HD2 (47.8%). The decrease in the effective DM degradability between HD1 and HD4 was different between varieties, for example, variety Winn showed a decrease of 12.5% (from 45.3% at HD1 to 32.8% at HD4), and this wide range indicates the deterioration of DM degradability with increasing plant maturity, the same happened for variety NK Lemoro. On the other hand, the EDMD for variety NK Magitop showed only slight decrease of 3.80% (from 47.3% at HD1 to 43.5% at HD4) which indicates a wide window for harvesting this variety without deterioration of degradability. Therefore, varieties here can be classified according to the EDMD into high degradability (NK Magitop and NX1775) and low degradability (Winn and NK Lemoro).

Table 16. Effective rumen dry matter degradability (% ± SD) of maize stover of the four varieties at the four harvest dates by passage rate of 6%h^{-1}

Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety	MSE HD	P-Value
NK Magitop	47.3^{Aa} ± 0.78	47.8^{Aa} ± 0.75	45.6^{Ab} ± 0.73	43.5^{Ac} ± 0.45	**46.1^{A}**	0.68	0.0002
Winn	45.3^{ABa} ± 2.23	37.6^{Bb} ± 1.89	37.2^{Cb} ± 1.99	32.8^{Bc} ± 2.66	**38.2^{B}**	2.23	0.0009
NK Lemoro	42.7^{Ba} ± 3.03	39.2^{Bb} ± 1.51	38.1^{Cbc} ± 2.15	32.6^{Bc} ± 0.97	**38.2^{B}**	2.09	0.0025
NX1775	44.2^{ABb} ± 1.44	49.6^{Aa} ± 1.54	42.1^{Bb} ± 1.02	42.3^{Ab} ± 0.30	**44.6^{A}**	1.19	0.0002
Mean HD	**44.9^{a}**	**43.6^{ab}**	**40.7^{bc}**	**37.8^{c}**			
MSE variety	2.08	1.49	1.60	1.45			
P-Value	0.1277	0.0001	0.0007	0.0001			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

It is obvious that DM degradability of maize stover affected strongly by both stage of maize maturity and variety. The EDMD in Exp 2 is lower than that of Exp 1. This is may be attributed to the year of cultivation as Exp 1 cultivation was at 2006 but Exp 2 was at 2007, and the environmental factors have a role in the chemical composition of the plant and in turn stover degradability. But the best degradability is still for variety NK Magitop. Varieties here can be classified into two categories (high and low in degradability) as varieties NK Magitop and NX1775 are high in degradability and varieties Winn and NK Lemoro are low in degradability.

3.1.1.3 Exp 3, 2008

The aim of this experiment was to study the effect of maturity stage and maize variety on the in situ rumen degradability of maize stover. Five new varieties (NX17066, NX10126, NX20026, NX04016 and NX1485) in addition to NK Magitop were used. Those six varieties cultivated in 2008 and harvested at three maturity dates (the period between HD1 and HD3 was about 35 days, starting from beginning of September until the first week of October, as this period covers the practical harvest time).

3.1.1.3.1 Dry matter and chemical composition of maize stover

Table 17 and 18 illustrate the dry matter and the chemical compositions of the maize stover of the six varieties at the three harvest dates. Regarding to maize stover dry matter it increased with increasing plant maturity and the mean of the harvest date significantly increased from 19.0% at HD1 to 29.4% at HD3. On the other hand there was no significant difference in stover DM content between the means of the varieties. It ranged from 21.9% at variety NX20026 to 25.3% at variety NK Magitop. It is obvious that the difference in DM content between HD2 and HD3 in the different varieties was much higher than that between HD1 and HD2. For example, variety NX17066 showed an increase of 9% from 22.0% at HD2 to 31.0% at HD3, but it showed an increase of 2.9% from 19.1% at HD1 to 22.0% at HD2.

For stover crude ash content, the overall mean for harvest dates and varieties was 5.29% and there was no significant difference between the means of the harvest dates (5.08, 5.41 and 5.37% for HD1, HD2 and HD3 respectively). But on the other hand there was a significant difference between the means of the varieties. It ranged from 4.80% for variety NX1485 to 5.74% for variety NX04016.

Stover CP content decreased with increasing plant maturity and the mean of the harvest date significantly decreased from 5.96% at HD1 to 5.00% at HD3. Also there was a significant difference in stover CP content between the means of the varieties. It ranged from 4.94% for variety NX1485 to 6.15% for variety NX20026.

For stover EE content it was very low and no significant difference between the means of the harvest dates was notcied (0.63, 0.70 and 0.49% for HD1, HD2 and

HD3 respectively). Also there is no significant difference between the means of the varieties. It ranged from 0.43% for variety NX10126 to 0.72% for variety NK Magitop.

Table 17. Dry matter and chemical composition of maize stover of the six varieties at the three harvest dates

Nutrient	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
DM (%)	NKMagitop	21.3	23.2	31.4	**25.3**
	NX17066	19.1	22.0	31.0	**24.0**
	NX10126	18.8	22.1	30.2	**23.7**
	NX20026	18.6	20.1	27.0	**21.9**
	NX04016	18.4	23.0	28.9	**23.4**
	NX1485	18.1	21.5	28.2	**22.6**
	Mean HD	**19.0^{c}**	**22.0^{b}**	**29.4^{a}**	
Crude ash (%)	NK Magitop	4.73	5.25	5.09	**5.02^{BC}**
	NX17066	5.08	5.67	5.49	**5.41^{AB}**
	NX10126	5.17	5.14	5.01	**5.11^{BC}**
	NX20026	5.29	5.94	5.70	**5.64^{A}**
	NX04016	5.67	5.58	5.97	**5.74^{A}**
	NX1485	4.55	4.87	4.97	**4.80^{C}**
	Mean HD	**5.08**	**5.41**	**5.37**	
CP (%)	NK Magitop	5.44	5.36	4.96	**5.25^{AB}**
	NX17066	6.41	4.88	4.94	**5.41^{AB}**
	NX10126	6.23	4.97	4.91	**5.37^{AB}**
	NX20026	6.57	5.88	5.99	**6.15^{A}**
	NX04016	5.50	4.86	4.61	**4.99^{B}**
	NX1485	5.62	4.57	4.64	**4.94^{B}**
	Mean HD	**5.96^{a}**	**5.09^{b}**	**5.00^{b}**	
EE (%)	NK Magitop	0.65	0.89	0.63	**0.72**
	NX17066	0.95	0.22	0.44	**0.54**
	NX10126	0.22	0.62	0.46	**0.43**
	NX20026	0.46	0.97	0.52	**0.65**
	NX04016	0.80	0.94	0.31	**0.68**
	NX1485	0.71	0.53	0.56	**0.60**
	Mean HD	**0.63**	**0.70**	**0.49**	

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Regarding to stover CF content it increased with increasing plant maturity and the mean of the harvest date significantly increased from 31.1% at HD1 to 35.4% at HD3. On the other hand, there was no significant difference in stover CF content between the means of the varieties. It ranged from 30.0% for variety NX1485 to 34.2% for variety NX17066. Variety NX17066 showed the highest value at HD3

39.1%. Variety NX1485 had nearly equal values at the three harvest date (29.2, 30.2 and 30.9% at HD1, HD2 and HD3 respectively).

Table 18. Crude fiber and crude fiber fractions of maize stover of the six varieties at the three harvest dates

Nutrient	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
CF (%)	NK Magitop	30.2	31.7	35.2	**32.4**
	NX17066	32.5	30.9	39.1	**34.2**
	NX10126	31.7	32.5	35.7	**33.3**
	NX20026	31.6	34.0	35.2	**33.6**
	NX04016	31.3	33.7	36.4	**33.8**
	NX1485	29.2	30.0	30.9	**30.0**
	Mean HD	**31.1^{b}**	**32.1^{b}**	**35.4^{a}**	
NDF (%)	NKMagitop	57.3	60.5	65.6	**61.1**
	NX17066	61.5	60.7	70.6	**64.3**
	NX10126	58.3	61.3	68.4	**62.7**
	NX20026	57.6	62.6	68.6	**62.9**
	NX04016	56.1	63.2	67.3	**62.2**
	NX1485	56.8	59.2	59.9	**58.6**
	Mean HD	**57.9^{c}**	**61.3^{b}**	**66.7^{a}**	
NDF (%)	NK Magitop	32.8	32.8	37.7	**34.4**
	NX17066	36.2	34.4	44.3	**38.3**
	NX10126	34.9	37.8	38.7	**37.1**
	NX20026	34.4	37.2	39.5	**37.0**
	NX04016	31.9	37.9	40.5	**36.8**
	NX1485	32.2	33.3	33.7	**33.1**
	Mean HD	**33.7^{b}**	**35.6^{b}**	**39.1^{a}**	
ADL (%)	NK Magitop	3.70	4.10	4.20	**4.00^{AB}**
	NX17066	3.50	3.80	5.00	**4.10^{AB}**
	NX10126	3.80	5.30	4.80	**4.63^{A}**
	NX20026	4.40	3.80	3.70	**3.97^{AB}**
	NX04016	3.50	3.70	4.40	**3.87^{AB}**
	NX1485	3.50	3.20	3.70	**3.47^{B}**
	Mean HD	**3.73**	**3.98**	**4.30**	

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Regarding to stover NDF content it increased with increasing plant maturity and the mean of harvest date increased significantly from 57.9% at HD1 to 66.7% at HD3 with an increase of 8.8%. There was no significant differences in stover NDF between means of the different varieties. It ranged from 58.6% for variety NX1485 to 64.3% for variety NX17066.

Belong to stover ADF content it increased with increasing plant maturity and the mean of harvest date increased significantly from 33.7% at HD1 to 39.1% at HD3. There was no significant differences in stover ADF between means of the different varieties. It ranged from 31.9% for variety NX1485 to 38.3% for variety NX17066.

Stover ADL content increased with increasing plant maturity (3.73, 3.98 and 4.30% for HD1, HD2 and HD3 respectively). Means of stover ADL for variety NX10126 (4.63%) was significantly higher than that for variety NX1485 (3.47%).

3.1.1.3.2 In situ rumen dry matter degradability of maize stover

Table 19 shows DM degradability of maize stover of the six varieties at the three harvest dates after various incubation times. About DM degradation course, it is clear that DM degradability increased with increasing the incubation time. Means of dry matter degradability were 30.0, 31.0, 34.0, 38.0, 49.0, 57.0, 68.0, 72.0 and 74.0% at 0, 2, 4, 8, 16, 24, 48, 72 and 96 h respectively.

It is obvious that the DM washing losses (0 h) decreased with increasing plant maturity and mean of the harvest date significantly decreased from 34.7% at HD1 to 23.8% at HD3 with a decrease of 10.9%. There was also a significant difference between the means of the varieties and it ranged from 25.7% for variety NX17066 to 34.0% for variety NX1485. Variety NX17066 showed the highest DM washing losses at HD2 (31.8%). The decrease in the DM washing losses between HD1 and HD3 was different between varieties. For example, variety NX17066 it showed a decrease of 14.4% from 29.9% at HD1 to 15.5% at HD3, while variety NX1485 showed only a decrease of 7.4% from 38.2% at HD1 to 30.6% at HD3.

Regarding to the DM degradability after short incubation times (2, 4, 8 and 16 h) it had the same panel as 0 h, as it decreased with increasing plant maturity and there was a significant difference between the means of the harvest dates. Also there was a significant difference between the means of the varieties at 2 h and 4 h but not at 8 h and 16 h of incubation.

Table 19. In situ dry matter degradability (% ± SD) of maize stover for the six varieties at the three harvest dates after various incubation times

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MSE HD	P-Value
	NK Magitop	36.9^{Ba} ± 0.48	32.3^{BCb} ± 0.58	28.7^{Bc} ± 0.41	32.6^{AB}	0.53	0.0001
	NX17066	29.9^{Eb} ± 0.85	31.8^{Ca} ± 0.14	15.5^{Fc} ± 0.27	25.7^{C}	0.52	0.0001
	NX10126	34.6^{Ca} ± 0.10	32.9^{ABb} ± 0.24	24.0^{Cc} ± 0.24	30.5^{ABC}	0.21	0.0001
	NX20026	33.6^{Da} ± 0.22	28.4^{Db} ± 0.27	21.0^{Ec} ± 0.34	27.7^{BC}	0.28	0.0001
0 h	**NX04016**	35.2^{Ca} ± 0.59	28.7^{Db} ± 0.38	22.9^{Dc} ± 0.39	28.9^{ABC}	0.46	0.0001
	NX1485	38.2^{Aa} ± 0.71	33.2^{Ab} ± 0.27	30.6^{Ac} ± 0.45	34.0^{A}	0.51	0.0001
	Mean HD	**34.7^{a}**	**31.2^{b}**	**23.8^{c}**			
	MSE variety	0.56	0.34	0.36			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	37.5^{Aa} ± 0.87	33.0^{ABb} ± 0.52	29.7^{Bc} ± 0.63	**33.4^{AB}**	0.53	0.0001
	NX17066	30.9^{Db} ± 0.65	32.6^{Ba} ± 0.74	17.0^{Fc} ± 0.43	**26.8^{C}**	0.43	0.0001
	NX20026	34.4^{Ca} ± 1.07	28.3^{Cb} ± 1.04	22.9^{Ec} ± 0.68	**28.5^{BC}**	0.65	0.0001
	NX10126	35.4^{BCa} ± 0.85	34.1^{Ab} ± 0.60	25.4^{Cc} ± 0.72	**31.6^{ABC}**	0.61	0.0001
2 h	**NX04016**	36.1^{Ba} ± 0.66	29.3^{Cb} ± 1.01	24.0^{Dc} ± 0.76	**29.8^{ABC}**	0.82	0.0001
	NX1485	38.1^{Aa} ± 1.38	33.8^{ABb} ± 0 .72	31.1^{Ac} ± 0.64	**34.3^{A}**	0.85	0.0002
	Mean HD	**35.4^{a}**	**31.8^{b}**	**25.0^{c}**			
	MSE variety	0.74	0.70	0.54			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	40.2^{Ba} ± 0.94	35.4^{ABb} ± 0.60	31.3^{Bc} ± 0.92	**35.6^{A}**	0.77	0.0001
	NX17066	33.2^{Eb} ± 0.93	34.8^{Bb} ± 0.89	19.1^{Ec} ± 0.43	**29.0^{B}**	0.80	0.0001
	NX10126	37.8^{Da} ± 1.00	37.5^{Aa} ± 1.40	27.0^{Cb} ± 0.72	**34.1^{AB}**	0.92	0.0001
	NX20026	38.4^{CDa} ± 1.14	31.8^{Cb} ± 1.67	25.8^{Dc} ± 0.57	**32.0^{AB}**	1.24	0.0001
4 h	**NX04016**	39.8^{BCa} ± 1.37	32.1^{Cb} ± 0.72	25.9^{CDc} ± 0.83	**32.6^{AB}**	0.89	0.0001
	NX1485	42.1^{Aa} ± 1.07	36.7^{ABb} ± 0.45	33.9^{Ac} ± 0.63	**37.6^{A}**	0.70	0.0001
	Mean HD	**38.6^{a}**	**34.7^{b}**	**27.2^{c}**			
	MSE variety	0.93	1.09	0.62			
	P-Value	0.0001	0.0001	0.0001			
	NK Magitop	45.0^{ABa} ± 2.98	40.1^{Ab} ± 1.89	34.3^{Ac} ± 1.60	**39.8^{A}**	2.23	0.0032
	NX17066	40.0^{Ba} ± 1.89	38.4^{Aa} ± 2.23	23.8^{Dc} ± 1.23	**34.1^{A}**	1.52	0.0001
	NX10126	41.9^{ABa} ± 3.45	40.9^{Aa} ± 3.78	31.6^{Bb} ± 1.86	**38.1^{A}**	3.24	0.0147
	NX20026	43.0^{ABa} ± 3.67	37.4^{Aa} ± 2.57	29.2^{BCb} ± 1.99	**36.5^{A}**	2.88	0.0031
8 h	**NX04016**	43.9^{ABa} ± 2.94	37.5^{Ab} ± 3.42	28.8^{Cc} ± 3.02	**36.7^{A}**	2.66	0.0013
	NX1485	46.5^{Aa} ± 2.05	39.8^{Ab} ± 3.06	35.8^{Ab} ± 1.66	**40.7^{A}**	2.37	0.0042
	Mean HD	**43.4^{a}**	**39.0^{b}**	**30.6^{c}**			
	MSE variety	2.79	3.10	1.41			
	P-Value	0.1434	0.6491	0.0001			
	NK Magitop	53.2^{Aa} ± 4.12	51.5^{Aab} ± 0.93	47.1^{Ab} ± 0.81	**50.6^{A}**	2.58	0.0748
	NX17066	51.9^{Aa} ± 4.38	49.7^{Aa} ± 1.94	32.7^{Cb} ± 3.34	**44.8^{A}**	3.48	0.001
	NX10126	51.5^{Aa} ± 3.12	50.3^{Aa} ± 3.66	40.9^{Bb} ± 3.60	**47.6^{A}**	3.14	0.0116
	NX20026	54.3^{Aa} ± 1.64	50.0^{Ab} ± 2.12	42.5^{Bc} ± 1.55	**48.9^{A}**	1.70	0.0004
16 h	**NX04016**	55.9^{Aa} ± 1.56	50.1^{Ab} ± 1.45	42.7^{Bc} ± 1.01	**49.6^{A}**	1.30	0.0001
	NX1485	53.6^{Aa} ± 3.45	50.8^{Aab} ± 3.43	47.7^{Ab} ± 1.67	**50.7^{A}**	2.73	0.0982
	Mean HD	**53.4^{a}**	**50.4^{b}**	**42.3^{c}**			
	MSE variety	3.22	2.46	1.99			
	P-Value	0.6212	0.9484	0.0001			

Continue Table 19

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MSE HD	P-Value
24 h	**NK Magitop**	61.3^{Aa} ± 2.96	56.7^{Aab} ± 3.13	53.5^{Ab} ± 2.80	$\mathbf{57.2^{A}}$	3.12	0.0586
	NX17066	59.9^{Aa} ± 1.82	58.2^{Aa} ± 2.90	45.9^{Cb} ± 2.74	$\mathbf{54.7^{A}}$	2.52	0.0009
	NX10126	60.7^{Aa} ± 0.75	61.1^{Aa} ± 1.33	51.0^{ABb} ± 2.91	$\mathbf{57.6^{A}}$	1.84	0.0008
	NX20026	59.4^{Aa} ± 3.22	59.4^{Aa} ± 3.89	49.8^{ABb} ± 4.34	$\mathbf{56.2^{A}}$	4.23	0.0492
	NX04016	59.2^{Aa} ± 2.13	56.8^{Aa} ± 2.53	50.4^{ABb} ± 3.73	$\mathbf{55.5^{A}}$	3.16	0.0358
	NX1485	61.5^{Aa} ± 2.02	58.6^{Aab} ± 2.08	55.9^{Ab} ± 1.35	$\mathbf{58.7^{A}}$	1.47	0.0101
	Mean HD	$\mathbf{60.3^{a}}$	$\mathbf{58.5^{a}}$	$\mathbf{51.1^{b}}$			
	MSE variety	2.37	2.82	3.35			
	P-Value	0.7411	0.4464	0.0484			
48 h	**NK Magitop**	69.9^{Aa} ± 1.18	67.3^{Cb} ± 1.31	65.8^{ABb} ± 0.43	$\mathbf{67.7^{A}}$	1.13	0.0111
	NX17066	71.0^{Aa} ± 2.07	68.8^{BCa} ± 1.28	60.2^{Db} ± 0.93	$\mathbf{66.7^{A}}$	1.56	0.0003
	NX10126	69.5^{Aa} ± 2.08	70.7^{Aa} ± 0.72	63.4^{Cb} ± 1.33	$\mathbf{67.9^{A}}$	1.51	0.0022
	NX20026	69.7^{Aa} ± 1.45	67.5^{Cb} ± 0.90	64.0^{BCc} ± 0.45	$\mathbf{67.1^{A}}$	1.00	0.0012
	NX04016	69.5^{Aa} ± 0.53	67.8^{Cb} ± 0.85	64.0^{BCc} ± 0.48	$\mathbf{67.1^{A}}$	0.61	0.0001
	NX1485	69.3^{Aab} ± 1.43	70.5^{ABa} ± 0.65	67.0^{Ab} ± 2.01	$\mathbf{68.9^{A}}$	1.62	0.0948
	Mean HD	$\mathbf{69.8^{a}}$	$\mathbf{68.8^{a}}$	$\mathbf{64.1^{b}}$			
	MSE variety	1.65	0.99	1.14			
	P-Value	0.8067	0.0024	0.0002			
72 h	**NK Magitop**	73.4^{BCa} ± 0.80	73.1^{ABa} ± 0.65	70.6^{ABb} ± 0.56	$\mathbf{72.4^{A}}$	0.53	0.0013
	NX17066	74.9^{Aa} ± 0.54	72.3^{ABb} ± 0.35	64.6^{Dc} ± 0.69	$\mathbf{70.6^{A}}$	0.47	0.0001
	NX10126	74.2^{ABa} ± 0.86	73.2^{ABa} ± 0.97	67.8^{Cb} ± 1.50	$\mathbf{71.7^{A}}$	1.16	0.0011
	NX20026	72.2^{Ca} ± 0.93	71.8^{ABa} ±1.57	69.3^{BCb} ± 0.42	$\mathbf{71.1^{A}}$	1.04	0.0289
	NX04016	73.1^{BCa} ± 0.65	71.6^{Bb} ± 1.02	68.4^{Cc} ± 0.67	$\mathbf{71.0^{A}}$	0.72	0.0005
	NX1485	72.4^{Cab} ± 1.21	73.5^{Aa} ± 0.79	71.8^{Ab} ± 0.86	$\mathbf{72.6^{A}}$	0.64	0.0437
	Mean HD	$\mathbf{73.4^{a}}$	$\mathbf{72.6^{a}}$	$\mathbf{68.8^{b}}$			
	MSE variety	0.66	0.86	0.86			
	P-Value	0.0022	0.1033	0.0001			
96 h	**NK Magitop**	75.6^{ABa} ± 0.84	74.7^{Aa} ± 0.84	71.3^{Bb} ± 0.55	$\mathbf{73.9^{A}}$	0.76	0.001
	NX17066	76.3^{Aa} ± 1.51	74.3^{Aa} ± 1.15	66.3^{Cb} ± 1.20	$\mathbf{72.3^{A}}$	1.41	0.0003
	NX10126	75.6^{ABa} ± 0.87	75.3^{Aa} ± 1.74	70.6^{Bb} ± 0.92	$\mathbf{73.8^{A}}$	1.26	0.0045
	NX20026	73.9^{BCa} ± 1.41	74.8^{Aa} ± 0.97	70.6^{Bb} ± 2.19	$\mathbf{73.1^{A}}$	1.04	0.0061
	NX04016	75.4^{ABa} ± 0.44	75.7^{Aa} ± 1.00	71.3^{Bb} ± 0.52	$\mathbf{74.1^{A}}$	0.38	0.0001
	NX1485	73.5^{Ca} ± 0.81	75.1^{Aa} ± 1.18	74.0^{Aa} ± 1.13	$\mathbf{74.2^{A}}$	0.87	0.1468
	Mean HD	$\mathbf{75.1^{a}}$	$\mathbf{75.5^{a}}$	$\mathbf{70.7^{b}}$			
	MSE variety	0.94	1.11	0.98			
	P-Value	0.0209	0.6818	0.0001			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Concerning to the DM degradability after long incubation times (24, 48, 72 and 96 h), it increased with increasing plant maturity and the mean of the harvest date at HD3 was significantly higher than that at HD1 and HD2. But there was no significant difference between the means of the varieties.

The difference in DM degradability between the harvest dates and between the varieties decreased with increasing the incubation time. For example, the difference between HD1 and HD3 for variety NX17066 at 0 h was 14.4%, but at 96 h this difference decreased to 10.0% from 76.3% at HD1 to 66.3% at HD3. On the other hand, this difference for variety NX1485 at 0 h was 7.6%, but at 96 h there was no difference between HD1 (73.5%) and HD3 (74.0%). Also the difference in DM washing losses between the mean of variety NX1485 (34.0%) and variety NX17066 (25.7%) was 8.3%, but at 96 h this difference in DM degradability between variety NX1485 (74.2%) and variety NX17066 (72.3%) became 1.9%.

3.1.1.3.3 Parameters of rumen dry matter degradability of maize stover

Table 20 illustrate the parameters of rumen DM degradability of maize stover of the different varieties at the different harvest dates. Regarding to the rapidly soluble fraction (a) it is obvious that it decreased with increasing plant maturity and the mean of harvest date significantly decreased from 34.8% at HD1 to 24.3% at HD3 with a decrease of 10.5%. There was also a significant difference in the rapidly soluble fraction between the means of the varieties. It ranged from 26.2% for variety NX17066 to 34.3% for variety NX1485. Variety NX17066 showed a progressive decrease in the rapidly soluble fraction from 32.4% at HD2 to16.3% at HD3, also variety NX10126 decreased from 33.1% at HD2 to 24.3% at HD3.

Belong to the slowly degradable fraction (b) it increased with increasing plant maturity and the mean of harvest date significantly increased from 40.9% at HD1 to 48.4% at HD3 with an increase of 7.5%. There was also a significant difference in the slowly degradable fraction between the means of the varieties. It ranged from 40.9% for variety NX1485 to 47.4% for variety NX17066. Variety NX17066 showed the lowest slowly degradable fraction at HD2 (42.4%). It is obvious that when the rapidly soluble fraction decreased the slowly degradable fraction increased and the vice versa.

Table 20. Parameters of rumen degradability (% ± SD) of maize stover of the six varieties at the three harvest dates

Parameters	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	37.0^{Aa} ± 0.67	32.4^{Bb} ± 0.70	29.6^{Bc} ± 0.44	**33.0^{AB}**	0.61	0.0001
	NX17066	30.0^{Db} ± 0.95	32.4^{Ba} ± 0.51	16.3^{Ec} ± 0.12	**26.2^{C}**	0.63	0.0001
	NX10126	34.9^{Ba} ± 0.48	33.1^{ABb} ± 0.23	24.3^{Cc} ± 0.52	**30.8^{ABC}**	0.43	0.0001
	NX20026	33.6^{Ca} ± 0.22	28.4^{Cb} ± 0.62	21.4^{Fc} ± 0.44	**27.8^{BC}**	0.46	0.0001
	NX04016	35.2^{Ba} ± 0.59	28.7^{Cb} ± 0.39	23.4^{Dc} ± 0.32	**29.1^{ABC}**	0.45	0.0001
	NX1485	38.2^{Aa} ± 0.78	34.0^{Ab} ± 1.10	30.6^{Ac} ± 0.46	**34.3^{A}**	0.82	0.0001
	Mean HD	**34.8^{a}**	**31.5^{b}**	**24.3^{c}**			
	MSE variety	0.66	0.65	0.40			
	P-Value	0.0001	0.0001	0.0001			
b (%)	**NK Magitop**	39.2^{Cb} ± 1.30	43.6^{BCa} ± 0.92	42.8^{Ca} ± 1.06	**41.9^{BC}**	1.1	0.006
	NX17066	47.0^{Ab} ± 1.34	42.4^{Cc} ± 1.14	52.7^{Aa} ± 0.27	**47.4^{A}**	1.03	0.0001
	NX10126	41.6^{Bb} ± 1.42	43.1^{BCb} ± 1.35	48.6^{Ba} ± 2.22	**44.4^{ABC}**	1.71	0.0057
	NX20026	40.8^{BCc} ± 0.48	46.0^{ABb} ± 1.33	52.1^{Aa} ± 1.55	**46.3^{A}**	1.21	0.0001
	NX04016	40.4^{BCb} ± 1.07	47.0^{Aa} ± 1.83	49.3^{Ba} ± 1.77	**45.6^{AB}**	1.59	0.0012
	NX1485	36.2^{Dc} ± 0.58	41.6^{Cb} ± 2.22	44.9^{Ca} ± 0.88	**40.9^{C}**	1.42	0.0008
	Mean HD	**40.9^{c}**	**44.0^{b}**	**48.4^{a}**			
	MSE variety	1.09	1.53	1.44			
	P-Value	0.0001	0.0063	0.0001			
A (%)	**NK Magitop**	23.8^{ABb} ± 1.66	24.0^{Ab} ± 0.49	27.6^{Ba} ± 0.78	**25.1^{A}**	1.09	0.009
	NX17066	23.0^{Bc} ± 0.86	25.2^{Ab} ± 0.75	31.0^{Aa} ± 0.37	**26.4^{A}**	0.69	0.0001
	NX10126	23.5^{Bb} ± 1.03	23.8^{Ab} ± 1.13	27.1^{Ba} ± 2.04	**24.8^{A}**	1.46	0.0421
	NX20026	25.7^{Aa} ± 0.48	25.7^{Aa} ± 1.69	26.5^{BCa} ± 1.33	**26.0^{A}**	1.23	0.652
	NX04016	24.4^{ABb} ± 0.72	24.3^{Ab} ± 1.46	27.3^{Ba} ± 1.59	**25.3^{A}**	1.31	0.052
	NX1485	25.6^{Aa} ± 1.18	24.5^{Aa} ± 1.21	24.5^{Ca} ±1.09	**24.9^{A}**	1.16	0.4314
	Mean HD	**24.3^{b}**	**24.6^{b}**	**27.3^{a}**			
	MSE variety	1.06	1.19	1.31			
	P-Value	0.0392	0.4274	0.0017			
c (%)	**NK Magitop**	4.36^{a} ± 1.18	3.78^{a} ± 0.55	4.42^{a} ± 0.48	**4.19**	0.81	0.6084
	NX17066	4.56^{a} ± 0.58	4.42^{a} ± 0.11	3.66^{b} ± 0.27	**4.21**	0.37	0.0493
	NX10126	4.12^{a} ± 0.17	4.26^{a} ± 0.35	3.57^{a} ± 0.85	**3.98**	0.54	0.3646
	NX20026	4.68^{a} ± 0.93	4.93^{a} ± 1.12	3.69^{a} ± 0.70	**4.44**	0.92	0.2949
	NX04016	4.28^{a} ± 0.63	4.14^{a} ± 0.80	3.87^{a} ± 0.70	**4.10**	0.72	0.7955
	NX1485	4.45^{a} ± 1.05	4.97^{a} ± 1.09	3.65^{a} ± 0.36	**4.35**	0.91	0.2855
	Mean HD	**4.41^{a}**	**4.42^{a}**	**3.81^{b}**			
	MSE variety	0.83	0.76	0.60			
	P-Value	0.959	0.4158	0.5764			
t_0 (h)	**NK Magitop**	2.59^{ab} ± 1.12	2.09^{Ab} ± 0.41	4.80^{Aa} ± 1.69	**3.16^{A}**	1.19	0.0672
	NX17066	2.24^{ABa} ± 0.61	3.81^{Aa} ± 1.61	3.33^{ABa} ± 0.20	**3.13^{A}**	1.00	0.2249
	NX10126	2.74^{Aa} ± 0.90	2.22^{Aa} ± 1.21	2.62^{Ba} ± 0.87	**2.53^{A}**	1.01	0.8064
	NX20026	1.59^{ABa} ± 0.10	2.81^{Aa} ± 0.69	2.03^{Ba} ± 1.02	**2.14^{A}**	0.71	0.1837
	NX04016	1.40^{Bc} ± 0.21	2.10^{Ab} ± 0.45	3.49^{ABa} ± 0.32	**2.33^{A}**	0.34	0.0008
	NX1485	1.92^{ABa} ± 0.26	5.11^{Aa} ± 4.65	2.75^{Ba} ± 0.79	**3.26^{A}**	2.93	0.3899
	Mean HD	**2.08^{b}**	**3.02^{ab}**	**3.17^{a}**			
	MSE variety	0.65	2.10	0.95			
	P-Value	0.146	0.4577	0.0529			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

For the non degradable part (A) it significantly increased with increasing plant maturity and the mean of harvest date at HD3 (27.3%) was significantly higher than that at HD1 (24.3%) and HD2 (24.6%). But on the other hand, there was no significant difference in the non degradable fraction between the means of varieties. It ranged from 24.8% for variety NX10126 to 26.4% for variety NX17066. Variety NX17066 showed the highest non degradable fraction among the harvest dates and varieties at HD3 (31.0%).

Concerning to the rate of degradation (c) the overall mean was 4.22%h^{-1} and the mean of the harvest date at HD1 (4.41%h^{-1}) was significantly higher than that at HD3 (3.82%h^{-1}). But on the other hand, there was no significant difference between the means of the varieties. It ranged from 3.98%h^{-1} for NX10126 to 4.44%h^{-1} for variety NX20026.

Regarding to the lag time (t_0), the mean of the harvest date at HD3 (3.17 h) was significantly higher than that at HD1 (2.08 h). There was no significant difference in the lag time between the means of the varieties. It ranged from 2.14 h for variety NX20026 to 3.26 h for variety NX1485. Variety NX1485 showed the highest lag time among the harvest dates and varieties at HD2 (5.11 h).

3.1.1.3.4 Effective rumen dry matter degradability of maize stover

Table 21 shows the effective rumen degradability of maize stover of the six varieties at the three harvest dates by passage rate of 6%h^{-1}. It is obvious that effective DM degradability significantly decreased with increasing plant maturity and the mean of harvest date significantly decreased from 50.0% at HD1 to 39.7% at HD3 with a decrease of 10.3%. Also the mean of variety NX1485 (48.2%) was significantly higher than that of variety NX17066 (42.3%). The decrease in the EDMD between HD1 and HD3 was different between varieties. However variety NX1485 it decreased from 51.8% at HD1 to 45.0% at HD3 with a decrease of 6.8%, variety NX17066 decreased from 47.7% at HD1 to 32.6% at HD3 with a decrease of 15.1%. The varieties here can be classified according to EDMD into three categories, in which varieties NX1485 and NK Magitop are high in degradability, varieties NX20026, NX04016 and NX10126 are intermediate in degradability and variety NX17066 is low in degradability.

Table 21. Effective rumen dry matter degradability (% ± SD) of maize stover of the six varieties at the three harvest dates by passage rate of 6%h^{-1}

Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MSE HD	P-Value
NK Magitop	51.0^{Aa} ± 2.04	47.2^{ABb} ± 1.10	43.2^{Bc} ± 0.96	$\mathbf{47.1^{AB}}$	1.44	0.0017
NX17066	47.7^{Ba} ± 1.24	46.7^{ABa} ± 1.07	32.6^{Db} ± 0.75	$\mathbf{42.3^{B}}$	1.05	0.0001
NX10126	49.3^{ABa} ± 0.36	48.8^{Aa} ± 1.61	39.5^{Cb} ± 1.25	$\mathbf{45.9^{AB}}$	1.22	0.0001
NX20026	49.7^{ABa} ± 1.79	45.7^{Bb} ± 1.79	38.8^{Cc} ± 1.06	$\mathbf{44.7^{AB}}$	1.58	0.0004
NX04016	50.6^{Aa} ± 1.12	45.5^{Bb} ± 1.49	39.0^{Cc} ± 1.09	$\mathbf{45.0^{AB}}$	1.24	0.0001
NX1485	51.8^{Aa} ± 1.32	47.8^{ABb} ± 1.79	45.0^{Ac} ± 0.34	$\mathbf{48.2^{A}}$	1.31	0.0021
Mean HD	$\mathbf{50.0^{a}}$	$\mathbf{47.0^{b}}$	$\mathbf{39.7^{c}}$			
MSE variety	1.43	1.50	0.94			
P-Value	0.0513	0.1315	0.0001			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

It is obvious that chemical composition and DM degradability of maize stover strongly affected by both stage of maize maturity and variety. The decrease in the DM degradability between HD1 and HD3 is different between varieties. In NX17066 variety this decrease had wide range which indicated the deterioration of DM degradability with increasing plant maturity. But on the other hand, this range was small for NX1485 and NK Magitop varieties which indicated a wide window for harvesting those varieties without deterioration of their degradability. Varieties here can be classified according to DM degradability into three categories, in which varieties NX1485 and NK Magitop are high in degradability, varieties NX10126, NX20026 and NX04016 are intermediate in degradability and variety NX17066 is low in degradability.

3.1.2 Effect of maturity stage, maize variety and conservation method on rumen degradability of maize stover (Exp 4)

In this experiment maize stover of two maize varieties (NX1485 and NX20026) harvested in 2008 at three harvest dates was used to study the effect of maturity stage, maize variety and conservation method (fresh (freeze dried), oven dried at 60℃ and ensiling) on rumen dry matter degradabilit y of maize stover.

3.1.2.1 Dry matter and chemical composition of maize stover

Dry matter and chemical composition of maize stover of the two maize varieties at the three harvest dates after the different conservation methods are presented in Table 22 and 23. It is conspicuous that maize stover DM increased with increasing plant maturity in the two varieties after the different conservation methods. The overall mean of stover DM was about 22.1% and there was no significant difference between the means of the six treatments. There was also no significant difference in stover DM between the means of the three conservation methods (22.3%, 22.2% and 21.8% for fresh, oven dried (at 60 ℃) and ensiled stover respectively).

Stover crude ash content was around 5.60% and nearly had the same value at the three harvest dates for the two varieties after the three conservation methods. There was a significant difference between means of the six treatments. Mean of stover ash content for variety NX20026 after fresh (5.83%), oven dried (5.76%) and ensiling (6.36%) was significantly higher than their corresponding mean for variety NX1485 (5.24, 5.06 and 5.73% for fresh, oven dried and ensiling respectively). Mean of stover crude ash content after ensiling (6.00%) was significantly higher than that after fresh (5.50%) and oven dried (60 ℃) stover (5.40%).

Belong to stover CP content it decreased with increasing plant maturity in the two varieties and after the three conservation methods and the overall mean was about 5.80%. Mean of stover CP content of variety NX20026 after fresh (6.13%), oven dried (6.31%) and ensiling (7.02%) was only numerically higher than their corresponding mean for variety NX1485 (4.44, 5.03 and 5.49% for fresh, oven dried and ensiling respectively). Mean of stover CP after ensiling (6.30%) was significantly higher than that after oven dried (5.70%) and fresh (5.30%).

Table 22. Dry matter and chemical composition of maize stover of the two varieties at the three harvest dates after the different conservation methods

Nutrient	Treatment	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	Mean CM[1]
DM (%)	NX1485 freeze dried	18.1	21.5	28.2	**22.6**	**22.3**
	NX20026 freeze dried	18.6	20.1	27:0	**21.9**	
	NX1485 oven dried	18.5	20.9	27.8	**22.4**	**22.2**
	NX20026 oven dried	19.3	19.4	27.1	**21.9**	
	NX1485 after ensiling	18.6	21.0	27.1	**22.2**	**21.8**
	NX20026 after ensiling	18.6	19.1	26.5	**21.4**	
Crude ash (%)	NX1485 freeze dried	4.75	5.40	5.58	5.24^{CD}	5.50^{B}
	NX20026 freeze dried	5.35	6.09	6.04	5.83^{B}	
	NX1485 oven dried	5:00	4.94	5.24	5.06^{D}	5.40^{B}
	NX20026 oven dried	5.75	5.71	5.81	5.76^{BC}	
	NX1485 after ensiling	6.07	5.37	5.74	5.73^{BC}	6.00^{A}
	NX20026 after ensiling	6.52	6.32	6.24	6.36^{A}	
CP (%)	NX1485 freeze dried	4.59	4.36	4.38	4.44^{B}	5.30^{B}
	NX20026 freeze dried	5.95	6.34	6.09	6.13^{AB}	
	NX1485 oven dried	6:00	4.45	4.64	5.03^{B}	5.70^{B}
	NX20026 oven dried	7.74	5.75	5.45	6.31^{AB}	
	NX1485 after ensiling	6.61	4.95	4.92	5.49^{AB}	6.30^{A}
	NX20026 after ensiling	8.87	5.92	6.26	7.02^{A}	
EE (%)	NX1485 freeze dried	0.80	1.02	0.71	0.84^{C}	1.00^{B}
	NX20026 freeze dried	1.06	1.40	0.85	1.10^{ABC}	
	NX1485 oven dried	1.12	0.97	0.79	0.96^{BC}	1.10^{B}
	NX20026 oven dried	1.52	1.13	0.85	1.17^{ABC}	
	NX1485 after ensiling	2.10	1.65	1.20	1.65^{AB}	1.80^{A}
	NX20026 after ensiling	2.68	1.21	1.72	1.87^{A}	

Means along the same column bearing different capital letters are significantly different
1 = Mean of conservation methods of the two varieties

Regarding to maize stover EE content it had the direction that it decreased with increasing plant maturity for the two varieties after the three conservation methods. Mean of stover EE content for variety NX20026 after fresh (1.10%), oven dried (1.17%) and ensiling (1.87%) was only numerically higher than their corresponding mean for variety NX1485 (0.84, 0.96 and 1.65% for fresh, oven dried and ensiling respectively). Mean of stover EE content after ensiling (1.80%) was significantly higher than that after fresh (1.00%) and after oven dried (1.10%).

About stover CF content it increased with increasing plant maturity in the two varieties after the three conservation methods. There was a significant difference between means of the six treatments. Mean of stover CF content for variety NX20026 after fresh (32.5%), oven dried (33.3%) and ensiling (36.0%) was only numerically higher than their corresponding mean for variety NX1485 (30.2, 30.8 and 34.0% for fresh, oven dried and ensiling respectively). Mean of stover CF after ensiling (35.0%) was significantly higher than that of fresh stover (31.4%).

Regarding to stover NDF content it increased with increasing plant maturity in the two varieties after the three conservation methods. There was no significant difference between the means of the six treatments. There was also no significant difference in stover NDF between the means of the three conservation methods (60.8%, 60.1% and 62.3% for fresh, oven dried (at 60 °C) and ensiled stover respectively).

Table 23. Crude fiber and crude fiber fractions of maize stover of the two varieties at the three harvest dates after the different conservation methods

Nutrient	Treatment	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	Mean CM[1]
CF (%)	NX1485 freeze dried	28.8	30.1	31.5	30.2^{C}	31.4^{B}
	NX20026 freeze dried	30.8	32.5	34.2	32.5^{BC}	
	NX1485 oven dried	29.2	31.2	32.1	30.8^{BC}	32.1^{B}
	NX20026 oven dried	30.7	34:0	35.3	33.3^{ABC}	
	NX1485 after ensiling	33.9	33.6	34.4	34.0^{AB}	35.0^{A}
	NX20026 after ensiling	33.5	36.3	38.3	36.0^{A}	
NDF (%)	NX1485 freeze dried	56.8	59.2	59.9	58.6	60.8
	NX20026 freeze dried	57.6	62.6	68.6	62.9	
	NX1485 oven dried	53.7	58.9	60.8	57.8	60.1
	NX20026 oven dried	57.7	61.3	68.4	62.5	
	NX1485 after ensiling	58.7	60.1	66.9	61.9	62.3
	NX20026 after ensiling	57.8	65.9	64.4	62.7	
ADF (%)	NX1485 freeze dried	32.7	33.3	33.7	33.2^{B}	35.1^{B}
	NX20026 freeze dried	34.4	37.2	39.2	36.9^{AB}	
	NX1485 oven dried	32.2	40.2	41.6	38.0^{AB}	37.4^{AB}
	NX20026 oven dried	35.5	35.7	39.4	36.9^{AB}	
	NX1485 after ensiling	38.0	38.3	40.0	38.8^{AB}	39.4^{A}
	NX20026 after ensiling	36.4	42.8	40.7	40.0^{A}	
ADL (%)	NX1485 freeze dried	3.50	3.20	3.70	3.47	4.15
	NX20026 freeze dried	3.30	5.40	5.80	4.83	
	NX1485 oven dried	5.70	2.90	4.8	4.47	4.27
	NX20026 oven dried	4.00	4.10	4.10	4.07	
	NX1485 after ensiling	4.10	4.20	4.90	4.40	4.60
	NX20026 after ensiling	3.90	5.70	4.80	4.80	

Means along the same column bearing different capital letters are significantly different
1 = Mean of conservation methods of the two varieties

Belong to stover ADF content it increased with increasing plant maturity. Mean of stover ADF content for variety NX20026 after fresh (36.9%) and ensiling (40.0%) was only numerically higher than their corresponding mean for variety NX1485 (33.2, and 38.8% for fresh and ensiling respectively). Mean of stover ADF after ensiling (39.0%) was significantly higher than that of fresh stover (35.1%).

There was no significant difference in stover ADL content between the means of the six treatments as it ranged from 3.47% for NX1494 fresh stover to 4.83% for NX20026 fresh stover. There was no significant difference between the three conservation methods (4.15, 4.27 and 4.60% for fresh, oven dried and ensilage respectively).

3.1.2.2 In situ dry matter degradability of maize stover

Table 24 shows DM degradability of maize stover of the two varieties at the three harvest dates after the three conservation methods at various incubation times. About DM degradation course it is clear that it increased with increasing the incubation time. Regarding to DM washing losses it decreased significantly with increasing plant maturity in the two varieties and after the three conservation methods. Mean of stover DM washing losses for variety NX1485 after fresh (36.9%), oven dried (33.8%) and ensiling (28.5%) was significantly higher than their corresponding mean for variety NX20026 (29.8, 27.8 and 23.8% for fresh, oven dried and ensiling respectively). There was also a significant difference between means of the conservation methods; with highest DM washing losses after freeze dried (33.4%) followed by oven dried (30.8%) then ensiling (26.2%).

Regarding to stover DM degradability after the other incubation times (2, 4, 8, 16, 24, 48, 72 and 96 h) it had the same trend like 0 h, as it decreased with increasing plant maturity. Also NX1485 variety was higher than variety NX20026 in DM degradability. Maize stover dry matter degradability after ensiling was significantly lower than that after fresh (freeze dried) and oven dried stover. As well as dry matter degradability of maize stover after freeze dried (fresh) was significantly higher than oven dried (60 ℃) and ensiling at 4 h, but at the other incubation times there was no significant difference between fresh and oven dried (60 ℃) stover.

Table 24. In situ DM degradability (% ± SD) of maize stover of the two varieties at the three harvest dates after the different conservation methods and various incubation times

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
0 h	**NX1485 FD[2]**	42.2^{Aa} ± 0.43	36.0^{Ab} ± 0.37	32.4^{Ac} ± 0.34	**36.9^{A}**	**33.4^{A}**	0.37	0.0001
	NX20026 FD[2]	35.8^{Ca} ± 0.49	28.1^{Db} ± 0.55	25.5^{Cc} ± 0.35	**29.8^{B}**		0.47	0.0001
	NX1485 OD[3]	36.7^{Ba} ± 0.12	35.0^{Bb} ± 0.33	29.7^{Bc} ± 1.07	**33.8^{A}**	**30.8^{B}**	0.65	0.0001
	NX20026 OD[3]	30.7^{Da} ± 0.42	27.0^{Eb} ± 0.11	25.6^{Cc} ± 0.43	**27.8^{B}**		0.35	0.0001
	NX1485 S[4]	29.8^{Ea} ± 0.76	29.7^{Ca} ± 0.62	25.8^{Cb} ± 0.20	**28.5^{B}**	**26.2^{C}**	0.58	0.0002
	NX20026 S[4]	27.2^{Fa} ± 0.15	24.1^{Fb} ± 0.47	20.1^{Dc} ± 0.99	**23.8^{C}**		0.64	0.0001
2 h	**NX1485 FD[2]**	41.4^{Aa} ± 0.24	35.4^{Ab} ± 0.26	31.8^{Ac} ± 0.91	**36.2^{A}**	**32.8^{A}**	0.40	0.0001
	NX20026 FD[2]	34.2^{Ca} ± 0.85	28.2^{Db} ± 0.65	25.8^{Cc} ± 0.47	**29.4^{B}**		0.68	0.0001
	NX1485 OD[3]	37.0^{Ba} ± 0.49	34.5^{Bb} ± 0.38	29.2^{Bc} ± 0.28	**33.6^{A}**	**30.2^{A}**	0.23	0.0001
	NX20026 OD[3]	29.8^{Da} ± 0.55	26.3^{Eb} ± 0.74	24.4^{Dc} ± 0.38	**26.8^{B}**		0.44	0.0001
	NX1485 S[4]	28.9^{Ea} ± 0.70	29.4^{Ca} ± 0.67	25.7^{Cb} ± 0.84	**28.0^{B}**	**25.6^{B}**	0.55	0.0003
	NX20026 S[4]	26.7^{Fa} ± 0.84	23.0^{Fb} ± 0.66	19.9^{Ec} ± 1.12	**23.2^{C}**		0.73	0.0001
4 h	**NX1485 FD[2]**	44.0^{Aa} ± 0.86	37.8^{Ab} ± 1.13	33.1^{Ac} ± 1.12	**38.3^{A}**	**35.2^{A}**	1.00	0.0001
	NX20026 FD[2]	36.6^{Ca} ± 0.64	31.8^{Cb} ± 0.72	27.6^{Cc} ± 0.40	**32.0^{BC}**		0.57	0.0001
	NX1485 OD[3]	39.9^{Ba} ± 0.81	35.6^{Bb} ± 0.49	30.2^{Bc} ± 0.70	**35.2^{AB}**	**32.1^{B}**	0.62	0.0001
	NX20026 OD[3]	32.5^{Da} ± 0.56	28.5^{Eb} ± 0.71	25.7^{Cc} ± 0.80	**28.9^{C}**		0.64	0.0001
	NX1485 S[4]	30.8^{Ea} ± 1.03	30.0^{Da} ± 0.81	27.3^{Cb} ± 1.08	**29.4^{C}**	**27.3^{C}**	0.90	0.0072
	NX20026 S[4]	27.5^{Fa} ± 1.18	25.3^{Fb} ± 0.39	22.5^{Ec} ± 1.03	**25.1^{D}**		0.53	0.0001
8 h	**NX1485 FD[2]**	48.9^{Aa} ± 2.99	42.7^{Aab} ± 3.73	36.6^{Ab} ± 2.67	**42.7^{A}**	**40.4^{A}**	3.48	0.0141
	NX20026 FD[2]	42.5^{BCa} ± 2.27	39.3^{ABa} ± 3.04	32.6^{Bb} ± 1.71	**38.1^{AB}**		2.48	0.0073
	NX1485 OD[3]	44.2^{ABa} ± 3.60	39.2^{ABa} ± 3.36	32.4^{Bb} ± 1.69	**38.6^{AB}**	**37.2^{A}**	2.88	0.007
	NX20026 OD[3]	40.7^{BCDa} ± .87	35.2^{BCb} ± 2.76	31.4^{Bb} ± 1.58	**35.8^{BC}**		2.19	0.0058
	NX1485 S[4]	36.3^{Da} ± 4.44	35.4^{BCa} ± 3.77	30.4^{Ba} ± 2.67	**34.0^{BC}**	**33.2^{B}**	3.60	0.1784
	NX20026 S[4]	37.4^{CDa} ± 2.26	30.9^{Cb} ± 1.45	28.9^{Bb} ± 2.60	**32.4^{C}**		1.82	0.0029
16 h	**NX1485 FD[2]**	60.7^{ABa} ± 1.26	56.3^{Aa} ± 2.29	49.6^{ABb} ± 3.15	**55.5^{A}**	**54.1^{A}**	2.50	0.0046
	NX20026 FD[2]	57.5^{BCa} ± 1.29	52.3^{BCb} ± 2.46	48.3^{ABc} ± 1.68	**52.7^{AB}**		1.67	0.0016
	NX1485 OD[3]	61.1^{Aa} ± 2.50	55.0^{ABb} ± 2.24	51.8^{Ab} ± 1.11	**56.0^{A}**	**54.2^{A}**	1.65	0.0013
	NX20026 OD[3]	59.6^{ABa} ± 0.73	52.4^{BCb} ± 1.75	45.4^{Bc} ± 2.47	**52.4^{AB}**		1.83	0.0002
	NX1485 S[4]	53.8^{Da} ± 2.13	50.2^{Cb} ± 2.48	48.7^{ABb} ± 1.85	**50.9^{AB}**	**49.6^{B}**	1.73	0.0272
	NX20026 S[4]	54.6^{CDa} ± 2.32	45.4^{Db} ± 2.04	44.9^{Bb} ± 5.21	**48.3^{B}**		3.55	0.0264

Continue Table 24

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
24 h	**NX1485 FD[2]**	63.7^{Aa} ± 0.96	61.2^{Aa} ± 2.74	56.0^{Ab} ± 0.86	**60.3^{A}**	**58.0^{A}**	1.86	0.0065
	NX20026 FD[2]	57.5^{ABa} ± 2.67	56.2^{ABa} ± 3.50	53.0^{Aa} ± 2.06	**55.6^{BC}**		2.73	0.1925
	NX1485 OD[3]	63.3^{Aa} ± 2.86	58.5^{ABab} ± 3.20	55.4^{Ab} ± 1.55	**59.1^{AB}**	**57.1^{A}**	2.89	0.0406
	NX20026 OD[3]	60.0^{Aa} ± 5.14	54.4^{Ba} ± 3.03	50.6^{Aa} ± 6.84	**55.0^{BC}**		5.79	0.2185
	NX1485 S[4]	57.6^{ABa} ± 1.38	55.1^{Bb} ± 0.50	51.8^{Ac} ± 1.40	**54.8^{BC}**	**53.6^{B}**	1.14	0.0025
	NX20026 S[4]	52.4^{Ba} ± 7.99	49.3^{Ca} ± 2.52	55.2^{Aa} ± 3.59	**52.3^{C}**		4.05	0.2828
48 h	**NX1485 FD[2]**	71.3^{ABa} ± 1.43	71.1^{Aa} ± 1.04	67.0^{Ab} ± 2.51	**69.8^{A}**	**68.0^{A}**	1.92	0.058
	NX20026 FD[2]	67.8^{BCa} ± 0.43	66.8^{BCb} ± 0.35	63.8^{ABc} ± 0.56	**66.1^{BC}**		0.27	0.0001
	NX1485 OD[3]	71.3^{ABa} ± 1.43	71.1^{Aa} ± 1.04	67.0^{Ab} ± 2.51	**69.8^{A}**	**68.0^{A}**	1.92	0.058
	NX20026 OD[3]	67.8^{BCa} ± 0.43	66.8^{BCb} ± 0.35	63.8^{ABc} ± 0.56	**66.1^{BC}**		0.27	0.0001
	NX1485 S[4]	66.9^{Ca} ± 2.19	65.3^{CDa} ± 1.56	64.7^{ABc} ± 1.26	**65.6^{C}**	**64.5^{B}**	1.62	0.3173
	NX20026 S[4]	67.5^{BCa} ± 3.52	62.7^{Dab} ± 0.59	59.8^{Cb} ± 2.21	**63.3^{C}**		2.50	0.025
72 h	**NX1485 FD[2]**	74.5^{Aa} ± 1.00	74.2^{Aa} ± 1.31	71.4^{Ab} ± 1.00	**73.4^{A}**	**71.9^{A}**	1.26	0.0415
	NX20026 FD[2]	70.9^{Ba} ± 1.40	71.0^{BCa} ± 1.42	69.1^{Aa} ± 0.75	**70.3^{BC}**		1.28	0.1952
	NX1485 OD[3]	75.5^{Aa} ± 1.00	72.7^{ABb} ± 1.38	70.6^{Ab} ± 1.43	**72.9^{A}**	**72.0^{A}**	1.34	0.0127
	NX20026 OD[3]	74.8^{Aa} ± 1.33	69.7^{CDb} ± 1.05	68.6^{Ab} ± 1.79	**71.0^{AB}**		1.52	0.0051
	NX1485 S[4]	71.0^{Ba} ± 0.99	70.5^{BCa} ± 0.75	69.4^{Aa} ± 1.59	**70.3^{BC}**	**69.2^{B}**	1.07	0.2476
	NX20026 S[4]	71.9^{Ba} ± 1.57	67.7^{Db} ± 0.98	64.7^{Bb} ± 2.36	**68.1^{C}**		1.80	0.0078
96 h	**NX1485 FD[2]**	76.3^{ABa} ± 1.51	76.7^{Aa} ± 1.18	74.3^{Aa} ± 1.51	**75.8^{A}**	**74.1^{AB}**	1.51	0.1953
	NX20026 FD[2]	72.8^{Cab} ± 0.77	73.2^{BCa} ± 1.13	71.2^{ABb} ± 0.49	**72.4^{CD}**		0.91	0.0726
	NX1485 OD[3]	77.7^{Aa} ± 1.01	75.3^{ABab} ± 1.61	73.8^{Ab} ± 1.18	**75.6^{AB}**	**74.5^{A}**	1.40	0.0384
	NX20026 OD[3]	76.8^{ABa} ± 0.82	71.6^{CDb} ± 0.85	71.6^{Ab} ± 0.82	**73.3^{BCD}**		0.83	0.0004
	NX1485 S[4]	74.7^{BCa} ± 1.02	73.9^{BCa} ± 1.33	72.8^{Aa} ± 3.01	**73.8^{ABC}**	**72.5^{B}**	2.12	0.5618
	NX20026 S[4]	75.4^{Ba} ± 1.22	70.2^{Db} ± 0.62	68.1^{Bb} ± 1.85	**71.2^{D}**		1.15	0.0006

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties, 2 = Freeze dried, 3 = Oven dried, and 4 = ensilsd

3.1.2.3 Parameters of rumen dry matter degradability of maize stover

Table 25 illustrate parameters of rumen DM degradability of maize stover of the two varieties at the three harvest dates after the three conservation methods. Belong to the rapidly soluble fraction (a) of maize stover it significantly decreased with increasing plant maturity. Mean of stover rapidly soluble fraction for variety NX1485 after fresh (36.7%), oven dried (33.8%) and ensiling (28.2%) was significantly higher than their corresponding mean for variety NX20026 (29.6, 27.3 and 23.5% for fresh, oven dried and ensiling respectively). Mean of stover rapidly soluble fraction after ensiling (25.9%) was significantly lower than that after oven dried (30.6%) and freeze dried stover (33.2%).

Regarding to slowly degradable fraction (b) of maize stover it increased with increasing plant maturity except at ensiled stover of variety NX20026 in which it had the tendency to decreased with increasing plant maturity (47.8, 47,3 and 45.9% for HD1, HD2 and HD3 respectively). Mean of stover slowly degradable fraction of variety NX20026 after fresh (42.2%), and oven dried (45.6%) was significantly higher than their corresponding mean for variety NX1485 (38.4 and 40.5% for fresh and oven dried respectively). On the other hand, mean of stover slowly degradable fraction of variety NX20026 after ensiling (47.0%) was only numerically higher than that of variety NX1485 after ensiling (44.4%). Mean of stover slowly degradable fraction after ensiling (45.7%) was significantly higher than that after oven dried (43.1%) and freeze dried (40.3%). We must note that when the rapidly soluble fraction decreased the slowly degradable fraction increased and vice versa.

For the non degradable fraction (A) of maize stover it significantly increased with increasing plant maturity in the two varieties after the three conservation methods. Mean of stover non degradable fraction of variety NX20026 after fresh (28.2%) was significantly higher than that of variety NX1485 (24.9%). Mean of stover non degradable fraction of variety NX20026 after oven dried (27.1%), and ensiling (29.5%) was only numerically higher than their corresponding mean of variety NX1485 (25.7 and 27.3% for oven dried and ensiling respectively). Stover non degradable fraction after ensiling NX20026 at HD3 (34.1%) was the highest. Mean of stover non degradable fraction after ensiling (28.4%) was significantly higher than that after oven dried (26.6%).

Concerning to the rate of degradation (c) of maize stover there was no significant difference between the three harvest dates within the six treatments. The rate of degradation of maize stover of variety NX20026 after ensiling at HD3 ($6.75\%h^{-1}$) was the highest. There was no significant difference between means of the different conservation methods (5.15, 5.55 and $5.22\%h^{-1}$ for fresh, oven dried and ensiling conservation respectively).

Table 25. Parameters of rumen degradability (% ± SD) of maize stover of the two varieties at the three harvest dates after the different conservation methods

Parameters	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
a (%)	**NX1485 FD[2]**	42.0^{Aa} ± 0.30	35.8^{Ab} ± 0.27	32.3^{Ac} ± 0.17	**36.7^{A}**	**33.2^{A}**	0.25	0.0001
	NX20026 FD[2]	35.0^{Ca} ± 0.71	28.2^{Db} ± 0.57	25.6^{Cc} ± 0.27	**29.6^{B}**		0.55	0.0001
	NX1485 OD[3]	36.9^{Ba} ± 0.21	35.0^{Bb} ± 0.13	29.7^{Bc} ± 0.30	**33.8^{A}**	**30.6^{A}**	0.23	0.0001
	NX20026 OD[3]	30.2^{Da} ± 0.31	26.7^{Eb} ± 0.31	25.0^{Cc} ± 0.25	**27.3^{B}**		0.29	0.0001
	NX1485 S[4]	29.3^{Ea} ± 0.57	29.6^{Ca} ± 0.26	25.8^{Cb} ± 0.17	**28.2^{B}**	**25.9^{B}**	0.38	0.0001
	NX20026 S[4]	26.9^{Fa} ± 0.13	23.5^{Fb} ± 0.13	20.0^{Dc} ± 1.06	**23.5^{C}**		0.62	0.0001
b (%)	**NX1485 FD[2]**	33.4^{Eb} ± 2.07	40.2^{CDa} ± 1.60	41.6^{Ca} ± 2.60	**38.4^{D}**	**40.3^{C}**	2.13	0.0069
	NX20026 FD[2]	36.8^{Dc} ± 0.54	44.4^{ABb} ± 0.14	45.4^{ABCa} ± 0.07	**42.2^{BC}**		0.37	0.0001
	NX1485 OD[3]	39.9^{Ca} ± 0.46	39.4^{Da} ± 3.22	42.1^{BCa} ± 1.39	**40.5^{CD}**	**43.1^{B}**	2.04	0.2962
	NX20026 OD[3]	45.2^{Bab} ± 0.45	44.0^{ABb} ± 1.13	47.7^{Aa} ± 2.23	**45.6^{A}**		1.47	0.0537
	NX1485 S[4]	43.4^{Ba} ± 2.71	43.4^{BCa} ± 1.97	46.6^{Aa} ± 3.72	**44.4^{AB}**	**45.7^{A}**	2.89	0.3441
	NX20026 S[4]	47.8^{Aa} ± 0.25	47.3^{Aab} ± 1.37	45.9^{ABb} ± 0.66	**47.0^{A}**		0.89	0.094
A (%)	**NX1485 FD[2]**	24.6^{Ca} ± 1.83	24.0^{Ba} ± 1.44	26.1^{Ba} ± 2.73	**24.9^{C}**	**26.6^{AB}**	2.07	0.4918
	NX20026 FD[2]	28.2^{Aab} ± 0.60	27.4^{ABb} ± 0.58	29.0^{Ba} ± 0.32	**28.2^{AB}**		0.51	0.0283
	NX1485 OD[3]	23.3^{Cb} ± 0.67	25.7^{Bab} ± 3.15	28.2^{Ba} ± 1.66	**25.7^{BC}**	**26.4^{B}**	2.09	0.0743
	NX20026 OD[3]	24.6^{Cb} ± 0.25	29.4^{Aa} ± 1.12	27.3^{Bab} ± 2.48	**27.1^{ABC}**		1.58	0.0276
	NX1485 S[4]	27.3^{ABa} ± 2.44	27.0^{ABa} ± 2.22	27.6^{Ba} ± 3.82	**27.3^{ABC}**	**28.4^{A}**	2.91	0.9762
	NX20026 S[4]	25.3^{BCc} ± 0.28	29.0^{Ab} ± 1.29	34.1^{Aa} ± 0.79	**29.5^{A}**		0.89	0.0001
c (%)	**NX1485 FD[2]**	5.66 ± 0.88	5.21 ± 0.46	4.73 ± 0.97	**5.20**	**5.15**	0.80	0.4151
	NX20026 FD[2]	5.72 ± 0.78	4.97 ± 0.52	4.60 ± 0.37	**5.09**		0.59	0.1363
	NX1485 OD[3]	5.77 ± 1.05	5.97 ± 2.38	5.78 ± 0.11	**5.84**	**5.55**	1.50	0.9824
	NX20026 OD[3]	6.20 ± 1.15	5.35 ± 0.19	4.23 ± 1.52	**5.26**		1.11	0.1724
	NX1485 S[4]	6.11 ± 1.70	4.76 ± 0.89	4.86 ± 1.77	**5.24**	**5.22**	1.51	0.5138
	NX20026 S[4]	4.74 ± 1.35	4.10 ± 0.48	6.75 ± 0.94	**5.19**		1.38	0.1247
t_0 (h)	**NX1485 FD[2]**	3.54^{Aa} ± 2.05	3.82^{ABa} ± 2.16	5.39^{Aa} ± 2.01	**4.25^{AB}**	**3.63^{A}**	2.08	0.5353
	NX20026 FD[2]	3.50^{Aa} ± 1.75	2.21^{Ba} ± 0.37	3.28^{Aa} ± 0.14	**3.00^{B}**		1.04	0.3347
	NX1485 OD[3]	3.04^{Ab} ± 0.55	5.39^{Aab} ± 2.11	6.16^{Aa} ± 0.32	**4.86^{A}**	**4.11^{A}**	1.27	0.0548
	NX20026 OD[3]	3.06^{Aa} ± 0.54	3.16^{ABa} ± 0.62	3.88^{Aa} ± 1.74	**3.36^{AB}**		1.11	0.6351
	NX1485 S[4]	4.30^{Aa} ± 2.37	4.40^{ABa} ± 1.48	4.43^{Aa} ± 2.13	**4.37^{AB}**	**3.85^{A}**	2.03	0.9965
	NX20026 S[4]	2.80^{Aa} ± 0.89	3.13^{ABa} ± 0.20	4.04^{Aa} ± 2.04	**3.32^{AB}**		1.29	0.5121

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties, 2 = Freeze dried, 3 = Oven dried, and 4 = ensilsd

For the lag time (t_0) of maize stover there was no difference between the three harvest dates within the different treatment except for NX1485 after oven dry in which the HD3 (6.16 h) was significantly higher than HD1 (3.04 h). Mean of stover lag time of variety NX1485 after fresh (4.25 h), oven dried (4.86 h), and ensiling (4.37 h) was only numerically higher than their corresponding mean for variety NX20026 (3.00, 3.36 and 3.32 h for fresh, oven dried and ensiled respectively). There was no significant difference between the means of the different conservation methods (3.63, 4.11 and 3.85 h for fresh, oven dried and ensiled conservation respectively).

3.1.2.4 Effective rumen dry matter degradability of maize stover

Table 26 shows the effective rumen DM degradability of maize stover of the two varieties after the different conservation methods at the three harvest dates by passage rate of 6%h^{-1}. It is clear that there was a significant decrease in the EDMD with increasing plant maturity for the six treatments. Means of the harvest date at HD1, HD2 and HD3 were (52.4, 48.3 and 43.7%), (51.2, 46.2 and 42.0%) and (45.2, 41.8 and 40.1%) after freeze dried, oven dried and ensiled conservation respectively.

Table 26. Effective rumen DM degradability (% ± SD) of maize stover of the two varieties at the three harvest dates after the different conservation methods by passage rate of 6 %h^{-1}

Treatment	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
NX1485 freeze dried	55.1^{Aa} ± 1.28	50.7^{Ab} ± 1.94	45.5^{Ac} ± 0.93	**50.4^{A}**	**48.1^{A}**	1.43	0.0005
NX20026 freeze dried	49.6^{Ba} ± 0.98	45.8^{Bb} ± 1.57	41.8^{Bc} ± 0.79	**45.7^{BC}**		1.15	0.0005
NX1485 oven dried	53.1^{Aa} ± 1.99	48.6^{Ab} ± 0.15	44.0^{Ac} ± 0.89	**48.6^{AB}**	**46.5^{A}**	1.26	0.0004
NX20026 oven dried	49.2^{Ba} ± 1.30	43.8^{Bb} ± 0.95	40.0^{BCc} ± 1.77	**44.4^{CD}**		1.37	0.0005
NX1485 after ensiling	45.9^{Ca} ± 1.44	44.2^{Ba} ± 1.03	41.3^{Bb} ± 0.52	**43.8^{CD}**	**42.4^{B}**	1.06	0.0047
NX20026 after ensiling	44.5^{Ca} ± 1.99	39.4^{Cb} ± 0.57	38.8^{Cb} ± 1.88	**40.9^{D}**		1.62	0.0093

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties

There was significant difference between means of the six treatments. Mean of stover EDMD of variety NX1485 after fresh (50.4%), and after oven dried (48.6%) was significantly higher than their corresponding mean for variety NX20026 (45.7 and 44.4% for fresh and oven dried respectively). Mean of stover EDMD of variety NX1485 after ensiled (43.8%) was only numerically higher than that of variety NX20026 after ensiled (40.9%). Mean of stover EDMD after ensiled (42.4%) was significantly lower than that after oven dried (46.5%) and freeze dried stover (48.1%).

Maize stover dry matter degradability decreased significantly with increasing plant maturity. Maize variety plays a role in stover dry matter degradability and maize stover degradability of variety NX1485 was higher than that of variety NX20026. Maize stover dry matter degradability affected by the conservation method, and ensiled impair and decreased the effective rumen dry matter degradability of maize stover. No significant difference in effective dry matter degradability of maize stover between freeze dried (fresh) and oven dried at 60 °C conservation was noticed.

3.2 Effect of maturity stage, maize variety and conservation method on rumen degradability of maize grain (Exp 5)

The aim of this experiment was to study the effect of harvest date, endosperm type of the grain and the method of conservation (fresh (freeze dried), practical oven dried at 85 ℃ and ensiled) on the in situ rumen DM degradability of maize grain. Two types of maize grain, one from flint endosperm type (NX1485) and the other from dent endosperm type (NX20026) harvested at three maturity dates in 2008 were used.

3.2.1 Dry matter and chemical composition of maize grain

Dry matter and chemical composition of maize grain of the two varieties at the three harvest dates after the different conservation methods are presented in Table 27. Maize grain dry matter increased with increasing plant maturity in the two varieties after the different conservation methods. Maize grain dry matter of variety NX1485 (flint type endosperm) varied from 52.4% (HD1) over 61.2% (HD2) to 65.7% (HD3), whereas grain dry matter of variety NX20026 (dent type endosperm) started from 45.0% (HD1) to 59.2% (HD2) to 63.9% (HD3). There was no significant difference between the means of the three conservation methods (58.2, 57.8 and 57.6% for fresh, oven dried at 85 ℃ and ensiled co nservation respectively).

Maize grain starch content increased with increasing plant maturity. No significant difference in maize grain starch content was noticed between the two maize varieties after the different conservation methods. Mean of maize grain starch content of ensiled grain (73.5%) was significantly higher than that of freeze dried (69.0%) and oven dried grain (68.8%).

Regarding to maize grain crude ash content the overall mean was about 1.51%. There was no significant difference between the means of three conservation methods (1.43, 1.51 and 1.58% for fresh, oven dried at 85 ℃ and ensiled conservation respectively).

Table 27. Dry matter and chemical composition of maize grain of the two varieties at the three harvest dates after the different conservation methods

Fraction	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]
DM (%)	NX1485 freeze dried	52.3	61.6	66.7	**60.2**	**58.2**
	NX20026 freeze dried	44.1	59.5	65.0	**56.2**	
	NX1485 oven dried	52.0	61.9	66.3	**60.1**	**57.8**
	NX20026 oven dried	44.1	58.9	63.6	**55.5**	
	NX1485 after ensiling	52.9	60.0	64.0	**59.0**	**57.6**
	NX20026 after ensiling	46.8	59.3	62.6	**56.2**	
Starch (%)	NX1485 freeze dried	68.5	69.7	70.0	**69.4^{B}**	**69.0^{B}**
	NX20026 freeze dried	66.7	66-9	70.5	**68.6^{B}**	
	NX1485 oven dried	67.3	67.5	71.1	**68.6^{B}**	**68.8^{B}**
	NX20026 oven dried	66.4	68.9	71.7	**69.0^{B}**	
	NX1485 after ensiling	71.7	72.5	74.4	**72.9^{A}**	**73.5^{A}**
	NX20026 after ensiling	71.9	73.9	76.7	**74.2^{A}**	
Crude ash (%)	NX1485 freeze dried	1.45	1.20	1.33	**1.33^{B}**	**1.43**
	NX20026 freeze dried	1.70	1.36	1.52	**1.53^{AB}**	
	NX1485 oven dried	1.45	1.39	1.63	**1.49^{AB}**	**1.51**
	NX20026 oven dried	1.68	1.42	1.45	**1.52^{AB}**	
	NX1485 after ensiling	1.60	1.49	1.62	**1.57^{A}**	**1.58**
	NX20026 after ensiling	1.65	1.50	1.58	**1.58^{A}**	
CP (%)	NX1485 freeze dried	11.6	10.8	11.5	**11.3^{A}**	**10.6**
	NX20026 freeze dried	10.1	9.93	9.67	**9.89^{C}**	
	NX1485 oven dried	10.2	11.2	11.8	**11.1^{AB}**	**10.8**
	NX20026 oven dried	11.8	9.9	9.7	**10.5^{ABC}**	
	NX1485 after ensiling	11.7	11.2	11.9	**11.6^{A}**	**10.8**
	NX20026 after ensiling	10.1	9.91	9.98	**10.0^{BC}**	
EE (%)	NX1485 freeze dried	5.23	4.66	4.17	**4.69^{AB}**	**4.65**
	NX20026 freeze dried	4.50	4.61	4.71	**4.61^{AB}**	
	NX1485 oven dried	6.01	4.60	4.54	**5.08^{A}**	**4.59**
	NX20026 oven dried	3.92	4.22	4.14	**4.09^{B}**	
	NX1485 after ensiling	5.25	4.75	4.69	**4.90^{AB}**	**4.49**
	NX20026 after ensiling	3.57	4.20	4.48	**4.08^{B}**	
CF (%)	NX1485 freeze dried	3.66	2.89	2.61	**3.05^{AB}**	**2.95^{B}**
	NX20026 freeze dried	3.22	2.76	2.56	**2.85^{B}**	
	NX1485 oven dried	3.05	2.88	2.94	**2.96^{B}**	**3.05^{B}**
	NX20026 oven dried	3.42	2.67	3.3	**3.13^{AB}**	
	NX1485 after ensiling	3.64	3.59	3.63	**3.62^{A}**	**3.63^{A}**
	NX20026 after ensiling	3.61	3.7	3.6	**3.64^{A}**	

Means along the same column bearing different capital letters are significantly different
1= Mean of conservation methods of the two varieties

Belong to maize grain CP content it ranged from 10.0 to 11.0%. Mean of maize grain CP of variety NX1485 (flint type) after fresh (11.3%), and ensiled (11.6%) was significantly higher than their corresponding mean for variety NX20026 (9.89 and 10.0% for fresh and ensiled respectively). There was no significant difference in maize grain CP content between the three conservation methods (10.6, 10.8 and 10.8% for fresh (freeze dried), oven dried at 85 ℃ and ensiled conservation respectively).

For maize grain EE content it decreased with increasing plant maturity in variety NX1485, but in contrast it increased with increasing plant maturity in variety NX20026. Mean of maize grain EE of variety NX1485 (flint type) after oven dried (5.08%), was significantly higher than that of variety NX20026 (4.09%). On the other hand, there was no significant difference between means of three conservation methods (4.65, 4.59 and 4.49% for fresh, oven dried at 85 ℃ and ensiled conservation respectively).

About maize grain CF content there was a significant difference in maize grain CF content between means of the six treatments. The mean of ensiled grain (3.63%) was significantly higher than that of freeze dried (2.95%) and oven dried grain (3.05%).

3.2.2 In situ rumen dry matter degradability of maize grain

Table 28 shows dry matter degradability of maize grain of the two varieties at the three harvest dates after the different conservations methods at the various incubation times. It is obvious that DM washing losses significantly decreased with increasing plant maturity in the two maize grains after the different conservation methods. Mean of maize grain DM washing loses (0 h) of variety NX20026 after fresh (50.1%) and ensiled (85.8%) was significantly higher than their corresponding mean for variety NX1485 (38.0 and 79.7% for fresh and ensiled respectively). Mean of maize grain DM washing loses (0 h) of variety NX20026 after oven dried at 85 ℃ (23.2%) was only numerically higher than that of variety NX1485 (19.6%). Mean of maize grain DM washing loses (0 h) after ensiled (82.8%) was dramatically much higher than that after freeze dried (44.1%) and oven dried grain at 85 ℃ (21.4%).

Table 28. In situ dry matter degradability (% ± SD) of maize grain of the two varieties at the three harvest dates after the different conservation methods at various incubation times

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM	MSE HD	P-Value
0 h	**NX1485 FD[2]**	46.7^{Da} ± 0.40	38.7^{Db} ± 0.49	28.7^{Dc} ± 0.80	**38.0^{D}**	**44.1^{B}**	0.59	0.0001
	NX20026 FD[2]	60.1^{Ca} ± 0.89	47.8^{Cb} ± 0.40	42.6^{Cc} ± 0.17	**50.1^{C}**		0.57	0.0001
	NX1485 OD[3]	23.3^{Fa} ± 0.47	19.6^{Fb} ± 0.18	16.0^{Fc} ± 0.14	**19.6^{E}**	**21.4^{C}**	0.30	0.0001
	NX20026 OD[3]	26.2^{Ea} ± 0.34	23.3^{Eb} ± 0.38	20.3^{Ec} ± 0.31	**23.2^{E}**		0.34	0.0001
	NX1485 S[4]	85.9^{Ba} ± 0.21	78.6^{Bb} ± 0.66	74.8^{Bc} ± 0.48	**79.7^{B}**	**82.8^{A}**	0.48	0.0001
	NX20026 S[4]	87.3^{Aa} ± 0.05	85.5^{Ab} ± 0.98	84.5^{Ab} ± 0.28	**85.8^{A}**		0.59	0.0033
2 h	**NX1485 FD[2]**	56.1^{Ca} ± 1.90	47.3^{Db} ± 1.24	36.1^{Dc} ±1.51	**46.5^{C}**	**51.9^{B}**	1.11	0.0001
	NX20026 FD[2]	68.2^{Ba} ± 1.80	54.7^{Cb} ± 1.77	48.9^{Cc} ± 1.45	**57.2^{B}**		0.85	0.0001
	NX1485 OD[3]	25.5^{Ea} ± 1.41	21.5^{Fb} ± 0.96	16.7^{Fc} ± 0.93	**21.2^{D}**	**22.8^{C}**	1.03	0.0001
	NX20026 OD[3]	27.6^{Da} ± 1.25	24.3^{Eb} ± 0.77	21.1^{Ec} ± 0.95	**24.4^{D}**		1.47	0.0001
	NX1485 S[4]	85.3^{Aa} ± 1.21	80.4^{Bb} ± 1.28	77.9^{Bc} ± 1.34	**81.2^{A}**	**83.0^{A}**	1.58	0.0001
	NX20026 S[4]	86.4^{Aa} ± 0.96	84.3^{Ab} ± 1.17	83.3^{Ab} ± 1.65	**84.7^{A}**		1.08	0.0005
4 h	**NX1485 FD[2]**	62.7^{Ca} ± 2.04	50.4^{Db} ± 2.62	37.7^{Dc} ± 2.91	**50.3^{C}**	**55.5^{B}**	2.74	0.0007
	NX20026 FD[2]	70.7^{Ba} ± 3.08	60.1^{Cb} ± 1.96	51.2^{Cc} ± 1.99	**60.7^{B}**		0.90	0.0001
	NX1485 OD[3]	27.2^{Da} ± 1.33	22.9^{Fb} ± 1.02	18.5^{Fc} ± 1.17	**22.8^{D}**	**24.1^{C}**	1.13	0.0001
	NX20026 OD[3]	28.6^{Da} ± 1.18	25.2^{Eb} ± 1.26	22.2^{Ec} ± 0.77	**25.3^{D}**		2.50	0.0001
	NX1485 S[4]	87.2^{Aa} ± 1.86	81.7^{Bb} ± 2.42	79.6^{Bb} ± 3.61	**82.9^{A}**	**84.6^{A}**	2.32	0.0001
	NX20026 S[4]	86.9^{Aa} ± 1.83	85.4^{Aa} ± 2.12	86.5^{Aa} ± 1.69	**86.3^{A}**		1.87	0.3788
8 h	**NX1485 FD[2]**	66.8^{Ca} ± 2.93	56.7^{Db} ± 1.86	45.5^{Dc} ± 2.49	**56.3^{C}**	**62.7^{B}**	1.92	0.0003
	NX20026 FD[2]	83.2^{Ba} ± 2.02	66.1^{Cb} ± 1.95	57.6^{Cc} ± 2.47	**69.0^{B}**		1.48	0.0001
	NX1485 OD[3]	34.2^{Ea} ± 1.17	28.8^{Fb} ± 0.90	24.6^{Ec} ± 1.34	**29.2^{D}**	**30.5^{C}**	0.84	0.0001
	NX20026 OD[3]	37.6^{Da} ± 1.69	31.5^{Eb} ± 1.19	26.3^{Ec} ± 1.84	**31.8^{D}**		2.25	0.0001
	NX1485 S[4]	89.1^{Aa} ± 1.49	84.0^{Bb} ± 2.18	83.8^{Bb} ± 2.12	**85.7^{A}**	**86.6^{A}**	1.99	0.0001
	NX20026 S[4]	89.4^{Aa} ± 2.07	86.3^{Ab} ± 2.75	86.8^{Aab} ± 2.17	**87.5^{A}**		2.15	0.0509
16 h	**NX1485 FD[2]**	77.7^{Ca} ± 2.70	71.1^{Cb} ± 1.96	61.9^{Cc} ± 2.07	**70.2^{C}**	**74.9^{B}**	2.06	0.5578
	NX20026 FD[2]	90.2^{Ba} ± 3.55	75.2^{Bb} ± 2.44	73.4^{Bb} ± 2.90	**79.6^{B}**		3.33	0.0001
	NX1485 OD[3]	51.6^{Da} ± 3.34	46.8^{Db} ± 1.96	43.9^{Db} ± 2.41	**47.4^{D}**	**47.4^{C}**	2.57	0.0004
	NX20026 OD[3]	54.0^{Da} ± 2.89	48.0^{Db} ± 3.07	40.2^{Ec} ± 3.84	**47.4^{D}**		1.44	0.0001
	NX1485 S[4]	93.0^{ABa} ± 2.35	92.3^{Aa} ± 2.33	91.7^{Aa} ± 1.81	**92.3^{A}**	**92.7^{A}**	2.97	0.0001
	NX20026 S[4]	93.9^{Aa} ± 2.89	93.3^{Aa} ± 1.93	92.2^{Aa} ± 1.59	**93.1^{A}**		2.21	0.4433

Continued Table 28

Time	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM	MSE HD	P-Value
24 h	**NX1485 FD[2]**	87.8^{Ba} ± 2.92	81.2^{Cb} ± 2.30	69.7^{Dc} ± 2.46	**79.6^{C}**	**83.7^{B}**	1.67	0.0124
	NX20026 FD[2]	94.1^{Aa} ± 2.40	87.0^{Bb} ± 2.88	82.0^{Cc} ± 2.63	**87.7^{B}**		2.06	0.0001
	NX1485 OD[3]	58.7^{Da} ± 3.67	51.6^{Eb} ± 2.86	49.4^{Fb} ± 1.38	**53.3^{E}**	**55.7^{C}**	2.86	0.0001
	NX20026 OD[3]	66.9^{Ca} ± 2.75	54.7^{Db} ± 1.58	52.5^{Eb} ± 2.28	**58.0^{D}**		2.49	0.0001
	NX1485 S[4]	96.7^{Aa} ± 1.09	94.4^{Ab} ± 1.76	93.5^{Bb} ± 2.34	**94.9^{A}**	**95.5^{A}**	2.46	0.0001
	NX20026 S[4]	95.9^{Aa} ± 2.15	96.4^{Aa} ± 1.20	95.9^{Aa} ± 0.75	**96.1^{A}**		1.28	0.7469
48 h	**NX1485 FD[2]**	97.5^{Aa} ± 1.04	97.4^{Aa} ± 0.80	96.2^{Bb} ± 0.84	**97.0^{A}**	**97.6^{A}**	0.23	0.0979
	NX20026 FD[2]	98.5^{Aa} ± 0.23	98.2^{Aa} ± 0.40	97.5^{ABb} ± 0.44	**98.1^{A}**		2.53	0.0011
	NX1485 OD[3]	91.9^{Ba} ± 2.01	87.3^{Bb} ± 2.75	86.7^{Cb} ± 3.83	**88.6^{B}**	**88.5^{B}**	2.80	0.0119
	NX20026 OD[3]	91.8^{Ba} ± 3.04	88.6^{Bb} ± 3.06	84.9^{Dc} ± 0.83	**88.4^{B}**		0.89	0.0356
	NX1485 S[4]	98.3^{Aa} ± 0.34	98.3^{Aa} ± 0.31	98.1^{ABa} ± 0.18	**98.2^{A}**	**98.4^{A}**	0.32	0.0001
	NX20026 S[4]	98.6^{Aa} ± 0.18	98.4^{Aa} ± 0.22	98.4^{Aa} ± 0.20	**98.5^{A}**		0.17	0.1772

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties, 2 = Freeze dried, 3 = Oven dried, and 4 = ensiled

Concerning to maize grain DM degradability after the other incubation times (2, 4, 8 16, 24 and 48 h) it had the same trend like 0 h as it decreased with increasing plant maturity. Also mean of maize grain DM degradability of variety NX20026 (dent endosperm) after fresh (freeze dried) was significantly higher than that of variety NX1485 (flint endosperm). As well as mean of maize grain DM degradability after ensiled significantly was higher than that of freeze dried (fresh) and oven dried grain at 85 ℃.

3.2.3 Parameters of rumen dry matter degradability of maize grain

Parameters of rumen DM degradability of maize grain of the two varieties at the three harvest dates after the different conservation methods are presented in Table 29. Regarding to the rapidly soluble fraction of the maize grain (a) it significantly decreased with increasing plant maturity in the six treatments. Mean of maize grain rapidly soluble fraction of variety NX20026 after the three conservation methods (50.5, 24.2 and 85.2% for fresh (freeze drying), oven drying and ensiled respectively) was significantly higher than their corresponding mean for variety NX1485 (39.0, 20.6 and 79.8% respectively). Also mean of maize grain rapidly soluble fraction after ensiled (82.5%) was significantly much higher than that after fresh (22.4%) and oven dried grain at 85 ℃ (44.8%).

Concerning to the slowly degradable fraction (b) of maize grain it significantly increased with increasing plant maturity. Mean of maize grain slowly degradable fraction of variety NX1485 after fresh (61.0%) and ensiled (19.3%) was significantly higher than their corresponding mean for variety NX20026 (48.9, and 13.9% for fresh and ensiled respectively). There was a significant difference in the slowly degradable fraction between means of the three conservation methods. Those means were 77.6, 55.0 and 16.6% for oven dried at 85 ℃; freeze drie d (fresh) and ensied maize grain respectively. It is obvious that there was a relationship between the rapidly soluble fraction and the slowly degradable fraction, as the rapidly soluble fraction decreased the slowly degradable fraction increased and vice versa.

For non degradable fraction (A) it is obvious that maize grain was completely degradable after fresh (freeze dried) and oven dried grain at 85 ℃ but only little part left after ensiled grain. Mean of non degradable fraction after ensiled (0.90%) was higher than that after oven dried at 85 ℃ (0.00%) and freeze dried (0.28%) grain.

About the rate of degradation of maize grain (c) it decreased with increasing plant maturity. There was no significant difference in the rate of degradation of maize grain between the means of the two varieties after fresh (4.90 and 6.70%h^{-1} for NX1485 and NX20026 respectively) and after oven drying (3.5 and 3.8%h^{-1} for NX1485 and NX20026 respectively), but mean of NX20026 variety after ensiled (28.1%h^{-1}) was significantly higher than that of NX1485 (8.10%h^{-1}). Also mean of the rate of degradation of maize grain of the two varieties after ensiled (18.1%h^{-1}) was significantly higher than that after oven dried (3.65%h^{-1}) and freeze dried (5.80%h^{-1}).

Regarding to the lag time of maize grain (t_0) it increased with increasing plant maturity after fresh and oven dried grain but it decreased with increasing plant maturity after ensiled in which increased again at HD3 (5.06 h) for variety NX20026. There was no significant difference in the lag time of maize grain between means of the two varieties after fresh (0.12 and 0.21 h for NX1485 and NX20026 respectively) and after oven dried (4.75 and 5.93 h for NX1485 and NX20026 respectively), but mean of NX20026 variety after ensiled (4.49 h) was significantly higher than that of NX1485 (2.09 h). Mean of the two varieties after oven dried grain (5.34 h) was significantly higher than that of ensiled (3.29 h) and fresh grain (0.17 h).

Table 29. Parameters of rumen DM degradability (% ± SD) of maize grain of the two varieties at the three harvest dates after the different conservation methods

Parameters	Treatments	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
a (%)	**NX1485 FD[2]**	49.1^{Da} ± 0.60	39.4^{Db} ± 0.72	28.4^{Dc} ± 0.56	**39.0^{D}**	**44.8^{B}**	0.63	0.0001
	NX20026 FD[2]	60.3^{Ca} ± 0.48	48.8^{Cb} ± 0.54	42.5^{Cc} ± 0.37	**50.5^{C}**		0.46	0.0001
	NX1485 OD[3]	24.3^{Fa} ± 0.85	20.8^{Fb} ± 0.59	16.7^{Fc} ± 0.67	**20.6^{F}**	**22.4^{C}**	0.71	0.0001
	NX20026 OD[3]	27.3^{Ea} ± 0.61	24.1^{Eb} ± 0.41	21.3^{Ec} ± 0.50	**24.2^{E}**		0.51	0.0001
	NX1485 S[4]	85.8^{Ba} ± 0.21	78.7^{Bb} ± 0.36	74.9^{Bc} ± 0.21	**79.8^{B}**	**82.5^{A}**	0.27	0.0001
	NX20026 S[4]	86.7^{Aa} ± 0.65	84.5^{Ab} ± 1.34	84.3^{Ab} ± 0.77	**85.2^{A}**		0.96	0.001
b (%)	**NX1485 FD[2]**	50.8^{Cc} ± 0.79	60.6^{Cb} ± 0.72	71.6^{Ca} ± 0.56	**61.0^{B}**	**55.0^{B}**	0.69	0.0001
	NX20026 FD[2]	38.1^{Dc} ± 0.60	51.2^{Db} ± 0.54	57.5^{Da} ± 0.37	**48.9^{C}**		0.51	0.0001
	NX1485 OD[3]	75.7^{Ac} ± 0.85	79.2^{Ab} ± 0.59	83.3^{Aa} ± 0.67	**79.4^{A}**	**77.6^{A}**	0.71	0.0001
	NX20026 OD[3]	72.7^{BC} ± 0.61	75.9^{Bb} ± 0.41	78.7^{Ba} ± 0.50	**75.8^{A}**		0.51	0.0001
	NX1485 S[4]	13.3^{Ec} ± 1.00	20.6^{Eb} ± 1.71	24.1^{Ea} ± 1.15	**19.3^{D}**	**16.6^{C}**	1.32	0.0001
	NX20026 S[4]	12.4^{Eb} ± 1.30	14.8^{Fa} ± 1.73	14.6^{Fa} ± 1.53	**13.9^{E}**		1.52	0.025
A (%)	**NX1485 FD[2]**	0.10^{Ba} ± 0.24	0.00^{Aa} ± 0.00	0.00^{Ba} ± 0.00	**0.03^{B}**	**0.28^{B}**	0.14	0.3911
	NX20026 FD[2]	1.58^{Aa} ± 0.45	0.00^{Ab} ± 0.00	0.00^{Bb} ± 0.00	**0.53^{A}**		0.26	0.0001
	NX1485 OD[3]	0.00^{Ba} ± 0.00	0.00^{Aa} ± 0.00	0.00^{Ba} ± 0.00	**0.00^{B}**	**0.00^{B}**	0.00	
	NX20026 OD[3]	0.00^{Ba} ± 0.00	0.00^{Aa} ± 0.00	0.00^{Ba} ± 0.00	**0.00^{B}**		0.00	
	NX1485 S[4]	0.97^{Aa} ± 0.81	0.73^{Aa} ± 1.36	1.00^{Aa} ± 1.18	**0.90^{A}**	**0.90^{A}**	1.14	0.9053
	NX20026 S[4]	0.94^{Aa} ± 1.12	0.61^{Aa} ± 0.75	1.13^{Aa} ± 0.81	**0.89^{A}**		0.91	0.6142
c (%)	**NX1485 FD[2]**	5.83^{Aa} ± 0.00	5.00^{Bb} ± 0.00	4.00^{Bc} ± 0.00	**4.90^{B}**	**5.80^{B}**	0.004	0.0001
	NX20026 FD[2]	10.0^{Aa} ± 0.02	5.33^{Bb} ± 0.00	5.00^{Bb} ± 0.00	**6.70^{B}**		0.011	0.0001
	NX1485 OD[3]	3.83^{Aa} ± 0.00	3.33^{Ba} ± 0.00	3.50^{Ba} ± 0.00	**3.50^{B}**	**3.65^{B}**	0.004	0.2362
	NX20026 OD[3]	4.33^{Aa} ± 0.00	3.66^{Bb} ± 0.00	3.33^{Bb} ± 0.00	**3.80^{B}**		0.005	0.0134
	NX1485 S[4]	8.83^{Aa} ± 0.06	8.33^{ABa} ± 0.05	7.33^{Ba} ± 0.02	**8.10^{B}**	**18.10^{A}**	0.043	0.8307
	NX20026 S[4]	44.7^{Aa} ± 0.93	19.66^{Aa} ± 0.25	20.0^{Aa} ± 0.26	**28.1^{A}**		0.574	0.6945
t_0 (h)	**NX1485 FD[2]**	0.00^{Ba} ± 0.00	0.06^{Ca} ± 0.14	0.29^{Ca} ± 0.39	**0.12^{D}**	**0.17^{C}**	0.24	0.1112
	NX20026 FD[2]	0.09^{Bb} ± 0.14	0.06^{Cb} ± 0.15	0.49^{Ca} ± 0.38	**0.21^{D}**		0.25	0.0158
	NX1485 OD[3]	4.25^{Aa} ± 1.74	4.83^{Aa} ± 1.24	5.18^{Ba} ± 1.23	**4.75^{AB}**	**5.34^{A}**	1.43	0.5405
	NX20026 OD[3]	4.68^{Ab} ± 1.16	5.55^{Ab} ± 0.93	7.54^{Aa} ± 2.02	**5.93^{A}**		1.45	0.0113
	NX1485 S[4]	3.56^{Aa} ± 2.36	2.08^{BCab} ± 2.73	0.61^{Cb} ± 0.54	**2.09^{C}**	**3.29^{B}**	2.11	0.0842
	NX20026 S[4]	4.73^{Aa} ± 2.07	3.69^{ABb} ± 3.43	5.06^{Ba} ± 3.38	**4.49^{B}**		3.03	0.7191

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties, 2 = Freeze dried, 3 = Oven dried, and 4 = ensiled

3.2.4 Effective rumen dry matter degradability of maize grain

Effective rumen DM degradability of maize grain of the two varieties at the three harvest dates after the different conservation methods by passage rate of 6%h^{-1} is illustrated in Table 30. It is clear that there was a significant decreased in the effective DM degradability with increasing plant maturity for all treatments except NX20026 after ensiled treatment in which there was no significant difference in the effective DM degradability between the three harvest dates (92.1, 91.9 and 91.3% for HD1, HD2 and HD3 respectively). Also there was a significant difference between means of the six treatments. Variety NX20026 (dent endosperm) was significantly higher degradable than variety NX1485 (flint endosperm) after freeze dried (74.9 vs 65.8%) but not at oven dried at 85 ℃ (44.8 vs 42.7 %) and ensiled (91.8 vs 89.2%). This means that the difference in degradability between the two varieties (flint and dent endosperm) disappeared after oven dried at 85 ℃ and ensiled. Mean of ensiled maize grain was significantly higher in EDMD (90.5%) than fresh grain (70.4%) and oven dried grain at 85 ℃ (43.8%).

Table 30. The effective rumen DM degradability (% ± SD) of maize grain of the two varieties at the three harvest dates after the three conservation methods by passage rate of 6 %h^{-1}

Treatment	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety	MCM[1]	MSE HD	P-Value
NX1485 (flint) FD[2]	74.0^{Ca} ± 1.19	66.5^{Db} ± 0.85	56.9^{Dc} ± 1.13	**65.8^{C}**	**70.4^{B}**	1.06	0.0001
NX20026 (dent) FD[2]	84.0^{Ba} ± 1.40	72.8^{Cb} ± 1.00	67.8^{Cc} ± 1.04	**74.9^{B}**		1.16	0.0001
NX1485 (flint) OD[3]	47.1^{Ea} ± 0.75	42.1^{Fb} ± 0.92	38.9^{Ec} ± 0.57	**42.7^{D}**	**43.8^{C}**	0.76	0.0001
NX20026 (dent) OD[3]	50.3^{Da} ± 0.53	44.3^{Eb} ± 0.70	39.9^{Ec} ± 1.18	**44.8^{D}**		0.85	0.0001
NX1485 (flint) S[4]	91.7^{Aa} ± 0.71	88.4^{Bb} ± 1.12	87.3^{Bb} ± 1.07	**89.2^{A}**	**90.5^{A}**	0.98	0.0001
NX20026 (dent) S[4]	92.1^{Aa} ± 1.27	91.9^{Aa} ± 1.19	91.3^{Aa} ± 2.36	**91.8^{A}**		1.69	0.6793

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different
1 = Mean of conservation methods of the two varieties, 2 = Freeze dried, 3 = Oven dried, and 4 = ensiled

However dry matter degradability of fresh (freeze dried) grain and oven dried grain (at 85 °C) decreased significantly with increasing plant maturity dry matter degradability of ensiled maize grain did not affected greatly with increasing maturity. Whereas ensiled improved maize grain dry matter degradability greatly, oven dried at 85 °C impaired it. Maize variety (endosperm structu re) affects the dry matter degradability of maize grain after fresh conservation and maize grain of variety NX20026 (dent type) was significantly higher in degradability than that of variety 1485 (flint type). Ensiling and oven drying at 85 °C can reduce or eliminate the difference in dry matter degradability between the two maize varieties.

3.3 Rumen degradability of maize stover, maize cob, maize whole plant and maize whole plant silage (Exp 6)

The aim of this experiment was to study the effect of maturity stage and maize variety on the in situ DM degradability of maize stover, maize cob, maize whole plant and maize whole plant silage. Two maize varieties cultivated in year 2007 and harvested at three harvest dates were used in this experiment. In this experiment the different materials (maize stover, cob, whole plant and whole plant silage) were incubated together in the same time in the rumen of six fisulated dairy cows. But it was difficult to illustrate the data of the chemical composition and dry matter degradability of the different materials (maize stover, cob, whole plant and whole plant silage) in one table therefore, each component will be presented separately and the EDMD of the different components will be summarized together in one table at the end of the experiment.

3.3.1 Dry matter and chemical composition

3.3.1.1 Dry matter and chemical composition of maize stover

Dry matter and chemical composition of maize stover of the two varieties at the three harvest dates are presented in Table 31. Concerning to maize stover DM it is obvious that it increased with increasing plant maturity and this was clear in the two varieties. Mean of the harvest date increased from 21.2% at HD1 to 33.0% at HD3 with an increase of 11.8%. Mean of maize stover DM for variety NK Magitop (27.4%) was higher than that for variety NX1485 (23.6%). Variety NK Magitop showed the highest maize stover DM at HD3 (35.3%).

Regarding to stover crude ash content it increased with increasing plant maturity and means of the three harvest dates were 3.83%, 4.72% and 4.62% for HD1, HD2 and HD3 respectively. Mean of stover crude ash for variety NX1485 (4.89%) was higher than that for variety NK Magitop (3.89%).

For stover CP content it decreased with increasing plant maturity. Means of the three harvest dates were 6.25%, 5.59% and 5.05% for HD1, HD2 and HD3 respectively. There was no difference in stover CP content between means of the two varieties (5.62 and 5.64% for NK Magitop and NX1485 respectively).

Table 31. Dry matter and chemical composition of maize stover of the two varieties at the three harvest dates

Nutrients	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
DM (%)	**NK Magitop**	23.1	23.9	35.3	**27.4**
	NX1485	19.3	21.0	30.6	**23.6**
	Mean HD	**21.2**	**22.4**	**33.0**	
Crude ash (%)	**NK Magitop**	2.90	4.58	4.20	**3.89**
	NX1485	4.76	4.86	5.04	**4.89**
	Mean HD	**3.83**	**4.72**	**4.62**	
CP (%)	**NK Magitop**	6.23	5.56	5.07	**5.62**
	NX1485	6.27	5.62	5.02	**5.64**
	Mean HD	**6.25**	**5.59**	**5.05**	
EE (%)	**NK Magitop**	0.87	1.24	0.97	**1.03**
	NX1485	1.00	1.13	0.97	**1.03**
	Mean HD	**0.94**	**1.19**	**0.97**	
CF (%)	**NK Magitop**	30.7	32.3	33.4	**32.1**
	NX1485	31.2	30.8	35.5	**32.5**
	Mean HD	**31.0**	**31.6**	**34.5**	
NDF (%)	**NK Magitop**	59.0	60.1	63.4	**60.8**
	NX1485	56.2	59.2	67.1	**60.8**
	Mean HD	**57.6**^{b}	**59.7**^{ab}	**65.3**^{a}	
ADF (%)	**NK Magitop**	33.4	34.3	37.2	**35.0**
	NX1485	33.2	33.7	43.2	**36.7**
	Mean HD	**33.3**	**34.0**	**40.2**	
ADL (%)	**NK Magitop**	3.20	3.50	3.60	**3.40**
	NX1485	3.30	5.40	7.40	**5.40**
	Mean HD	**3.30**	**4.50**	**5.50**	

Means along the same row bearing different small letters are significantly different

Regarding to stover EE content it was very low (about 1.0%). Means of the harvest date were 0.94, 1.19 and 0.97% for HD1, HD2 and HD3 respectively. There was no difference in stover EE content between the two varieties (1.03% for both varieties).

Belong to maize stover CF content it increased with increasing plant maturity until it reach the highest value at HD3 and this was clear in the two varieties. Mean of the harvest date increased from 31.0% at HD1 to 34.5% at HD3 with an increase of 3.5%. There was no significant difference between means of the two varieties (32.1 and 32.5% for NK Magitop and NX1485 respectively).

Belong to maize stover NDF content it increased with increasing plant maturity. Mean of the harvest date significantly increased from 57.6% at HD1 to 65.3% at HD3 with an increase of 7.7%. There was no significant difference between means of the two varieties (60.8% both variety).

Regarding to maize stover ADF content it increased with increasing plant maturity. Mean of the harvest date increased not significantly from 33.3% at HD1 to 40.2% at HD3 with an increase of 6.90%. There was no significant difference between means of the two varieties (35.0 and 36.7% for NK Magitop and NX1485 respectively).

Concerning to maize stover ADL content it increased with increasing plant maturity. Mean of the harvest date increased not significantly from 3.30% at HD1 to 5.50% at HD3. There was no significant difference between means of the two varieties (3.40 and 5.40% for NK Magitop and NX1485 respectively).

3.3.1.2 Dry matter and chemical composition of maize cob

Dry matter and chemical composition of maize cob of the two varieties at the three harvest dates are presented in Table 32 and 33. For maize cob DM it is obvious that it increased with increasing plant maturity. Means of the harvest dates were 53.4%, 58.8% and 65.9% for HD1, HD2 and HD3 respectively, with an increase of 12.5% from HD1 to HD3. There was no significant difference between means of the two varieties (58.7 and 60.0% for NK Magitop and NX1485 respectively). Maize cob DM for variety NX1485 at HD1 (55.0%) was higher than that for variety NK Magitop (51.7%).

Regarding to maize cob starch content it increased with increasing plant maturity. Means of the harvest dates were 54.7%, 59.9% and 65.5% for HD1, HD2 and HD3 respectively, with an increase of 10.8% from HD1 to HD3. There was no significant difference between means of the two varieties (61.3 and 60.6% for NK Magitop and NX1485 respectively). Maize cob starch for variety NK Magitop at HD2 (63.4%) was higher than that for variety NX1485 (59.6%).

For maize cob crude ash content the overall mean of the two varieties was 1.46%. Means of the harvest dates were 1.55%, 1.42% and 1.42% for HD1, HD2 and HD3 respectively. There was no significant difference in cob crude ash content between means of the two varieties (1.51 and 1.41% for NK Magitop and NX1485 respectively).

Table 32. Dry matter and chemical composition of maize cob of the two varieties at the three harvest dates

Nutrients	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
DM (%)	NK Magitop	51.7	58.2	66.3	**58.7**
	NX1485	55.0	59.4	65.5	**60.0**
	Mean HD	**53.4**	**58.8**	**65.9**	
Starch (%)	NK Magitop	56.1	63.4	64.4	**61.3**
	NX1485	57.1	59.6	65.2	**60.6**
	Mean HD	**54.7**	**59.9**	**65.5**	
Crude ash (%)	NK Magitop	1.70	1.43	1.39	**1.51**
	NX1485	1.39	1.41	1.44	**1.41**
	Mean HD	**1.55**	**1.42**	**1.42**	
CP (%)	NK Magitop	8.59	8.02	9.28	**8.63**
	NX1485	8.83	8.88	8.71	**8.81**
	Mean HD	**8.71**	**8.45**	**9.0**	
EE (%)	NK Magitop	4.14	3.89	4.09	**4.04**
	NX1485	4.15	4.26	3.40	**3.94**
	Mean HD	**4.15**	**4.08**	**3.75**	
CF (%)	NK Magitop	8.51	8.84	8.38	**8.58**
	NX1485	11.2	8.58	9.00	**9.6**
	Mean HD	**9.87**	**8.71**	**8.69**	
NDF (%)	NK Magitop	23.2	19.5	23.0	**21.9**
	NX1485	30.1	25.5	23.6	**26.4**
	Mean HD	**26.7**	**22.5**	**23.3**	
ADF (%)	NK Magitop	11.9	9.00	11.1	**10.7**
	NX1485	13.2	10.2	9.20	**10.9**
	Mean HD	**12.6**	**9.6**	**10.2**	
ADL (%)	NK Magitop	1.50	2.40	2.70	**2.20**
	NX1485	3.00	3.10	3.20	**3.10**
	Mean HD	**2.30**	**2.80**	**3.00**	

Regarding to maize cob CP content the overall mean of the two varieties was 8.72%. It is clear that the values at the three harvest date for the two varieties were around this mean (8.71, 8.45 and 9.00% for HD1, HD2 and HD3 respectively). There was no significant difference between means of the two varieties (8.63 and 8.81% for NK Magitop and NX1485 respectively).

Belong to maize cob EE content the overall mean of the two varieties was 4.00%. Means of the harvest dates were 4.15%, 4.08% and 3.75% for HD1, HD2 and HD3 respectively. There was no significant difference between mean of the two varieties (4.04 and 3.94% for NK Magitop and NX1485 respectively). It seemed to be constant for variety NK Magitop at the three harvest dates (4.14, 3.89 and 4.09% for HD1, HD2 and HD3 respectively) but for variety NX1485 it suddenly decreased at HD3 (4.15, 4.26 and 3.40% for HD1, HD2 and HD3 respectively).

Concerning to maize cob CF content, the overall mean of the two varieties was 9.09%. Means of the harvest dates were 9.87, 8.71 and 8.69% for HD1, HD2 and HD3 respectively. Mean cob CF for variety NX1485 (9.60%) was higher than that for variety NK Magitop (8.58%). Maize cob CF seemed to be constant for variety NK Magitop at the three harvest dates (8.51, 8.84 and 8.83% for HD1, HD2 and HD3 respectively) but for variety NX1485 HD1 showed the highest value 11.2%.

Belong to maize cob NDF content it decreased with increasing plant maturity. Mean of the harvest date decreased not significantly from 26.7% at HD1 to 23.3% at HD3. There was no significant difference in maize cob NDF content between means of the two varieties (21.9 and 26.4% for NK Magitop and NX1485 respectively).

Regarding to maize cob ADF content it decreased with increasing plant maturity. Mean of the harvest date decreased not significantly from 12.6% at HD1 to 10.2% at HD3. There was no significant difference in maize cob between means of the two varieties (10.7 and 10.9% for NK Magitop and NX1485 respectively).

Concerning to maize cob ADL content it was aroud 2.70%. There was no significant difference in maize cob ADL content between means of the two varieties (2.20 and 3.10% for NK Magitop and NX1485 respectively).

3.3.1.3 Dry matter and chemical composition of maize whole plant

Dry matter and chemical composition of maize whole plant of the two varieties at the three harvest dates are presented in Table 33. For maize whole plant DM it is obvious that it increased with increasing plant maturity and the mean of the harvest date increased from 29.1% at HD1 to 44.6% at HD3 with an increase of 15.5%. Mean of DM of variety NK Magitop (36.7%) was higher than that for variety NX1485 (34.3%).

Belong to starch of maize whole plant it increased with increasing plant maturity and the mean of the harvest date increased from 27.2% at HD1 to 35.2% at HD3 with an increase of 8.00%. Mean of maize whole plant starch content for variety NX1485 (32.3%) was higher than that for variety NK Magitop (30.2%).

Regarding to maize whole plant crude ash content it decreased with increasing plant maturity and the mean of the harvest date decreased from 3.83% at HD1 to 2.73% at HD3. There was no difference in crude ash content of maize whole plant between the two varieties (2.96 and 3.38% for NK Magitop and NX1485 respectively). Variety NX1485 showed the highest crude ash at HD1 (4.55%).

Belong to maize whole plant CP content the three harvest dates were nearly equal in values. Means of CP of maize whole plant were 7.43, 7.26 and 7.18% for HD1, HD2 and HD3 respectively. Mean of maize whole plant CP content for variety NK Magitop (7.08%) was significantly lower than that of NX1485 (7.50%).

Concerning to maize whole plant EE content the overall mean was 2.67%. Means of maize whole plant EE content were 2.70, 2.66 and 2.66% for HD1, HD2 and HD3 respectively. There was no significant difference between the means of the two varieties (2.57 and 2.77% for NK Magitop and NX1485 respectively).

Maize whole plant CF content was 19.2%. Means of maize whole plant CF content were 20.3, 18.5 and 18.8% for HD1, HD2 and HD3 respectively. There was no significant difference in maize whole plant CF content between means of the two varieties (19.2 and 19.2% for NK Magitop and NX1485 respectively).

Table 33. Dry matter and chemical composition of fresh maize whole plant of the two varieties at the three harvest dates

Nutrients	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
DM (%)	**NK Magitop**	30.1	34.1	46.0	**36.7**
	NX1485	28.0	31.8	43.1	**34.3**
	Mean HD	**29.1**	**33.0**	**44.6**	
Starch (%)	**NK Magitop**	26.9	29.6	34.2	**30.2**
	NX1485	27.4	33.4	36.1	**32.3**
	Mean HD	**27.2**	**31.5**	**35.2**	
Crude ash (%)	**NK Magitop**	3.10	3.00	2.77	**2.96**
	NX1485	4.55	2.91	2.69	**3.38**
	Mean HD	**3.83**	**2.96**	**2.73**	
CP (%)	**NK Magitop**	7.12	7.03	7.10	**7.08^{B}**
	NX1485	7.74	7.51	7.26	**7.50^{A}**
	Mean HD	**7.43**	**7.26**	**7.18**	
EE (%)	**NK Magitop**	2.70	2.44	2.56	**2.57**
	NX1485	2.69	2.87	2.76	**2.77**
	Mean HD	**2.70**	**2.66**	**2.66**	
CF (%)	**NK Magitop**	19.9	18.5	19.1	**19.2**
	NX1485	20.7	18.5	18.5	**19.2**
	Mean HD	**20.3**	**18.5**	**18.8**	
NDF (%)	**NK Magitop**	44.1	46.0	45.4	**45.2**
	NX1485	44.4	44.6	42.3	**43.8**
	Mean HD	**44.3**	**45.3**	**43.9**	
ADF (%)	**NK Magitop**	22.8	21.8	22.8	**22.5**
	NX1485	21.1	21.5	22.1	**21.6**
	Mean HD	**22.0**	**21.7**	**22.5**	
ADL (%)	**NK Magitop**	2.80	3.60	1.90	**2.77**
	NX1485	1.80	3.10	3.10	**2.67**
	Mean HD	**2.30**	**3.35**	**2.50**	

Means along the same column bearing different capital letters are significantly different

Belong to maize whole plant NDF content it was around 44.0% at the three harvest dates. There was no significant difference in maize whole plant NDF content between means of the two varieties (45.2 and 43.8% for NK Magitop and NX1485 respectively).

Regarding to maize whole plant ADF content it was around 22.0% at the three harvest dates. There was no significant difference maize whole plant ADF content between means of the two varieties (22.5 and 21.6% for NK Magitop and NX1485 respectively).

There was no significant difference in maize whole plant ADL content between means of the two varieties (2.77 and 2.67% for NK Magitop and NX1485 respectively).

3.3.1.4 Dry matter and chemical composition of maize whole plant silage

Dry matter and chemical composition of maize whole plant silage of the two varieties at the three harvest dates are presented in Table 34. Dry matter of maize whole plant silage increased with increasing plant maturity. Mean of maize whole plant silage DM of the harvest date increased from 28.1% at HD1 to 44.5% at HD3 with an increase of 16.4%. Mean of dry matter of maize whole plant silage of variety NK Magitop (35.8%) was higher than that for variety NX1485 (33.7%).

Starch of maize whole plant silage increased with increasing plant maturity. Mean of the harvest date for starch of maize whole plant silage increased from 31.7% at HD1 to 40.4% at HD3 with an increase of 8.7%. Mean of starch of maize whole plant silage for the two varieties nearly had equal values (37.1 and 36.3% for NK Magitop and NX1485 respectively).

Regarding to maize whole plant silage crude ash content it decreased with increasing plant maturity. Means of crude ash of maize whole plant silage were 3.34, 3.13 and 3.27% for HD1, HD2 and HD3 respectively. There was no significant difference in maize whole plant silage crude ash content between means of the two varieties (3.06 and 3.42% for NK Magitop and NX1485 respectively).

Concerning to maize whole plant silage CP content the three harvest dates were nearly equal in values (7.83, 7.76 and 7.34% for HD1, HD2 and HD3 respectively). There was no difference in maize whole plant silage CP content between means of the two varieties (7.55 and 7.73% for NK Magitop and NX1485 respectively).

Table 34. Dry matter and chemical composition of maize whole plant silage of the two varieties at the three harvest dates

Nutrients	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
DM (%)	**NK Magitop**	29.2	32.3	45.8	**35.8**
	NX1485	26.9	31.0	43.1	**33.7**
	Mean HD	**28.1**	**31.7**	**44.5**	
Starch (%)	**NK Magitop**	31.5	38.7	41.2	**37.1**
	NX1485	31.9	37.5	39.5	**36.3**
	Mean HD	**31.7**	**38.1**	**40.4**	
Crude ash (%)	**NK Magitop**	3.28	3.14	2.78	**3.06**
	NX1485	3.40	3.11	3.75	**3.42**
	Mean HD	**3.34**	**3.13**	**3.27**	
CP (%)	**NK Magitop**	7.75	7.64	7.26	**7.55**
	NX1485	7.91	7.87	7.41	**7.73**
	Mean HD	**7.83**	**7.76**	**7.34**	
EE (%)	**NK Magitop**	3.08	3.2	3.25	**3.17**
	NX1485	3.62	3.57	3.23	**3.47**
	Mean HD	**3.35**	**3.39**	**3.24**	
CF (%)	**NK Magitop**	20.6	19.7	19.2	**19.8**
	NX1485	19.9	17.9	18.6	**18.8**
	Mean HD	**20.3**	**18.8**	**18.9**	
NDF (%)	**NK Magitop**	41.9	40.8	44.1	**42.3**
	NX1485	46.6	38.2	43.3	**42.7**
	Mean HD	**44.3**	**39.5**	**43.7**	
ADF (%)	**NK Magitop**	24.2	22.4	22.2	**22.9**
	NX1485	23.4	20.2	23.0	**22.2**
	Mean HD	**23.8**	**21.3**	**22.6**	
ADL (%)	**NK Magitop**	2.40	2.10	2.40	**2.30**
	NX1485	2.10	2.70	2.40	**2.40**
	Mean HD	**2.25**	**2.40**	**2.40**	

The overall mean of maize whole plant silage EE content was 3.32% and the means of the harvest dates were 3.35, 3.39 and 3.24% for HD1, HD2 and HD3 respectively. There was no significant difference in maize whole plant silage EE content between means of the two varieties (3.17 and 3.47% for NK Magitop and NX1485 respectively).

The overall mean of CF of maize whole plant silage was 19.2% and the means of the harvest dates were 20.3, 18.8 and 18.9% for HD1, HD2 and HD3 respectively. There was no difference in maize whole plant silage CF content between the means of the two varieties (19.8 and 18.8% for NK Magitop and NX1485 respectively).

Mean of maize whole plant silage NDF content at HD2 (39.5%) was lowered than HD1 (44.3%) and HD3 (43.7%). There was no significant difference in maize whole plant silage NDF content between means of the two varieties (42.3 and 42.7% for NK Magitop and NX1485 respectively).

The overall mean of maize whole plant silage ADF content was 22.5% and the means of the harvest dates were 23.8, 21.3 and 22.6% for HD1, HD2 and HD3 respectively. There was no significant difference in maize whole plant silage NDF content between means of the two varieties (22.9 and 22.2% for NK Magitop and NX1485 respectively).

The overall mean of maize whole plant silage ADL content was 2.35% and the means of the harvest dates were 2.25, 2.40 and 2.40% for HD1, HD2 and HD3 respectively.. There was no significant difference in maize whole plant silage ADL content between means of the two varieties (2.30 and 2.401% for NK Magitop and NX1485 respectively).

3.3.2 In situ rumen dry matter degradability

3.3.2.1 In situ rumen dry matter degradability of maize stover

Dry matter degradability of maize stover of the two varieties at the three harvest dates after the different incubation times are presented in Table 35. About the DM degradation course it is obvious that DM degradability increased with increasing the incubation time. Dry matter washing losses (0 h) of maize stover decreased with increasing plant maturity and this was clear in the two varieties. Mean of the harvest date decreased significantly from 33.0% at HD1 to 24.3% at HD3 with a decrease of 8.7%. The difference in stover DM degradability between mean of HD2 (29.8%) and mean of HD3 (24.3%) was higher than that between mean of HD2 and HD1 (33.0%). There was no significant difference in DM washing losses between the means of the two varieties (29.4 and 28.6% for NK Magitop and NX1485 respectively).

Table 35. In situ dry matter degradability (% ± SD) of maize stover, of the two varieties at the three harvest dates after the various incubation times

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
0 h	**NK Magitop**	32.3^{a} ± 0.52	30.5^{a} ± 2.53	25.5^{b} ± 0.61	**29.4**	1.53	0.0039
	NX1485	33.7^{a} ± 0.79	29.0^{b} ± 0.94	23.2^{c} ± 1.86	**28.6**	1.29	0.0002
	Mean HD	**33.0^{a}**	**29.8^{b}**	**24.3^{c}**			
	MSE variety	0.67	1.90	1.38			
	P-Value	0.0662	0.3709	0.1083			
2 h	**NK Magitop**	30.7^{Aa} ± 0.91	28.7^{Ab} ± 0.95	23.2^{Ac} ± 1.03	**27.5^{A}**	0.76	0.0001
	NX1485	32.0^{Aa} ± 1.06	28.2^{Ab} ± 0.98	21.9^{Bc} ± 1.15	**27.4^{A}**	0.81	0.0001
	Mean HD	**31.4^{a}**	**28.4^{b}**	**22.5^{c}**			
	MSE variety	0.87	0.63	0.96			
	P-Value	0.0521	0.2787	0.0388			
4 h	**NK Magitop**	31.5^{Aa} ± 2.45	30.4^{Aa} ± 1.98	24.3^{Ab} ± 2.40	**28.7^{A}**	2.12	0.0001
	NX1485	31.9^{Aa} ± 1.48	27.7^{Bb} ± 2.28	22.8^{Ac} ± 1.74	**27.5^{A}**	1.70	0.0001
	Mean HD	**31.7^{a}**	**29.0^{b}**	**23.5^{c}**			
	MSE variety	1.97	1.80	1.99			
	P-Value	0.0521	0.2787	0.0388			
8 h	**NK Magitop**	39.5^{Ba} ± 3.40	37.2^{Aa} ± 3.14	31.5^{Ab} ± 1.73	**36.1^{A}**	2.69	0.0003
	NX1485	44.3^{Aa} ± 2.82	39.1^{Ab} ± 3.07	32.0^{Ac} ± 1.32	**38.5^{A}**	2.73	0.0001
	Mean HD	**41.8^{a}**	**38.2^{b}**	**31.7^{c}**			
	MSE variety	3.01	3.00	1.09			
	P-Value	0.0202	0.2993	0.45			
16 h	**NK Magitop**	50.6^{a} ± 4.67	46.6^{a} ± 4.08	39.8^{b} ± 2.73	**45.7**	3.81	0.0007
	NX1485	48.1^{a} ± 3.85	47.4^{a} ± 4.39	39.0^{b} ± 2.49	**44.8**	3.44	0.0006
	Mean HD	**49.3^{a}**	**47.0^{a}**	**39.4^{b}**			
	MSE variety	4.40	3.83	2.35			
	P-Value	0.3355	0.7264	0.5872			
24 h	**NK Magitop**	56.7^{a} ± 3.13	54.1^{a} ± 3.54	48.5^{b} ± 5.34	**53.1**	4.15	0.0137
	NX1485	58.8^{a} ± 3.04	56.2^{a} ± 3.05	51.3^{b} ± 2.09	**55.4**	2.61	0.0006
	Mean HD	**57.6^{a}**	**55.1^{a}**	**49.9^{b}**			
	MSE variety	2.80	3.25	4.19			
	P-Value	0.1626	0.3028	0.2629			
48 h	**NK Magitop**	67.8^{a} ± 2.03	65.3^{ab} ± 1.77	63.4^{b} ± 3.59	**64.4**	2.37	0.0185
	NX1485	68.1^{a} ± 1.99	65.4^{a} ± 4.29	61.2^{b} ± 3.27	**64.9**	2.45	0.0008
	Mean HD	**68.0^{a}**	**65.4^{b}**	**62.3^{c}**			
	MSE variety	1.68	1.99	3.26			
	P-Value	0.7362	0.9639	0.2881			

Continue Table 35

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
72 h	**NK Magitop**	72.7^{a} ± 1.28	70.1^{b} ± 2.24	68.4^{b} ± 2.80	**70.4**	1.98	0.0061
	NX1485	71.7^{a} ± 1.86	71.5^{a} ± 1.57	68.0^{b} ± 2.91	**70.4**	2.11	0.0128
	Mean HD	**72.2^{a}**	**70.8^{a}**	**68.2^{b}**			
	MSE variety	1.53	1.58	2.78			
	P-Value	0.2741	0.1476	0.8205			
96 h	**NK Magitop**	74.8^{a} ± 2.09	72.9^{ab} ± 2.36	69.9^{b} ± 2.99	**72.5**	2.56	0.0196
	NX1485	74.4^{a} ± 1.37	72.6^{ab} ± 2.11	70.8^{b} ± 2.49	**72.6**	2.03	0.0238
	Mean HD	**74.5^{a}**	**72.8^{a}**	**70.3^{b}**			
	MSE variety	1.70	2.33	2.78			
	P-Value	0.867	0.8465	0.5973			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

For maize stover DM degradability of the other incubation times (2, 4, 8, 16, 24, 48, 72 and 96 h) it had the same direction like 0 h, as it decreased significantly with increasing plant maturity. Also there was no significant difference in maize stover DM degradability between means of the two varieties.

3.3.2.2 In situ rumen dry matter degradability of maize cob

Table 36 shows DM degradability of maize cob of the two varieties at the three harvest dates after the different incubation times. About the DM degradation course it is clear that it increased with increasing incubation time. Dry matter washing losses (0 h) of maize cob decreased significantly with increasing plant maturity and this was clear in the two varieties. Mean of harvest date decreased significantly from 29.7% at HD1 to 15.1% at HD3 respectively with a decrease of 14.6%. The difference in maize cob DM washing losses between mean of HD2 (25.5%) and HD3 (15.1%) was higher than that between mean of HD2 and HD1 (29.7%). There was no significant difference in maize cob DM washing losses between the means of the two varieties (23.5 and 23.4% for NK Magitop and NX1485 respectively).

Concerning to maize cob dry matter degradability after 2, 4, 8, 16 and 24 h of incubation it had the same trend like 0 h, as it decreased with increasing plant maturity. Mean of cob DM degradability at HD1 was significantly higher than that at HD3. There was no significant difference in maize cob DM degradability between the means of the two varieties.

Table 36. In situ dry matter degradability (% ± SD) of maize cob of the two varieties at the three harvest dates after the various incubation times

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
0 h	**NK Magitop**	$28.7^{Aa} \pm 1.47$	$27.2^{Aa} \pm 0.41$	$14.6^{Bb} \pm 0.33$	**23.5^{A}**	0.90	0.0001
	NX1485	$30.8^{Aa} \pm 1.34$	$23.7^{Bb} \pm 0.30$	$15.7^{Ac} \pm 0.30$	**23.4^{A}**	0.81	0.0001
	Mean HD	**29.7^{a}**	**25.5^{b}**	**15.1^{c}**			
	MSE variety	1.40	0.37	0.32			
	P-Value	0.1403	0.0003	0.0145			
2h	**NK Magitop**	$38.7^{a} \pm 1.99$	$34.9^{b} \pm 1.74$	$21.9^{c} \pm 1.40$	**31.8**	1.51	0.0001
	NX1485	$39.9^{a} \pm 2.29$	$32.8^{b} \pm 1.95$	$21.4^{c} \pm 0.80$	**31.4**	1.71	0.0001
	Mean HD	**39.3^{a}**	**33.9^{b}**	**21.6^{c}**			
	MSE variety	1.99	1.79	0.81			
	P-Value	0.3325	0.0663	0.3156			
4 h	**NK Magitop**	$42.6^{a} \pm 2.99$	$34.1^{b} \pm 2.69$	$24.1^{c} \pm 2.37$	**33.6**	2.48	0.0001
	NX1485	$40.2^{a} \pm 3.43$	$34.7^{b} \pm 1.88$	$22.3^{c} \pm 2.09$	**32.4**	1.89	0.0001
	Mean HD	**41.4^{a}**	**34.4^{b}**	**23.2^{c}**			
	MSE variety	2.62	1.83	2.10			
	P-Value	0.1349	0.5922	0.1733			
8 h	**NK Magitop**	$50.3^{a} \pm 5.58$	$48.8^{a} \pm 3.53$	$32.6^{b} \pm 2.90$	**43.9**	4.04	0.0001
	NX1485	$51.2^{a} \pm 4.26$	$44.6^{b} \pm 4.30$	$31.0^{c} \pm 3.41$	**42.3**	3.67	0.0001
	Mean HD	**50.8^{a}**	**46.7^{b}**	**31.8^{c}**			
	MSE variety	5.04	3.25	2.96			
	P-Value	0.7644	0.0517	0.3686			
16 h	**NK Magitop**	$61.6^{a} \pm 8.16$	$55.6^{a} \pm 10.4$	$43.2^{b} \pm 8.12$	**53.5**	8.98	0.0064
	NX1485	$58.3^{a} \pm 8.56$	$52.4^{ab} \pm 7.73$	$43.5^{b} \pm 7.48$	**51.4**	7.89	0.0182
	Mean HD	**59.9^{a}**	**54.0^{a}**	**43.4^{b}**			
	MSE variety	8.57	9.15	6.84			
	P-Value	0.5104	0.5567	0.9331			
24 h	**NK Magitop**	$73.8^{a} \pm 8.28$	$73.0^{a} \pm 8.80$	$69.0^{a} \pm 7.98$	**71.9**	7.83	0.5319
	NX1485	$73.1^{a} \pm 3.87$	$69.4^{a} \pm 7.37$	$62.0^{b} \pm 6.95$	**68.2**	5.88	0.016
	Mean HD	**73.5^{a}**	**71.2^{ab}**	**65.5^{b}**			
	MSE variety	5.08	7.73	7.63			
	P-Value	0.8214	0.4321	0.1466			
48 h	**NK Magitop**	88.8 ± 4.20	88.6 ± 6.69	88.3 ± 1.82	**88.6**	4.63	0.9753
	NX1485	88.0 ± 2.47	88.5 ± 3.04	85.1 ± 3.89	**87.2**	2.8	0.107
	Mean HD	**88.4**	**88.6**	**86.7**			
	MSE variety	3.31	4.79	2.54			
	P-Value	0.6769	0.9822	0.0574			

Continue Table 36

<table>
<tr><th>Time</th><th>Variety</th><th>HD1 (03.09.07)</th><th>HD2 (17.09.07)</th><th>HD3 (15.10.07)</th><th>Mean variety</th><th>MSE HD</th><th>P-Value</th></tr>
<tr><td rowspan="5">72 h</td><td>NK Magitop</td><td>91.1^{ab} ± 1.40</td><td>92.4^a ± 1.06</td><td>91.4^b ± 0.69</td><td>91.6</td><td>0.96</td><td>0.0958</td></tr>
<tr><td>NX1485</td><td>91.1^a ± 0.74</td><td>91.4^a ± 1.31</td><td>90.6^a ± 1.19</td><td>91.0</td><td>0.89</td><td>0.3602</td></tr>
<tr><td>Mean HD</td><td>91.1^{ab}</td><td>91.9^a</td><td>91.0^b</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>MSE variety</td><td>0.97</td><td>0.89</td><td>0.92</td></tr>
<tr><td>P-Value</td><td>0.9224</td><td>0.0776</td><td>0.1635</td></tr>
<tr><td rowspan="5">96 h</td><td>NK Magitop</td><td>92.2^{ab} ± 0.61</td><td>93.4^a ± 2.16</td><td>91.8^b ± 0.93</td><td>92.5</td><td>1.03</td><td>0.0373</td></tr>
<tr><td>NX1485</td><td>91.6^a ± 0.54</td><td>92.1^a ± 0.63</td><td>92.0^a ± 0.42</td><td>91.9</td><td>0.89</td><td>0.3602</td></tr>
<tr><td>Mean HD</td><td>91.9^{ab}</td><td>92.8^a</td><td>91.9^b</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>MSE variety</td><td>4.77</td><td>1.14</td><td>0.61</td></tr>
<tr><td>P-Value</td><td>0.1061</td><td>0.0757</td><td>0.4582</td></tr>
</table>

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Regarding to maize cob DM degradability after 48, 72 and 96 h of incubation, it was nearly equal in values at the three harvest dates and there was no significant difference between means of the two varieties.

3.3.2.3 In situ rumen dry matter degradability of maize whole plant

Dry matter degradability of maize whole plant of the two varieties at the three harvest dates after the different incubation times are presented in Table 37. Maize whole plant dry matter degradability increased with increasing the incubation time. Dry matter washing losses (0 h) decreased significantly with increasing plant maturity and the mean of the harvest date significantly decreased from 40.2% at HD1 to 27.8% at HD3. No significant difference in maize whole plant dry matter washing losses between means of the two varieties was noticed (35.8 and 33.9% for NK Magitop and NX1485 respectively).

Concerning to maize whole plant DM degradability after the other incubation times (2, 4, 8, 16 and 24, 48, 72 h) it had the same direction like 0h, as it decreased significantly with increasing plant maturity. Also there was no significant difference between means of the two varieties. At 96 h of incubation there was no significant difference in maize whole plant DM degradability between means of the harvest dates (83.6, 84.0 and 83.3% for HD1, HD2 and HD3 respectively) and no significant difference between means of the two varieties (83.8 and 83.5% for NK Magitop and NX1485 respectively).

Table 37. In situ dry matter degradability (% ± SD) of maize whole plant of the two varieties at the three harvest dates after the various incubation times

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
0 h	**NK Magitop**	41.8^{Aa} ± 0.62	38.2^{Ab} ± 0.96	27.4^{Ac} ± 1.08	**35.8^{A}**	0.91	0.0001
	NX1485	38.6^{Ba} ± 0.34	35.0^{Bb} ± 1.24	28.2^{Ac} ± 0.58	**33.9^{A}**	0.82	0.0001
	Mean HD	**40.2^{a}**	**36.6^{b}**	**27.8^{c}**			
	MSE variety	0.50	1.11	0.87			
	P-Value	0.0014	0.0258	0.3515			
2 h	**NK Magitop**	40.5^{Aa} ± 1.26	37.4^{Ab} ± 0.95	29.8^{Ac} ± 2.05	**35.9^{A}**	1.27	0.0001
	NX1485	40.1^{Aa} ± 1.87	34.9^{Bb} ± 1.10	29.1^{Ac} ± 1.19	**34.7^{A}**	1.21	0.0001
	Mean HD	**40.3^{a}**	**36.2^{b}**	**29.4^{c}**			
	MSE variety	1.48	0.65	1.42			
	P-Value	0.6275	0.0001	0.3944			
4 h	**NK Magitop**	40.1^{Aa} ± 1.60	39.4^{Aa} ± 1.62	28.8^{Ab} ± 1.52	**36.1^{A}**	1.34	0.0001
	NX1485	40.3^{Aa} ± 2.24	35.0^{Bb} ± 2.46	29.2^{Ac} ± 1.50	**34.8^{A}**	1.9	0.0001
	Mean HD	**40.2^{a}**	**37.2^{b}**	**30.0^{c}**			
	MSE variety	1.65	1.83	1.43			
	P-Value	0.6275	0.0001	0.3944			
8 h	**NK Magitop**	49.5^{Aa} ± 4.26	47.3^{Aa} ± 4.24	36.4^{Ab} ± 2.93	**44.4^{A}**	3.82	0.0001
	NX1485	48.5^{Aa} ± 4.68	42.8^{Bb} ± 3.02	35.4^{Ac} ± 4.69	**42.2^{A}**	4.01	0.0002
	Mean HD	**49.0^{a}**	**45.1^{b}**	**35.9^{c}**			
	MSE variety	4.39	3.43	3.86			
	P-Value	0.6275	0.0001	0.3944			
16 h	**NK Magitop**	54.4^{a} ± 5.60	54.9^{a} ± 4.18	47.9^{b} ± 4.53	**52.4**	4.77	0.0382
	NX1485	59.3^{a} ± 4.32	56.2^{a} ± 4.27	47.6^{b} ± 3.51	**54.4**	3.86	0.0003
	Mean HD	**56.9^{a}**	**55.6^{a}**	**47.7^{b}**			
	MSE variety	5.02	3.96	3.95			
	P-Value	0.1227	0.5767	0.8986			
24 h	**NK Magitop**	65.8^{a} ± 5.22	64.8^{a} ± 4.68	58.1^{b} ± 5.37	**62.9**	4.71	0.0243
	NX1485	68.2^{a} ± 3.95	63.7^{a} ± 4.45	54.7^{b} ± 6.40	**62.2**	4.8	0.0007
	Mean HD	**67.0^{a}**	**64.3^{a}**	**56.4^{b}**			
	MSE variety	4.58	4.35	5.27			
	P-Value	0.3822	0.6586	0.2913			
48 h	**NK Magitop**	77.5^{ab} ± 3.07	79.2^{a} ± 2.15	75.9^{b} ± 2.88	**77.5**	2.39	0.0907
	NX1485	79.0^{a} ± 1.78	79.0^{a} ± 1.90	77.1^{b} ± 1.52	**78.4**	1.39	0.056
	Mean HD	**79.1^{a}**	**78.2^{a}**	**76.5^{b}**			
	MSE variety	2.21	1.45	2.13			
	P-Value	0.268	0.7736	0.35			

Continue Table 37

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
72 h	**NK Magitop**	81.5[a] ± 1.72	82.0[a] ± 2.41	79.9[a] ± 2.90	**81.1**	2.27	0.2847
	NX1485	82.3[a] ± 1.63	82.3[a] ± 1.98	80.5[a] ± 2.18	**81.7**	1.92	0.2083
	Mean HD	**81.9[a]**	**82.2[a]**	**80.2[b]**			
	MSE variety	1.63	1.85	2.67			
	P-Value	0.413	0.8132	0.7204			
96 h	**NK Magitop**	84.0 ± 1.34	84.4 ± 0.83	83.0 ± 1.41	**83.8**	1.16	0.1302
	NX1485	83.2 ± 2.46	83.5 ± 2.20	83.7 ± 1.37	**83.5**	2.04	0.9216
	Mean HD	**83.6**	**84.0[a]**	**83.3[a]**			
	MSE variety	1.96	1.60	1.36			
	P-Value	0.4847	0.3698	0.4157			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.3.2.4 In situ rumen dry matter degradability of maize whole plant silage

Dry matter degradability of maize whole plant silage of the two varieties at the three harvest dates after the various incubation times are illustrated in Table 38. Maize whole plant silage DM degradability increased with increasing the incubation time. Maize whole plant silage DM washing losses (0 h) increased with increasing plant maturity and mean of the harvest date significantly increased from 53.2% at HD1 to 56.2% at HD3. Mean of maize whole plant silage DM washing losses of variety NX1485 (56.5%) was significantly higher than that of variety NK Magitop (53.7%).

Regarding to maize whole plant silage DM degradability after 2 h and 4 h of incubation it had the same trend like 0 h but after 2 h of incubation mean of NK Magitop (51.4%) was significantly lower than that of NX1485 (53.3%).

Concerning to maize whole plant silage DM degradability after 8 and 72 h of incubation HD2 was significantly higher than HD1 (55.3 and 58.1% for HD1 and HD2 respectively after 8 h and 81.8 and 83.3% for HD1 and HD2 respectively after 72 h). There was no significant difference in maize whole plant silage DM degradability between means of the three harvest dates after 16, 24, 48 and 96 h of incubation.

Table 38. In situ dry matter degradability (% ± SD) of maize whole plant silage of the two varieties at the three harvest dates after the various incubation times

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
0 h	**NK Magitop**	51.7^{Bb} ± 0.55	54.1^{Ba} ± 0.80	55.3^{Aa} ± 0.77	**53.7^{B}**	0.71	0.0025
	NX1485	54.7^{Ab} ± 0.96	57.7^{Aa} ± 0.64	57.2^{Aa} ± 1.31	**56.5^{A}**	1.01	0.0229
	Mean HD	**53.2^{b}**	**55.9^{a}**	**56.2^{a}**			
	MSE variety	0.78	0.73	1.08			
	P-Value	0.0097	0.0036	0.0919			
2 h	**NK Magitop**	49.7^{Bb} ± 1.42	50.9^{Bb} ± 1.90	53.5^{Aa} ± 1.36	**51.4^{B}**	1.25	0.0003
	NX1485	51.4^{Ab} ± 1.06	55.8^{Aa} ± 0.90	52.7^{Ab} ± 2.04	**53.3^{A}**	1.33	0.0001
	Mean HD	**50.6^{b}**	**53.4^{a}**	**53.1^{a}**			
	MSE variety	1.11	1.03	1.64			
	P-Value	0.0239	0.0001	0.3863			
4 h	**NK Magitop**	48.7 ± 2.31	50.3 ± 1.96	50.9 ± 1.56	**50.0**	1.77	0.1248
	NX1485	49.7 ± 2.34	51.6 ± 3.53	50.2 ± 1.83	**50.7**	2.49	0.4032
	Mean HD	**49.2**	**51.0**	**50.6**			
	MSE variety	2.20	2.42	1.83			
	P-Value	0.4603	0.3643	0.5336			
8 h	**NK Magitop**	54.6^{a} ± 4.95	56.6^{a} ± 3.47	57.4^{a} ± 3.20	**56.2**	2.76	0.2274
	NX1485	55.9^{b} ± 1.97	59.6^{a}± 3.63	56.2^{b} ± 2.09	**57.2**	1.98	0.0093
	Mean HD	**55.3^{b}**	**58.1^{a}**	**56.8^{ab}**			
	MSE variety	2.56	2.69	1.88			
	P-Value	0.4039	0.0816	0.2942			
16 h	**NK Magitop**	59.1 ± 7.32	62.9 ± 3.89	60.9 ± 6.17	**61.0**	5.67	0.5276
	NX1485	59.3 ± 6.43	63.1 ± 5.27	61.3 ± 5.78	**61.2**	5.71	0.5373
	Mean HD	**59.2**	**63.0**	**61.1**			
	MSE variety	6.83	4.01	5.86			
	P-Value	0.9557	0.9357	0.909			
24 h	**NK Magitop**	69.5 ± 4.74	70.4 ± 5.00	70.9 ± 5.74	**70.3**	5.08	0.89
	NX1485	72.0 ± 4.50	74.0 ± 2.15	72.0 ± 3.48	**72.7**	3.17	0.4721
	Mean HD	**70.8**	**72.2**	**71.4**			
	MSE variety	4.10	3.87	4.69			
	P-Value	0.3118	0.1396	0.6989			
48 h	**NK Magitop**	77.6 ± 3.30	78.1 ± 3.67	78.3 ± 2.00	**78.0**	3.00	0.9236
	NX1485	77.5 ± 4.71	79.9 ± 3.43	79.7 ± 1.61	**79.0**	3.35	0.4342
	Mean HD	**77.6**	**79.0**	**79.0**			
	MSE variety	4.04	3.33	1.69			
	P-Value	0.97	0.3835	0.1925			

Continue Table 38

Time	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
72 h	**NK Magitop**	82.2^{a} ± 1.30	82.6^{a} ± 2.19	83.5^{a} ± 1.24	**82.8**	1.45	0.3047
	NX1485	81.5^{b} ± 1.27	83.9^{a} ± 1.37	82.5^{b} ± 1.78	**82.6**	1.28	0.0166
	Mean HD	**81.8^{b}**	**83.3^{a}**	**82.8^{ab}**			
	MSE variety	1.04	1.66	1.33			
	P-Value	0.3323	0.215	0.1213			
96 h	**NK Magitop**	83.2 ± 1.77	83.9 ± 2.24	83.9 ± 1.71	**83.7**	1.79	0.7298
	NX1485	83.1 ± 1.58	84.5 ± 1.87	83.9 ± 1.35	**83.8**	1.51	0.3276
	Mean HD	**83.2**	**84.2**	**83.9**			
	MSE variety	1.68	1.09	1.54			
	P-Value	0.9505	0.5609	0.9767			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.3.3 Parameters of rumen dry matter degradability

3.3.3.1 Parameters of rumen dry matter degradability of maize stover

Parameters of rumen DM degradability of maize stover, of the two varieties at the three harvest dates are illustrated at Table 39. Concerning the rapidly soluble fraction (a) of maize stover it decreased significantly with increasing plant maturity and mean of the harvest date decreased significantly from 32.0% at HD1 to 23.3% at HD3 with a decrease of 8.7%. There was no significant difference in maize stover rapidly soluble fraction between means of the two varieties (28.3 and 27.8% for NK Magitop and NX1485 respectively).

Regarding to the slowly degradable fraction (b) of maize stover it increased significantly with increasing plant maturity and mean of the harvest date increased significantly from 42.9% at HD1 to 49.3% at HD3. On the other hand, there was no significant difference in maize stover rapidly soluble fraction between the means of the two varieties (45.8 and 45.3% for NK Magitop and NX1485 respectively).

Concerning to the non degradable fraction (A) of maize stover it increased with increasing plant maturity and mean of harvest date significantly increased from 25.1% at HD1 to 27.4% at HD3. There was no significant difference in maize stover non degradable fraction between means of the two varieties (26.0 and 26.9% for NK Magitop and NX1485 respectively).

Table 39. Parameters of rumen dry matter degradability (% ± SD) of maize stover of the two varieties at the three harvest dates

Parameter	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	31.2^{Ba} ± 0.77	29.4^{Ab} ± 0.76	24.2^{Ac} ± 0.49	**28.3^{A}**	0.68	0.0001
	NX1485	32.7^{Aa} ± 0.83	28.4^{Bb} ± 0.59	22.4^{Bc} ± 0.57	**27.8^{A}**	0.67	0.0001
	Mean HD	**32.0^{a}**	**29.9^{b}**	**23.3^{c}**			
	MSE variety	0.80	0.68	0.53			
	P-Value	0.0094	0.0323	0.0001			
b (%)	**NK Magitop**	43.8^{b} ± 1.88	44.3^{a} ± 2.56	49.2^{a} ± 3.52	**45.8**	2.74	0.0065
	NX1485	42.1^{b} ± 1.99	44.6^{b} ± 2.05	49.4^{a} ± 2.26	**45.3**	2.1	0.0001
	Mean HD	**42.9^{b}**	**44.4^{b}**	**49.3^{a}**			
	MSE variety	1.94	2.32	2.96			
	P-Value	0.1595	0.8594	0.9317			
A (%)	**NK Magitop**	25.0^{a} ± 2.24	26.3^{a} ± 2.92	26.6^{a} ± 3.49	**26.0**	2.93	0.6051
	NX1485	25.2^{a} ± 2.54	27.1^{a} ± 2.19	28.3^{a} ± 2.74	**26.9**	2.5	0.1378
	Mean HD	**25.1^{b}**	**26.7^{ab}**	**27.4^{a}**			
	MSE variety	2.39	2.59	3.18			
	P-Value	0.867	0.8465	0.5973			
c (%)	**NK Magitop**	4.52^{a} ± 0.94	4.11^{a} ± 0.88	3.60^{a} ± 0.97	**4.07**	0.94	0.2588
	NX1485	4.60^{a} ± 1.33	4.77^{a} ± 1.03	3.78^{a} ± 0.21	**4.37**	0.99	0.2059
	Mean HD	**4.56^{a}**	**4.44^{ab}**	**3.69^{b}**			
	MSE variety	1.17	0.97	0.70			
	P-Value	0.9235	0.2721	0.6874			
t_0 (h)	**NK Magitop**	3.66 ± 1.45	3.69 ± 1.33	4.00 ± 0.92	**3.78**	1.25	0.8722
	NX1485	3.39 ± 0.40	3.51 ± 0.49	3.28 ± 0.62	**3.39**	0.51	0.7306
	Mean HD	**3.53**	**3.60**	**3.64**			
	MSE variety	1.06	3.60	0.78			
	P-Value	0.6692	0.7703	0.1401			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

For maize stover dry matter degradation rate (c) it decreased with increasing plant maturity in the two varieties. Mean of maize stover dry matter degradation rate of HD1 ($4.56\%h^{-1}$) was significantly higher than that of HD3 ($3.69\%h^{-1}$). There was no significant difference in maize stover dry matter degradation rate between the means of the two varieties (4.07 and $4.37\%h^{-1}$ for NK Magitop and NX1485 respectively).

Concerning to the lag time (t_0) of maize stover the overall mean was about 3.60h and no significant difference between means of the harvest dates was noticed (3.53, 3.60 and 3.64 h for HD1, HD2 and HD3 respectively). Also there was no significant difference between means of the two varieties (3.78 and 3.39 h for NK Magitop and NX1485 respectively).

3.3.3.2 Parameters of rumen dry matter degradability of maize cob

Parameters of rumen DM degradability of maize cob of the two varieties at the three harvest dates are presented in Table 40. Belong to the rapidly soluble fraction (a) of maize cob it decreased significantly with increasing plant maturity and there was a significant difference between means of the three harvest dates (30.2%, 25.3% and 15.1% for HD1, HD2 and HD3 respectively). There was no significant difference in maize cob rapidly soluble fraction between means of the two varieties (23.7 and 23.4% for NK Magitop and NX1485 respectively). At HD3 maize cob rapidly soluble fraction of variety NX1485 (15.7%) was significantly higher than that of variety NK Magitop (14.6%).

Regarding to the slowly degradable fraction (b) of maize cob it increased significantly with increasing plant maturity in the two varieties and mean of the harvest date significantly increased from 61.8% at HD1 to 81.8% at HD3 with an increase of 20%. There was no significant difference in maize cob slowly degradable fraction between means of the two varieties (71.4 and 70.9% for NK Magitop and NX1485 respectively).

For the non degradable fraction (A) of maize cob it decreased with increasing plant maturity and mean of HD1 (8.03%) was significantly higher than that of HD3 (3.08%). There was no significant difference in maize cob non degradable fraction between means of the two varieties (4.89 and 5.71% for NK Magitop and NX1485 respectively). Variety NX1485 showed the highest maize cob non degradable fraction at HD1 (10.1%).

Maize cob dry matter degradation rate (c) decreased with increasing plant maturity and the mean of the harvest date decreased significantly from 5.10%h^{-1} at HD1 to 3.74% h^{-1} at HD3. On the other hand there was no significant difference in maize cob dry matter degradation rate between the means of the two varieties (4.55 and 4.30%h^{-1} for NK Magitop and NX1485 respectively).

Concerning to the lag time (t_0) of maize cob the overall mean was about 0.48 h and the mean at HD3 (0.99 h) was significantly higher than that at HD1 (0.19 h). There was no significant difference in maize cob lag time between the means of the two varieties (0.42 and 0.53 h for NK Magitop and NX1485 respectively).

Table 40. Parameters of rumen dry matter degradability (% ± SD) of maize cob of the two varieties at the three harvest dates

Parameter	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	30.6^{Aa} ± 2.32	26.0^{Ab} ± 3.07	14.6^{Bc} ± 0.00	**23.7^{A}**	2.23	0.0001
	NX1485	29.8^{Aa} ± 4.23	24.7^{Ab} ± 0.83	15.7^{Ac} ± 0.00	**23.4^{A}**	2.49	0.0001
	Mean HD	**30.2^{a}**	**25.3^{b}**	**15.1^{c}**			
	MSE variety	3.41	2.25	0.00			
	P-Value	0.698	0.3561	0.0001			
b (%)	**NK Magitop**	63.5^{c} ± 1.57	68.5^{b} ± 2.54	82.2^{a} ± 1.73	**71.4**	1.99	0.0001
	NX1485	60.1^{c} ± 4.05	71.3^{b} ± 2.33	81.3^{a} ± 1.69	**70.9**	2.87	0.0001
	Mean HD	**61.8^{c}**	**69.9^{b}**	**81.8^{a}**			
	MSE variety	3.07	2.43	1.71			
	P-Value	0.0839	0.0765	0.3959			
A (%)	**NK Magitop**	5.94^{Ba} ± 1.56	5.55^{Aa} ± 1.02	3.18^{Aa} ± 1.73	**4.89^{A}**	3.19	0.2982
	NX1485	10.13^{Aa} ± 2.87	4.03^{Ab} ± 2.17	2.98^{Ab} ± 1.69	**5.71^{A}**	2.30	0.0001
	Mean HD	**8.03^{a}**	**4.79^{ab}**	**3.08^{b}**			
	MSE variety	2.31	3.87	1.71			
	P-Value	0.0105	0.5105	0.8411			
c (%)	**NK Magitop**	4.80^{a} ± 0.98	4.91^{a} ± 1.20	3.96^{a} ± 0.60	**4.55**	0.93	0.1851
	NX1485	5.40^{a} ± 0.86	3.98^{b} ± 0.74	3.52^{b} ± 0.33	**4.30**	0.68	0.0006
	Mean HD	**5.10^{a}**	**4.44^{ab}**	**3.74^{b}**			
	MSE variety	0.92	0.95	0.49			
	P-Value	0.2786	0.1187	0.153			
t_0 (h)	**NK Magitop**	0.16^{b} ± 0.31	0.39^{ab} ± 0.41	0.70^{a} ± 0.44	**0.42**	0.39	0.086
	NX1485	0.22^{b} ± 0.54	0.10^{b} ± 0.21	1.28^{a} ± 0.47	**0.53**	0.43	0.0004
	Mean HD	**0.19^{b}**	**0.25^{b}**	**0.99^{a}**			
	MSE variety	0.44	0.33	0.46			
	P-Value	0.8266	0.1601	0.0527			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.3.3.3 Parameters of rumen dry matter degradability of maize whole plant

Parameters of rumen DM degradability of maize whole plant of the two varieties at the three harvest dates are presented in Table 41. The rapidly soluble fraction (a) of maize whole plant decreased significantly with increasing plant maturity and mean of the harvest date decreased significantly from 39.8% at HD1 to 28.2% at HD3 with a decrease of 11.6%. No significant difference in the rapidly soluble fraction of maize whole plant between means of the two varieties was noticed (34.4 and 34.0% for NK Magitop and NX1485 respectively).

The slowly degradable fraction (b) of maize whole plant increased significantly with increasing plant maturity and mean of the harvest date increased significantly from 44.5% at HD1 to 57.7% at HD3 with an increase of 13.2%. There was no significant difference in slowly degradable fraction of maize whole plant between means of the two varieties (49.9 and 50.9% for NK Magitop and NX1485 respectively).

Regarding to the non degradable fraction (A) of maize whole plant there was no significant difference between means of the harvest dates (15.8, 14.8 and 14.1% for HD1, HD2 and HD3 respectively). Also there was no significant difference in the non degradable fraction of maize whole plant between means of the two varieties (14.7 and 15.0% for NK Magitop and NX1485 respectively).

Dry matter degradation rate (c) of maize whole plant decreased with increasing plant maturity and mean of the harvest date at HD1 (4.59%h^{-1}) was significant higher than that at HD3 (3.88%h^{-1}). No significant difference in maize whole plant DM degradation rate between means of the two varieties was noticed (4.27 and 4.56%h^{-1} for NK Magitop and NX1485 respectively).

Concerning to the lag time (t_0) of maize whole plant it decreased from HD1 to HD2 then it increased again from HD2 to HD3 (4.62, 3.94 and 4.79 h for HD1, HD2 and HD3 respectively). Also there was no significant difference in maize whole plant lag time between means of the two varieties (4.50 and 4.41 h for NK Magitop and NX1485 respectively).

Table 41. Parameters of rumen dry matter degradability (% ± SD) of maize whole plant of the two varieties at the three harvest dates

Parameter	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	40.6^{Aa} ± 1.06	37.7^{Ab} ± 0.39	27.9^{Ac} ± 0.57	**34.4^{A}**	0.86	0.0001
	NX1485	38.9^{Ba} ± 0.54	34.7^{Bb} ± 0.48	28.5^{Ac} ± 0.39	**34.0^{A}**	0.48	0.0001
	Mean HD	**39.8^{a}**	**36.2^{b}**	**28.2^{c}**			
	MSE variety	0.84	0.44	0.73			
	P-Value	0.0049	0.0001	0.1691			
b (%)	**NK Magitop**	43.8^{c} ± 2.68	48.2^{b} ± 1.81	57.6^{a} ± 4.70	**49.9**	3.29	0.0001
	NX1485	45.2^{c} ± 2.29	50.0^{b} ± 1.23	57.7^{a} ± 2.25	**50.9**	1.99	0.0001
	Mean HD	**44.5^{c}**	**49.1^{b}**	**57.7^{a}**			
	MSE variety	2.49	1.55	3.68			
	P-Value	0.354	0.0795	0.9805			
A (%)	**NK Magitop**	15.6 ± 1.94	14.1 ± 1.59	14.5 ± 4.27	**14.7**	2.86	0.6564
	NX1485	15.9 ± 2.24	15.4 ± 1.29	13.8 ± 2.20	**15.0**	1.96	0.1727
	Mean HD	**15.8**	**14.8**	**14.1**			
	MSE variety	2.09	1.44	3.40			
	P-Value	0.791	0.1634	0.7362			
c (%)	**NK Magitop**	4.66^{a} ± 1.07	4.15^{a} ± 0.78	4.01^{a} ± 1.18	**4.27**	1.02	0.5259
	NX1485	5.24^{a} ± 1.39	4.68^{ab} ± 0.51	3.74^{b} ± 0.33	**4.56**	0.87	0.0295
	Mean HD	**4.59^{a}**	**4.42^{ab}**	**3.88^{b}**			
	MSE variety	1.24	0.66	0.87			
	P-Value	0.4371	0.1912	0.6062			
t_0 (h)	**NK Magitop**	5.69 ± 4.68	3.66 ± 1.41	4.15 ± 1.72	**4.50**	2.99	0.4899
	NX1485	3.56 ± 1.41	4.23 ± 1.02	5.43 ± 2.79	**4.41**	1.90	0.2565
	Mean HD	**4.62**	**3.94**	**4.79**			
	MSE variety	3.46	1.23	2.32			
	P-Value	0.4371	0.1912	0.6062			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.3.3.4 Parameters of rumen dry matter degradability of maize whole plant silage

Parameters of rumen DM degradability of maize whole plant silage of the two varieties at the three harvest dates are illustrated in Table 42. Regarding to the rapidly soluble fraction (a) of maize whole plant silage it increased significantly with increasing plant maturity and mean of the harvest dates increased significantly from 51.1% at HD1 to 53.0.% at HD3. No significant difference in the rapidly soluble fraction of maize whole plant silage between means of the two varieties was detected (51.7 and 53.4% for NK Magitop and NX1485 respectively).

For the slowly degradable fraction (b) of maize whole plant silage there was no significant between means of the harvest dates (33.0, 31.8, and 32.1% for HD1, HD2 and HD3 respectively). There was also no significant difference in the slowly degradable fraction of maize whole plant silage between means of the two varieties (33.4 and 31.1% for NK Magitop and NX1485 respectively).

For the non degradable fraction (A) of maize whole plant silage there was no significant difference between means of the harvest dates (15.9, 14.8 and 14.9% for HD1, HD2 and HD3 respectively). Also there was no significant difference in the non degradable fraction of maize whole plant silage between means of the two varieties (14.9 and 15.5% for NK Magitop and NX1485 respectively).

Regarding to dry matter degradation rate of maize whole plant silage (c) there was no significant difference between means of the harvest dates (5.58, 4.37 and 5.32%h^{-1} for HD1, HD2 and HD3 respectively). No significant difference in dry matter degradation rate of maize whole plant silage between means of the two varieties (4.65 and 5.53%h^{-1} for NK Magitop and NX1485 respectively). Variety NX1485 showed the highest dry matter degradation rate of maize whole plant silage at HD3 (6.77%h^{-1}).

Concerning to the lag time (t_0) of maize whole plant silage, means of the harvest dates decreased from HD1 to HD2 then it increased again from HD2 to HD3 (7.37, 5.37 and 6.87 h for HD1, HD2 and HD3 respectively). Also there was no significant difference in maize whole plant silage lag time between means of the two varieties (6.05 and 7.02 h for NK Magitop and NX1485 respectively).

Table 42. Parameters of rumen dry matter degradability (% ± SD) of maize whole plant silage of the two varieties at the three harvest dates

Parameter	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
a (%)	**NK Magitop**	50.1^{Bc} ± 0.46	52.0^{Bb} ± 1.08	53.1^{Aa} ± 0.83	**51.7^{A}**	0.83	0.0001
	NX1485	52.2^{Ac} ± 1.19	55.0^{Aa} ± 1.09	53.0^{Ab} ± 1.96	**53.4^{A}**	1.47	0.0137
	Mean HD	**51.1^{b}**	**53.5^{a}**	**53.0^{a}**			
	MSE variety	0.91	1.08	1.50			
	P-Value	0.0029	0.0007	0.991			
b (%)	**NK Magitop**	34.0 ± 2.03	32.8 ± 2.02	33.2 ± 2.53	**33.4**	2.21	0.6275
	NX1485	31.9 ± 3.18	30.7 ± 1.54	30.9 ± 4.53	**31.1**	3.32	0.7956
	Mean HD	**33.0**	**31.8**	**32.1**			
	MSE variety	2.67	1.80	3.67			
	P-Value	0.1914	0.0653	0.2925			
A (%)	**NK Magitop**	15.9 ± 1.75	15.2 ± 1.50	13.7 ± 3.09	**14.9**	2.23	0.2704
	NX1485	16.0 ± 2.25	14.4 ± 1.08	16.1 ± 2.63	**15.5**	2.1	0.3092
	Mean HD	**15.9**	**14.8**	**14.9**			
	MSE variety	2.02	1.31	2.87			
	P-Value	0.9211	0.2858	0.1846			
c (%)	**NK Magitop**	5.80 ± 3.07	4.28 ± 1.18	3.88 ± 1.33	**4.65**	2.36	0.3566
	NX1485	5.36 ± 2.54	4.46 ± 1.25	6.77 ± 3.79	**5.53**	2.73	0.3598
	Mean HD	**5.58**	**4.37**	**5.32**			
	MSE variety	3.17	1.21	2.84			
	P-Value	0.8142	0.7972	0.1076			
t_0 (h)	**NK Magitop**	7.49 ± 4.42	5.25 ± 1.26	5.42 ± 1.16	**6.05**	2.74	0.3161
	NX1485	7.24 ± 4.40	5.48 ± 1.02	8.32 ± 5.38	**7.02**	4.05	0.4897
	Mean HD	**7.37**	**5.37**	**6.87**			
	MSE variety	4.40	1.15	3.89			
	P-Value	0.9252	0.7311	0.2257			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

3.3.4 Effective rumen dry matter degradability

The effective rumen DM degradability of maize stover, maize cob, maize whole plant and maize whole plant silage of the two varieties at the three harvest dates by passage rate of 6%h^{-1} is presented in Table 43. Belong to the EDMD of maize stover and maize cob it decreased significantly with increasing plant maturity especially at the late harvest date (mean of EDMD of the harvest date for maize stover was 46.7, 43.9 and 38.2% for HD1, HD2 and HD3 respectively, whereas mean of EDMD of the harvest date for maize cob was 58.0, 54.2 and 44.6% for HD1, HD2 and HD3 respectively). There was no significant difference between means of the two varieties for maize stover and also for maize cob (42.7 and 43.2% for maize stover of NK Magitop and NX1485 respectively and 53.2 and 51.3% for maize cob of NK Magitop and NX1485 respectively). Mean of maize cob EDMD (52.3%) was higher about 9.30% than that of maize stover (43.0%).

Table 43. Effective rumen dry matter degradability (% ± SD) of maize stover, maize cob, maize whole plant and maize whole plant silage of the two varieties at the three harvest dates by passage rate of 6%h^{-1}

Component	Variety	HD1 (03.09.07)	HD2 (17.09.07)	HD3 (15.10.07)	Mean variety	MSE HD	P-Value
Maize stover	**NK Magitop**	46.2^{a} ± 2.09	43.6^{b} ± 2.06	38.3^{c} ± 1.96	**42.7**	2.04	0.0001
	NX1485	47.3^{a} ± 1.56	44.2^{b} ± 2.11	38.0^{c} ± 1.10	**43.2**	1.64	0.0001
	Mean HD	**46.7^{a}**	**43.9^{b}**	**38.2^{c}**			
	MSE variety	1.85	2.08	1.59			
	P-Value	0.3227	0.6634	0.7517			
Maize cob	**NK Magitop**	58.2^{a} ± 2.38	55.6^{a} ± 2.89	45.7^{b} ± 1.87	**53.2**	2.41	0.0001
	NX1485	57.8^{a} ± 2.23	52.7^{b} ± 2.14	43.5^{c} ± 1.86	**51.3**	2.08	0.0001
	Mean HD	**58.0^{a}**	**54.2^{b}**	**44.6^{c}**			
	MSE variety	2.31	2.54	1.87			
	P-Value	0.7802	0.0703	0.0646			
Maize whole plant	**NK Magitop**	54.3^{a} ± 2.96	53.4^{a} ± 2.59	45.4^{b} ± 2.37	**51.1**	2.65	0.0001
	NX1485	55.6^{a} ± 2.42	51.7^{b} ± 2.03	44.7^{c} ± 2.70	**50.7**	2.40	0.0001
	Mean HD	**55.0^{a}**	**52.5^{b}**	**45.1^{c}**			
	MSE variety	2.70	2.33	2.54			
	P-Value	0.4259	0.22	0.6305			
Maize whole plant silage	**NK Magitop**	59.9^{Aa} ± 2.70	61.1^{Ba} ± 1.58	62.1^{Aa} ± 0.94	**61.0**	1.89	0.1312
	NX1485	61.4^{Ab} ± 2.44	64.2^{Aa} ± 1.13	62.3^{Aab} ± 0.68	**62.6**	1.60	0.0239
	Mean HD	**60.6^{b}**	**62.7^{a}**	**62.2^{ab}**			
	MSE variety	2.50	1.38	0.82			
	P-Value	0.3517	0.0129	0.6803			

Means along the same column bearing different capital letters are significantly different
Means along the same row bearing different small letters are significantly different

Concerning to the EDMD of maize whole plant it decreased significantly with increasing plant maturity and the mean of the harvest date decreased significantly from 55.5% at HD1 to 45.1% at HD3 with a decrease of 10.4%. Whereas the EDMD of maize whole plant silage increased with increasing plant maturity and the mean of the harvest at HD2 (62.7%) was significantly higher than that at HD1 (60.6%). There was no significant difference between mean of the two varieties for maize whole plant and also for maize whole plant silage (51.1 and 50.7% for maize whole plant of NK Magitop and NX1485 respectively and 61.0 and 62.6% for maize whole plant silage of NK Magitop and NX1485 respectively). Mean of the EDMD of maize whole plant silage (62.0%) was higher about 11.1% than that of maize whole plant (50.9%). In the same time mean of EDMD of maize whole plant silage at HD3 (62.2%) was higher about 17.1% than that of maize whole plant at HD3 (45.1%), whereas mean of EDMD of maize whole plant silage at HD1 (60.6%) was higher about 5.50% than that of maize whole plant at HD1 (55.0%). This indicates that ensiling can reduces the decrease in EDMD of maize whole plant with increasing plant maturity.

Dry matter degradability of the different fresh materials (maize stover, maize cob and maize whole plant) decreased significantly with increasing plant maturity. On contrast to the fresh materials, ensiling improved the dry matter degradability of maize whole plant significantly from HD1 to HD2 and only slight decrease from HD2 to HD3. In the same time ensiling improved the dry matter degradability of maize whole plant than fresh one. Therefore, ensiling of maize whole plant reduced the maturity effect and showed a broad window for harvesting maize whole plant. There was no difference between the two maize varieties and this may be because grain of both varieties was from the flint type endosperm.

4. Discussion

4.1 Classification and components of maize plant

Maize plant belongs to the family Poaceae, subfamily Panicoideae which includes maize, sorghum and sudangrass. In addition to maize, this family includes important crops such as wheat, rice, barley and oats. Maize is one of the C4 crop that fixes CO_2 in oxalacetate rather than phosphoglyceric acid in C3 crop with a high rate of photosynthetic activity leading to high grain and biomass yield potential. They are characterized by higher vascular tissues proportion, higher photosynthetic efficiency, and more droughts and heat resistant than C3 grasses. C4 plants are generally less digestible than C3 plants Due to more compacted structure and low intercellular space in leaves and stems (Balasako and Nelsen, 2003). It is predominantly a cross pollinating species, a feature that has contributed to its broad morphological variability and geographical adaptability. Depending on the latitude and the climate in which it is grown, maize is classified into three distinct types, tropical, temperate, and subtropical (Xu et al., 2009).

Maize whole plant contains variable proportions of grain and stover, each of which can differ in their chemical composition and physical form. The relationship between maturity and composition is unique for maize plant among forages because it is a mixture of stover and grain. During maturity nutrients of cob and stover as well as the relation of cob to stover are changing, because as maize plant matures after silking it generates grain that dilutes the concentration and nutritional impact of the relatively mature stover (Gross and Peschke, 1980; Gruber et al., 1983; Deinum et al., 1984; Russel, 1986, Irlbeck et al., 1993; Zeller, 2009). The more grain produces the more non structural carbohydrates translocates out of the stems (Buxton et al., 1996) and so high proportion of cob improves the digestibility and the energy content of maize whole plant. Furthermore as long as the proportion of cob increases the energy concentration raises or at least stays constant in spite of decreasing digestibility of the stover (Ettle and Schwarz, 2003). The dynamics of this change differ from one variety to the other. Therefore, the harvest time has a great influence on the feeding value assessment of maize varieties.

Darby and Lauer (2002) stated that the appropriate dry matter for harvesting maize whole plant for silage making is ranged from 32.0 to 35.0%. Therefore, in this study harvesting of maize plant occurred at three harvest dates to study the effect of harvest stage on dry matter degradability of maize whole plant. Also in this study harvesting dates of maize plant based on that the second harvest date was simulate the normal harvesting time of maize plant such as farmers did in the field (whole plant contains 32.0 to 35.0% DM). The first and the third harvest dates were harvested about two weeks early or two weeks late than the second one respectively.

Maize whole plant dry matter and stover and cob proportions from the whole plant in the first three experiments are illustrated in Figure 3. It is obvious that whole plant dry matter differs according to maturity stage and variety. Maize whole plant DM at Exp 1 increased from 28.0% at early to 41.0% at late harvest with an increase of 13.0%. This increase in maize whole plant DM was accompanied with increasing in the proportion of maize cob from 49.0% at early to 57.5% at late harvest, and with decreasing in the proportion of maize stover from 51.0% at early to 42.5% at late harvest. These results are in agreement with those of Zeller (2009) as she find that maize whole plant DM increase from 27.0% to 41.0% when grain DM increase from 51.0% to 68.0% respectively. Gross (1979) and Gross and Peschke (1980) stated that maize whole plant dry matter is expected to increase with increasing cob proportion.

Also varieties differ in their maize whole plant DM and cob and stover proportion. For example, variety NX1494 showed the lowest maize whole plant DM (33.2%) at Exp 1, with 50.3 and 49.7% for cob and stover proportion respectively; in the same time variety NX0601 showed maize whole plant DM of 34.4%, with 57.1 and 42.9% for cob and stover proportion respectively. But variety NX10126 at Exp 3 showed maize whole plant DM of 33.3% but maize stover proportion (52.0%) was higher than cob proportion (48.0%). Höner (2001) studied maize whole plant DM and cob and stover proportion in four maize varieties and found that variety CGS5104 had maize whole plant DM of 35.9% and cob and stover proportion was 53.0 and 47.0% respectively. On contrarily variety Byzance had whole plant DM of 31.0% but with cob proportion of 57.0% which is higher than variety CGS5104. She concluded that not all varieties which high in maize whole plant DM have higher proportion of maize cob.

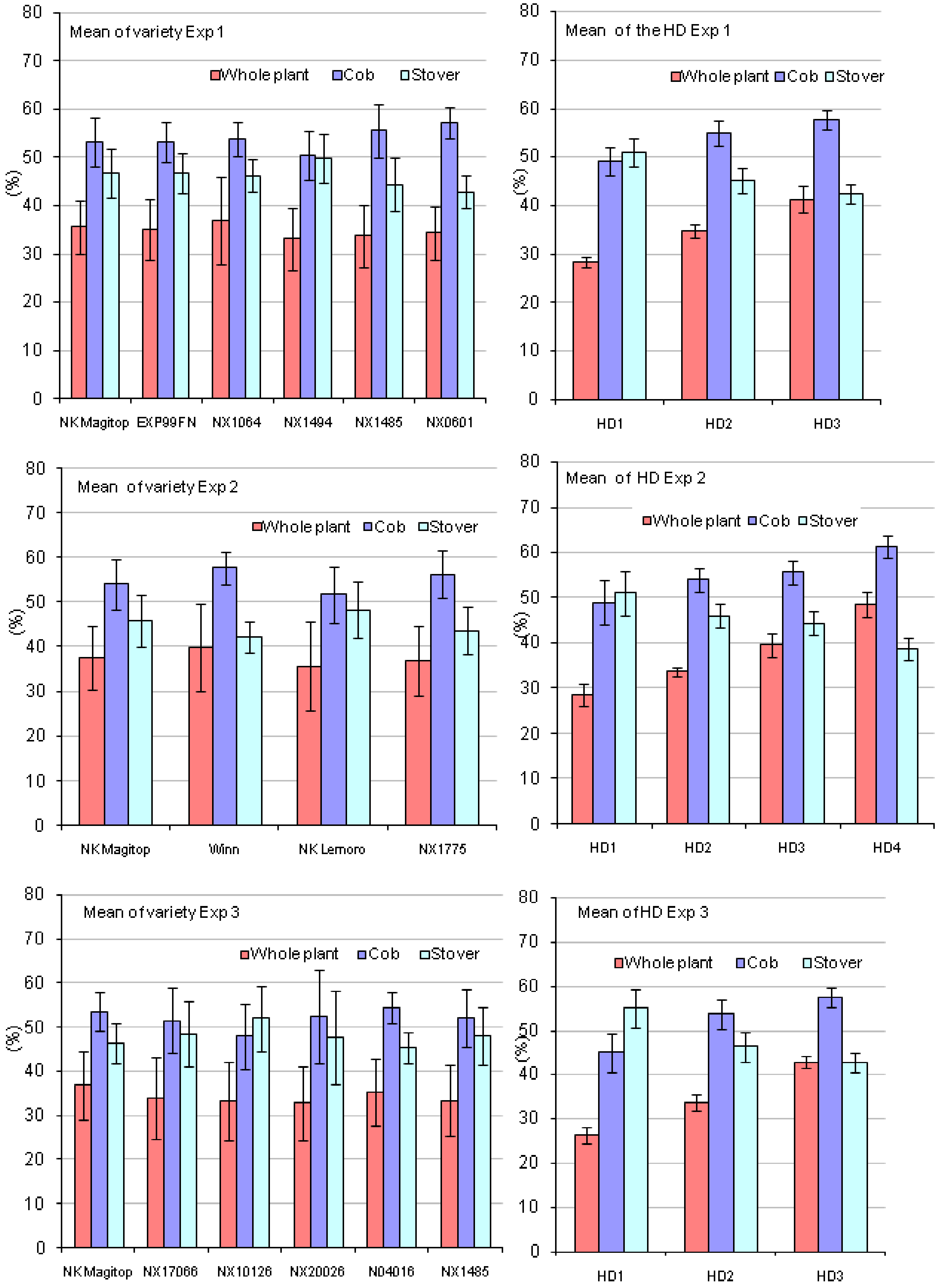


Figure 3. Whole plant DM, and stover and cob proportions as mean of the variety (left) and as a mean of the harvest date (right) for the first three experiments

4.1.1 Maize stover

Maize stover has a relatively low digestibility and concentration of energy. From the previous section it is clear that during harvesting maize plant for making maize silage (32.0 to 35.0% whole plant DM) about 50.0% more or less of the whole plant dry matter is stover. This is in agreement with Irlbeck et al. (1993) as they stated that nearly half the above ground dry matter of maize is stover. Thus, it is not surprising that stover digestibility has a large influence on maize forage quality. Stover digestibility, in turn, is related to fiber (cell wall) concentration and fiber digestibility of stems and leaves. Fiber concentration in maize stover is high, as is the situation for most C4, warm season species (Buxton et al., 1996).

Table 44. Effect of maturity stage and variety on maize stover crude fiber content in the first three experiments

	Mean of HD		*Mean of variety*	
Exp No	***First HD***	***Last HD***	***Lowest variety***	***Highest variety***
Exp 1	31.5	33.3	30.0	33.9
Exp 2	34.3	37.8	33.5	36.7
Exp 3	31.1	35.4	30.0	34.2
Zeller (2009)	33.2	36.7	33.0	37.2

Table 44 showed maize stover crude fiber for the first three experiments of this work and the work of Zeller (2009). These results indicated that maize stover crude fiber increased with increasing plant maturity. Furthermore, Figure 4 showed a positive correlation of R^2 = 0.45 between maize stover dry matter and crude fiber content. Mean of crude fiber in Exp 1 increased from 31.5% at early (19.7% stover DM) to 33.3% at late harvest (28.3% stover DM), in the same time in Exp 2 it increased from 34.3% at early (20.3% stover DM) to 37.8% at late harvest (37.1% stover DM), and in Exp 3 it increased from 31.1% at early (19.0% stover DM) to 35.4% at late harvest (29.4% stover DM). The increase in stover crude fiber with increasing plant maturity is attributed to the translocation of the soluble nutrients especially the water soluble carbohydrate (WSC) from stem and leaves to the grain, which lead to decrease of the proportion of total non structural carbohydrates in steam and leaves (stover) and increase in the cob proportion (Buxton et al., 1996).

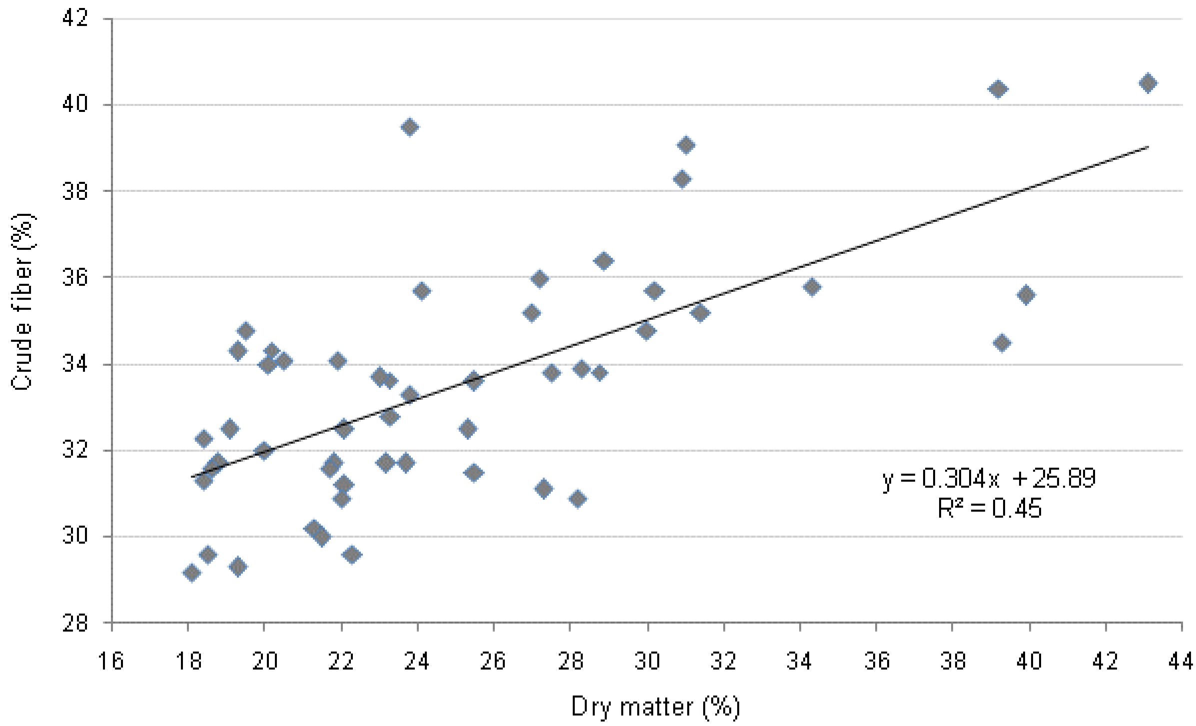


Figure 4. Relationship between maize stover dry matter and crude fiber content as affected by maturity stage

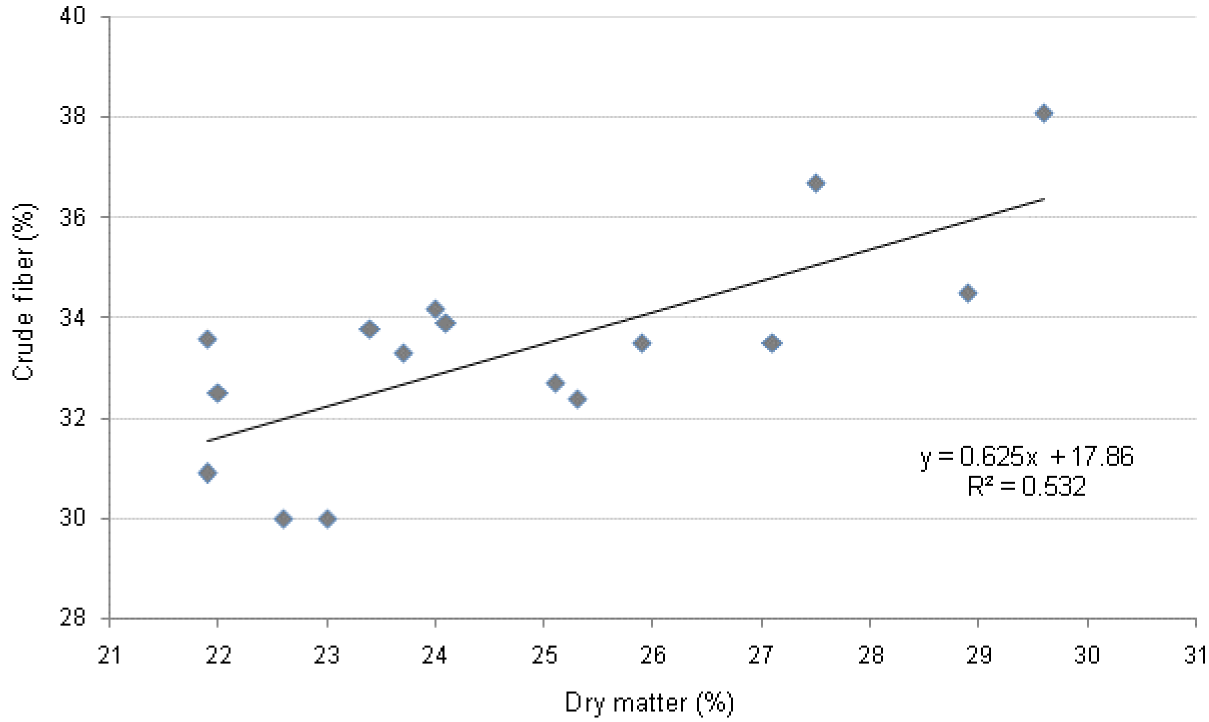


Figure 5. Relationship between maize stover dry matter and crude fiber content as affected by maize variety

These results are in agreement with those of Zeller (2009) as found also that stover crude fiber increased from 33.2% to 36.7% when maize stover DM increased from 19.6% to 28.0%.

Maize variety also plays a role in stover crude fiber content and there was a correlation of R^2 = 0.532 between dry matter and crude fiber content as a mean of variety (Figure 5). This is attributed to the difference in the proportional of the morphological fractions (steam, leaves and husk) of maize stover between varieties (Toolera and Sundstøl, 1999). In Exp. 1 for example the mean of stover crude fiber as mean of the variety increased from 30.0 to 33.9, the same it increased from 33.5 to 36.7% in Exp 2 and from 30.0 to 34.2% in Exp 3 (Table 40). Those results are in agreement with those of Zeller (2009) in which she found the mean of stover crude fiber for the variety increased from 33.7 to 37.2%.

Maize stover can be improved through selection for decreased fiber concentration or increased rate or extent of fiber digestion (Jung and Allen, 1995; Buxton et al., 1996). Decreasing fiber concentration of stover and/or increasing fiber digestibility can increase dry matter intake and animal performance (Waldo, 1985). Understanding the structure and components of plant cell wall (plant crude fiber) are necessary to understanding why the low digestibility of maize stover.

Plant cell wall structure and components

A distinguishing feature of plant cells relative to mammalian cells is the presence of a rigid cell wall that surrounds the lipid bilayer cell membrane. The plant cells are composed of two major fractions; cell walls and cellular contents. The cellular contents which are vulnerable to rapid disappearance or digestion consist of protein, lipids, sugar and starch (Smith, 1973). Plant cell wall is a layer of structural material involving the protoplast which can be 0.1-10 mm thick and composed of polysaccharides and lignin also cell wall contains a small amount of glycoproteins (Zahedifar, 1996). Classically, cell wall polysaccharides have been grouped into three fractions. a) Cellulose: the most resistant to chemical disruption. b) Hemicellulose: extracted by relatively strong alkali solution or mild acid hydrolysis; and c) Pectic polysaccharides: extracted by hot water, ammonium oxalates solution, and weak acids or chelating agents. The relative proportion of these polymers is dependent on the species, the cell type and the developmental stage, but on average, the cell wall is composed of 30.0 - 40.0% cellulose, 30% hemicellulose, 15.0 - 30.0% lignin and 5.0 - 10.0% proteins (Zahedifar, 1996).

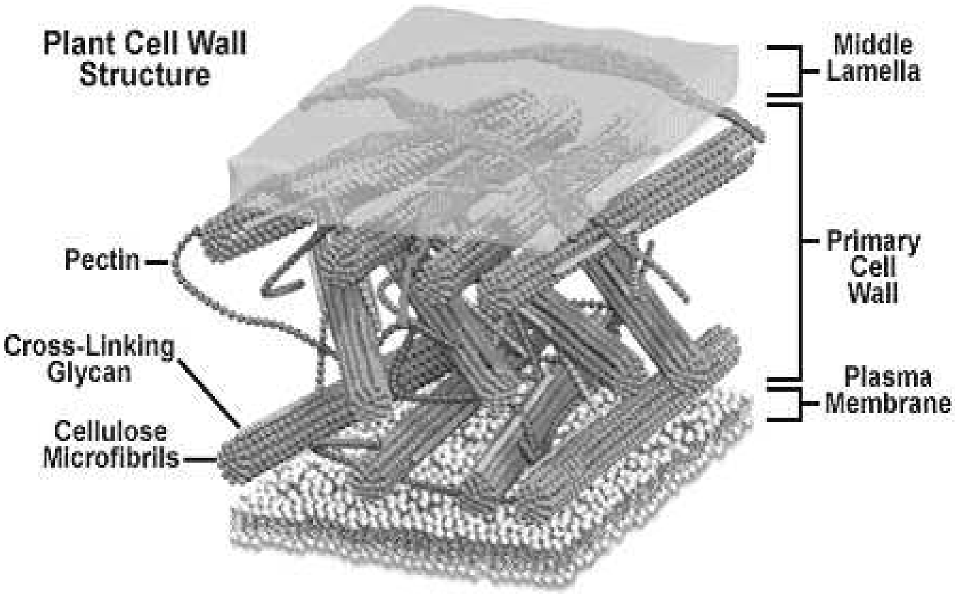


Figure 6. The presence of polysaccharides in different parts of the cell wall, (© Davidson, 1995)

The presence of polysaccharides in different parts of the cell wall is illustrated in Figure 6. Although cellulose is the predominant component of plant fiber, it is important to recognize that the cellulose microfibrils are tightly bound by covalent bonding in a matrix of other fiber components, particularly hemicelluloses and lignin (Jeffries, 1990). Analogous to reinforced concrete, digestion of cellulose is limited by this hemicellulose lignin encasement (see Figure 6).

Although variation in composition of cell walls from the same cell type found in different cultivars or species is small and appears to contribute little to any observed differences in whole plant digestibility, distinct and major differences are found in the composition of the walls of different cell types (Jung et al., 1993). The function of the cells that form the bulk of seed and storage organs differs from that of the cells forming the vegetative parts of the plant and this is often reflected in their composition (Abeysekara, 2003).

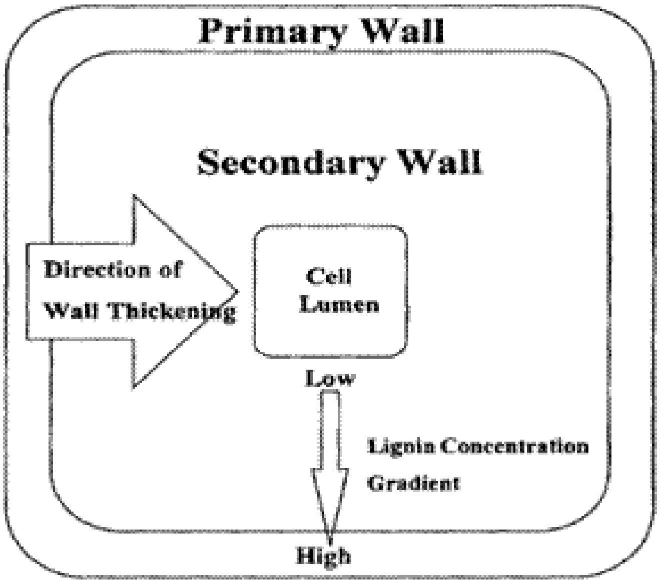


Figure 7. Schematic representation of plant cell and wall development Thickening of the wall proceeds from the primary cell-wall region toward the cell lumen. Lignin deposition begins in the primary wall and then progressively moves through the secondary wall, always lagging behind polysaccharide deposition. Lignin concentration is greatest in the primary wall region (Jung and Allen, 1995).

The cell wall of plants is an extracellular matrix with both structural and growth-regulating functions. The plant cell wall is composed of three layers, the middle lamella, the primary cell wall and the secondary cell wall (Van Soest, 1994) with the relative proportions depending on cell type and maturity. The growth and development of the cell wall in plants can be divided into two phases (Iiyama et al.1993; Terashima et al., 1993). Primary wall growth is that phase when the plant cell is increasing in size through wall elongation (Figure 7). The cell wall is a composite structure composed of polysaccharides, proteins, phenolic acids during primary growth pectins, xylans, and cellulose are all deposited, but there is no lignin deposition during this phase (Jung and Allen, 1995).

The middle lamella is composed of pectic substances which are thought to function as inter-cellular cement. The primary cell wall is usually found in young undifferentiated cells that are still growing (Selvendran, 1987). This layer consists mainly of cellulose, hemicellulose and pectins, but may contain a small amount of protein, which is a glycoprotein rich in hydroxyproline, arabinose and galactose. Once the plant has reached inflorescence, cell elongation ceases and the formation of the secondary cell wall begins to develop within the primary cell wall. Water content decreased significantly as lignin replaces it. During this phase the cell wall becomes progressively thicker as it grows from the inner edge of the primary wall toward the center of the plant cell (Bacic et al., 1988). The additional polysaccharide material that is deposited during secondary wall growth is richer in cellulose than xylans, and pectins are no longer being added to the wall. Lignification is initiated in the middle lamella and primary cell wall, after cell expansion ceases, and proceeds throughout the secondary cell wall as cells age. The concentration of lignin is higher in the middle lamella or the primary cell wall than the secondary cell wall (Saka and Goering, 1985), but because of greater thickness the later contains most of the lignin present in the plant (Harris, 1990; Jung et at., 1993). Deposition of hemicellulose and lignin increased within the secondary cell wall. Lignin precursors, the phenolic acids, crosslink hemicellulose and provide mechanical strength to the plant. As in the primary cell wall, cellulose is the most abundant substance in the secondary cell wall. The three layers often observed in the secondary cell wall (outer layer S1, middle layer S2 and inner layer S3) represent different orientations of microfibrils (Abeysekara, 2003). However Jung et al. (1993) reported that these layers have not been shown to have any differences in digestion characteristics. Inclusion of lignin in the wall begins in the middle lamella, the space between plant cells and the original primary wall region, and then proceeds into the secondary wall (Figure 8).

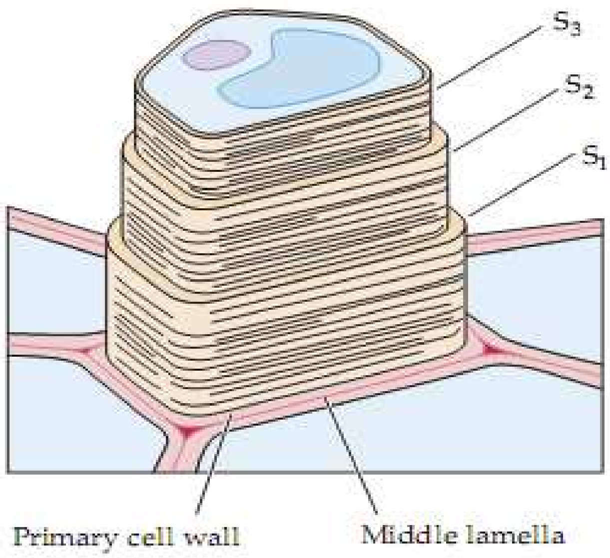


Figure 8. Simplified structure of the cell wall (Carpita and McCann, 2000)

The effect of this pattern of lignin deposition is that the most recently deposited polysaccharides of the secondary wall are not lignified and the middle lamella and primary wall region is the most intensely lignified. This may explain why ruminal microbes degrade plant cell walls from the lumen of the cell outward and why the middle lamella and primary wall regions of lignified cells are never completely digested (Engels, 1989). The preceding discussion of cell wall development is a generalization across plant cell types. Some cells, such as leaf mesophyll, undergo very little secondary wall thickening and deposit virtually no lignin (Delmer and Stone, 1988). In contrast, vascular tissues such as sclerenchyma become very extensively secondarily thickened and contain high concentrations of lignin. Lignin is the major component of the cell wall that is recognized as limiting digestion of the wall polysaccharides in the rumen (Jung and Deetz, 1993; Grabber, 2005).

The thick walled cells that lignified cause most of the low recovery of available energy from forage (Abeysekara, 2003). The accessibility of carbohydrates to rumen microbes is limited by the chemistry of the cell wall and the structural arrangement of each cell type within a tissue by which influence physical breakdown of forage, and hence the rate of passage and intake of forage. Nutritive value implies not only the proportion of nutrients present in the plant, but also the intake and the digestibility by the animals (Ingalls et al., 1965). Van Soest (1986) reported that forage intake is dependent upon the cell wall content, while forage digestibility is dependent on the cell wall (neutral detergent fiber) content and its availability determined by lignifications and other factors.

4.1.2 Maize grain

In contrast to the low energy and the low digestible stover, maize grain has a higher digestibility and concentration of energy. Grain contains a large amount of starch, which is highly digestible. An important goal in dairy cow management is the maximization of energy intake. Cows in early lactation often experience a negative energy balance, and energy status greatly affects peak milk yield and persistency of milk production. One approach to increasing energy intake is to increase the energy density of diets by feeding more fermentable grain (Oba and Allen, 2003). Starch is the primary nutrient of those ruminant diets used to promote high levels of energy. Thus, optimal starch utilization is fundamental to improving efficiency of production of animal products. The principal sources of starch in these diets are the cereal grains, most commonly wheat, barley, maize and sorghum grain. Starch makes up approximately 60 - 80% of the grain. Starch content of wheat grain (77.0% starch) is the highest among the grains, and then followed by 72.0% starch in both maize grain and sorghum then by 57.0 to 58.0% starch in barley and oats (Huntington, 1997). But Rowe and pethick (1994) stated that starch content of barley and oats are 61.0% and 42.0% respectively. Starch content of maize grain increasing with increasing plant maturity and there is a positive correlation of R^2 = 0.598 (Figure 9). The starch content of corn silage is a direct function of plant maturity and proportion of grain in the whole plant; Mahanna (1994) reported that starch content of corn silage increased from 22.0 to 35.0% as the percentage of grain in the silage increased from 32.0 to 50.0%. This is attributed to translocation of sugars from steam and leaves toward the grain during maize plant maturity until end of the filling period.

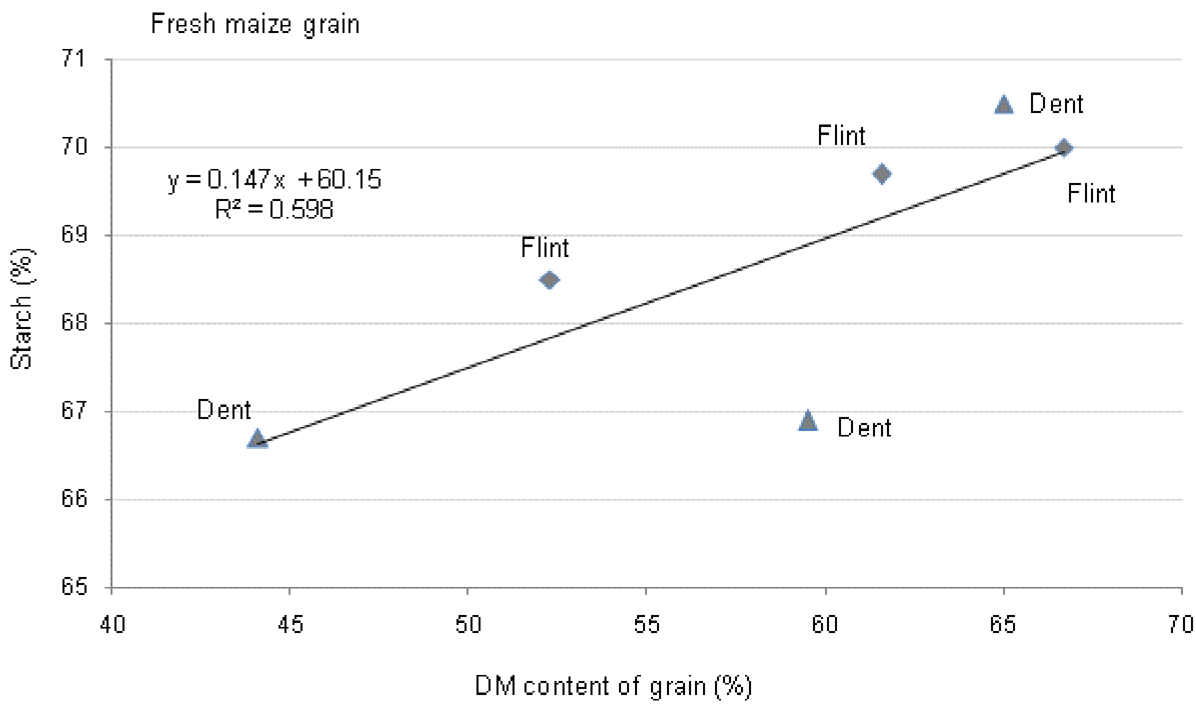


Figure 9. Relationship between maize grain dry matter and starch content as affected by maturity stage

<u>Chemistry and structure of starch in maize kernel</u>

For understanding why the differences in starch digestion between the different maturity stages as well as between maize varieties, it is important at first to know the structure of the maize kernel. There are three main components that make up the grain kernel, the endosperm represent 84.0%, the protective outer covering layer (pericarp) represents 6.00% and the embryo (germ) represent 10.0%. Figure 10 shows schematic diagram for composition of maize kernel. The endosperm surrounds the germ and the fibrous pericarp is the primary morphological structure protecting the embryo. Pericarp and germ contain little starch and they regulate water uptake in the kernel (Kotarski et al., 1992). The endosperm contains primarily starch and protein and small amounts of fat as phospholipids and ash. Corn endosperm is virtually devoid of fiber (ADF or NDF). It contains < 4.00% NDF and 0.09% phosphorus, as compared to the germ which contains 17.0% NDF and 0.97% phosphorus, and pericarp with 33.0% NDF and 0.29% phosphorus (Van Kempen et al., 2003).

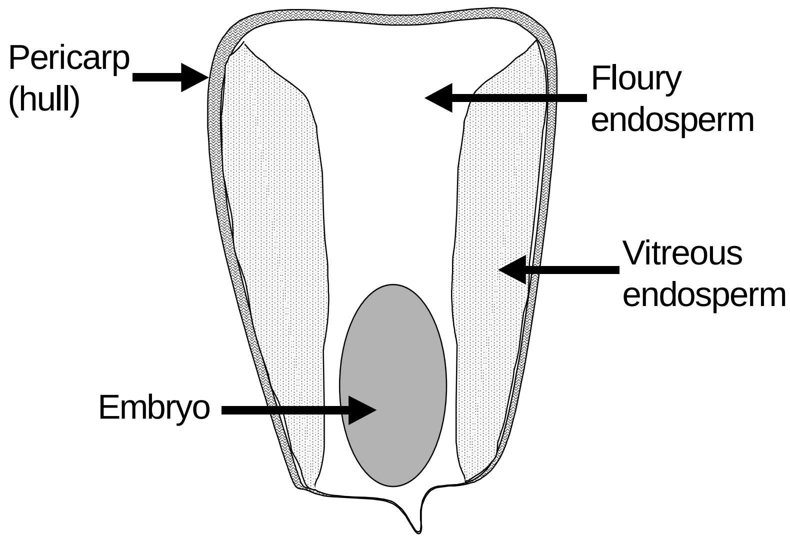


Figure 10. Schematic diagram for composition of maize kernel (from Kurtz, 2006)

Endosperm has four sections (the outermost aleurone, the peripheral endosperm, the underlying corneous endosperm and the innermost floury endosperm). The aleurone layer devoid from starch granules but it contains autolytic enzymes, amylases and protease inhibitors, water soluble vitamins, minerals and spherical bodies that contain protein and lipid (Kotarski et al., 1992). Structure of the starch granule in the peripheral and the corneous endosperm is different from that of the floury endosperm. In the peripheral and corneous endosperm, starch granules are surrounded by protein storage bodies embedded in a dense matrix of dried endosperm cells. This protein matrix hinders starch degradability as it is relatively impervious to water and hydrolytic enzymes. On the other hand, the floury endosperm has high density of starch granules with little cellular structure. Therefore, starch granules in the floury endosperm are more readily to enzymatic hydrolysis (Rooney and Miller, 1982; Earp and Rooncy; 1986 Kotarski et al., 1992).

Based on kernel characteristics, maize grains have been divided into 5 general classes: flint, popcorn, flour, dent, and sweet (Correa et al., 2006). Starch in the endosperm of flint corn is almost all hard (corneous, horny, or vitreous), whereas flour corn has virtually all of its starch as floury or soft endosperm (Pomeranz et al., 1984). Dent corn hybrids represent a cross of flint and floury types; hence, dent hybrids differ in their ratio of horny to floury endosperm. The vitreousness also varies with the position of kernels on the cob, and the growing environment (Watson, 1987).

Starch granule is primarily composed of two structurally distinct α-linked polymers of glucose, i.e. amylose and amylopectin. Amylose is an essentially unbranched polymer of α-1,4-linked D-glucose units, with a chain length of several hundred units. The more abundant component of starch, amylopectin, is a much larger polymer (1000 to 50.000) of D-glucose units linearly chained by α-1,4-linkages but with α-1,6 branch points every 20 to 25 glucose units (Rooney and Plugfelder, 1986). The proportions of the two polysaccharides vary among grain and varieties, with amylose contributing from zero to about 20.0% of the total (Rooney and Pflugfelder, 1986; Kotarski et al., 1992). Amylopectin is more digestible in rumen than amylose, which will cause waxy cultivars to have higher starch digestibility in the rumen (Rooney and Pflugfelder, 1986; Huntington, 1997; Akay et al., 2002; Huntington et al., 2006).

Starch stored in highly structured granules in various shapes and sizes (range from 0.50 to 175 microns). Starch granules have both crystalline and amorphous region. The crystalline region is primarily composed of amylopectin and resistant to water entry and enzyme attack. While the amorphous region (gel phase) is less dense and richer in amylose than the crystalline area but includes also the α-1,6 branch points of amylopectin. Water moves freely through it and amylase attack begins in this region, while the hydrolysis of the crystalline region occurs more slowly

(Rooney and Plugfelder, 1986). It is generally accepted (Santacruz, 2004) that a radial arrangement of the amylopectin glucan chains within the starch granules is responsible for the semicrystalline nature of starch, as mentioned above. In addition to an apparently general difference in the starch degradation characteristics between C3 and C4 plants (Blank et al., 1998) stated that the starch granules of maize grain have a stronger effect on starch gelatinization compared to starch of other cereals (Flachowsky, 1994; Kotarski et al., 1992).

Maize varieties are classified according to their relative proportions of amylose and amylopectin in to three types of class's normal, waxy and extender. Starch of the corn grain of the normal type consists of 20.0 to 30.0% amylose and about 70.0 – 80.0% of amylopectin (Rooney and Pflugfelder, 1986). The amylopectin consist up to 99% from the waxy type (Kotarski et al., 1992). Belong to the extender type; it has about 75.0 and 25.0% for amylose and amylopectin respectively (Michalet-Doreau and Champion, 1995).

4.2 Ruminant physiology and rumen environment

What makes ruminant animals unique is that ruminant stomach consisted of four chambers which divided into two compartments, nonsecretory forestomach compartment (reticulum, rumen and omasum) and secretory stomach compartment (abomasum). The forestomach is the main site of the microbial fermentation of the feed, whereas the abomasum is the site of enzymatic hydrolysis and it is similar to the stomach of a nonruminant animal (Leek, 2004). Ruminants characterized also with the phenomena of rumination in which reticulum allows for regurgitation of feed for further mechanical breakdown (McDonald et al., 2002).

Ruminants require roughage in their diets to maintain health by sustaining a stable environment in the rumen. Ruminant diets consist mainly of β-linked polysaccharides, such as cellulose, which cannot be broken down by mammalian digestive enzymes (McDonald et al., 2002). Animal needs enzymes that are only found in plants and microbes to be able to break down these polysaccharides and other feed components. Therefore, ruminants have developed a special system of digestion that involves microbial fermentation of food prior to its exposure to their own digestive enzymes. The ruminant provides the microorganisms with a habitat for their growth, rumen, and microorganisms supply the animal with fermentation acids, microbial protein and vitamins (Hungate, 1966).

Like other continuous culture systems, the rumen requires a number of homeostatic mechanisms that make rumen environment stable and so the microbes are not threatened. This achieved through maintenance of the rumen pH around 5.5 to 6.5, which plays a major role in ensuring proper fermentation and uptake of feed constituents (McDonald et al., 2002). Ruminal pH is affected by the fiber concentration of the diet and the balance between production of fermentation acids and the secretion of salivary buffers (Krause et al., 2002). Saliva contains buffering substances (phosphate and bicarbonate); in addition to, the rapid absorption of the acids and also ammonia helps to stabilize and minimize fluctuations in ruminal pH (McDonald et al., 2002). Cattle can produce up to 200 liters of saliva per day, which dilute the feed during eating and rumination. Salivation is not a response to reductions in intra ruminal pH but is rather a reflex response to increased chewing and rumination, which is a result of a more fibrous diet (Leek, 2004). The amount of saliva produced each day is related to dry matter intake therefore, it increased with higher dry matter contents of ingested feed (Bergsten et al., 1997). Regular fiber intake is important to ensure proper digestion and, to some extent; ruminants exhibit an appetite for fibre. Excess or deficiency of fiber lead to digestive problems as excess of fibre can inhibit feed intake whereas fiber deficiency may cause digestive upset (Forbes and Provenza, 2000). Moreover, the particle length of forage plays an important role to maintain ruminal function (Beauchemin et al., 1997).

The digesta stratification is the most important pre-condition for an optimal digestion of nutrients in reticulorumen, especially of structural carbohydrates. Rumen contents often exist in two phases: a lower liquid phase, in which fine feed particles are suspended, and a drier upper phase which made up of coarser solid materials. Feed particles of various shapes and sizes enter the rumen and are suspended in the liquid phase then moved to the lower digestive tract. Large, irregular feed particles and those of low specific gravity tend to move to the top of the rumen where they are retained for regurgitation and further mastication to reduce the particle size (McDonald et al., 2002). Schettini et al. (1999) stated that feed particles having greater specific gravity escaped from the rumen at a faster rate than feed particles which have lower specific gravity. Therefore, feed particle size and specific gravity have been shown to be the primary determinants of particle retention time in the rumen (Poncet, 1991). Attainment and maintenance of stable digesta stratification depends mainly on the amount and the quality of structural carbohydrates in the diet as well as on the degradation rate and extent of structural carbohydrates of rumen mat itself.

The activities, ability, and capacity of rumen microorganisms to degrade and to utilize the dietary feeds clearly determine ruminant performance. Although substrate competition is high in the rumen, there are integration and synergism among rumen microorganisms which make the utilization of substrates more efficient. Rumen is a highly complex ecosystem as it contains different microbial species with a great potential for microbial associations. Many relationships among rumen microorganisms are exist inside the rumen (Lee et al., 2000). Rumen microorganisms comprises several hundred species of bacterial species (10^9 to 10^{10}/mL of rumen fluid) (Hungate, 1966), 40 species of protozoa (10^5 to 10^7/mL of rumen fluid) (Williams and Coleman, 1997), and 5 species of fungi (< 105/mL of rumen fluid) (Orpin and Joblin, 1997). Rumen microorganisms are responsible for degradation of most plant cell wall in the rumen and responsible for 50 to 80% of cell wall degradation in vitro (Lee et al., 2000). Rumen bacteria are considered to be more important than rumen protozoa and fungi in determining the extent and the rate of feed degradation and utilization for production of microbial protein and VFA (Stewart et al., 1997). Microbial population and fermentation patterns vary with changing rumen environment. A continual supply of substrate, and salivary buffering salts and the removal of end products and residues will result in a relatively stable rumen environment, thus promoting high microbial populations and increased biomass.

Ruminal microbiota produces extracellular enzyme complexes which ferment polysaccharides (cellulose, hemicellulose, pectin and starch) to short chain VFA, which are then used by the host, providing energy and carbon for the growth and maintenance of rumen microorganisms (Wolin and Miller, 1997). The main short chain VFA produced in the rumen are acetic, propionic and butyric acids with molar proportions of 70:20:10 in hay based diet, and of 50:35:15 in concentrate based diet, respectively (Rémond et al., 1996). These short chain fatty acids represent the main energy source for ruminants, and provide about 60% of its energy needs. In addition, ruminal gases resulting also from the ruminal fermentation processes which consists approximately of 50 to 60% CO_2 and 30 to 40% methane (Engelhardt and Breves, 2000). Methane thereby sets a significant loss of energy (2 to 15% of gross energy) (Johnson et al., 1993).

Accumulation of short chain VFA within the rumen fluid tends to lower rumen pH. Therefore, VFA within the rumen are readily absorbed by passive absorption through the rumen epithelium (Sharp et al., 1982; Bergman, 1990). Production of VFA after feed fermentation may exceed absorption but there is a balance between production and absorption of VFA to prevent its accumulation to a level which reduces rumin pH. However, following a large meal, minor accumulation of VFA does normally occur resulting in a diurnal fluctuation of rumen pH. Animals consuming forage based diets can maintain a healthy ruminal pH. However, intake of more readily fermented carbohydrates (starch contained in cereal grains) results in lower ruminal pH. High fermented carbohydrates diets lead to increased rate of VFA production and accumulation generally reduce mean ruminal pH to between 5.6 and 6.2 (Schwartzkopf-Genswein et al., 2002).

4.2.1 Kinetics of fiber digestion in ruminant

Ruminant digestive process is a dynamic system involving an inflow of feed to the rumen and an outflow of liquid, bacteria and undigested feed residues to the lower tract. The extent of digestion of cell wall carbohydrates in the rumen is the result of two competing mechanisms, passage and digestion cited by (Mohamed, 1997). Waldo et al. (1972) developed a model for cell wall digestion in rumen, in which the potentially digestible cellulose fraction leave either by digestion or passage from the rumen, while the indigestible fraction can be removed only through passage. Mertens (1977a) combined the two processes into a mathematical model that can serve as a useful reference for describing the mechanisms involved in digestion, the model divided ruminal digestion into four components: digestion rate, digestion lag, potential extent of digestion and passage rate. Each component affects the apparent extend of digestion in a distinct manner and influenced by separate factors.

Rate of digestion defined as the proportion of the digestible fraction of a feedstuff or nutrient within feedstuff that is digested in a set time period. Mathematically it calculated as the difference between the disappearance rate and the passage rate. It is commonly measured with in vitro or in situ digestion. Factors affecting digestion rate can be divided into two categories: those inherent in the cell wall and those affecting the microbial populations or their enzyme system (Mertens, 1977b).

Rate of passage also called turnover rate or, for liquid digesta, dilution rate equals the proportion of the undigested residues from a given meal that passes a given point in the gut in a set period of time. It calculated as the flow of undigested residues from the rumen divided by the rumen volume of digesta. Digestibility usually is a competition between rates of passage and digestion. Digestible fiber leaves the rumen either by enzymatic breakdown or by passage to the lower tract. Allen and Mertens (1988) developed a simple model of fiber flow utilizing these fractional rate constant in this model digestibility determined as the fractional rate constant of digestion (kd) divided by the total fractional rate constant of disappearance from the rumen (kd + kp)

Digestion % = kd / (kd + kp)

and Passage % = kp / (kd + kp)

Therefore, fiber digestibility is directly related to rate of digestion. The intrinsic characteristics of the fiber including chemical composition and physical structure determined rate of fiber digestion. Plant tissues differ in their rates of disappearance and so tissue morphology also may affect accessibility and rate of digestion (Akin, 1986). Rate of digestion is positively related to the surface area that is accessible to enzymes (Stone et al., 1969; Robles et al., 1980). The maximal rate of fiber digestion is modified by non feed factors such as microbial attachment, enzyme production and enzyme activity (Allen and Mertens, 1988). From this model it is clear that digestibility of fiber decreased as rate of passage increased. Rate of passage is inversely related to rumen volume at a given level of intake. Rumen volume determines how much fermenting material can be accommodated at any one time. As rumen capacity has been found to be a linear function of body weight (Demment and Van Soest, 1982) and maintenance energy requirement is related to body weight to the three-quarters power (National Research Council, 2001), the ability to digest fiber tends to increase with body size because rate of passage is reduced relative to energy demand. Other factors either known or suspected to affect rate of passage include the initial particle size of the diet (Rodrigue and Allen, 1960), rumen motility (Sissons, 1984), and specific gravity (King and Moore, 1957; Ehle, 1984). Thus, any of these factors could alter digestibility through their effect on rate of passage (Allen and Mertens, 1988).

Digestion lag defined as delay prior to apparent digestion this time is required to exposing and wetting of feed and attachment of microbes to the feed stuff. Allen and Mertens (1988) stated that when feedstuffs enter the rumen, feed particles must become wetted with rumen fluid before rumen microbes and their enzymes can gain physical access to fermentation sites. The rate of fiber availability for access by rumen microbes is limited by the rate at which wetting occurs. Wetting rate is probably determined by the hydrophilic groups on particle surfaces, surface tension, concentration of rumen fluid gases and particle size and structure. Rumination and rumen movements probably modify wetting rate. However, fiber digestion rates will not be maximal until microbes and their enzymes are attached or in close proximity to fiber digestion sites. Therefore, microbial attachment to available fermentation sites is one step in the process referred to as fermentation lag. Allen and Mertens (1988) stated that microbial attachment is dependent on the number of available attachment sites, the mass of fiber digesting microbes in the rumen, the species composition of the microbial population and the ability of the different species to attach to and colonize the fiber. Plant surfaces are covered with cutin, which resists microbial fermentation and limits access of microbes to fermentation sites. Penetration of the feed particles by microbes occurs at fracture sites (Baker and Harris, 1947) caused by chopping, grinding and chewing. Once a feed particle is saturated with microbes, rate of digestion is determined by the fiber chemical composition, the surface area available for enzymatic attachment and the microbial enzymes activity (Allen and Mertens, 1988).

The extent of digestion defined as the amount of forage that can be digested if held in the rumen for an infinitive period of time. The potential extent of digestion of any forage appears to be set by factors inherent in the cell wall. These factors include chemical composition, plant morphology and crystallinity. Chemical composition appears to be the most important with lignin being highly correlated (r = 0.78) to cell wall indigestibility (Smith et al., 1972).

4.2.2 Starch digestion in rumen

Several species of ruminal bacteria are able to digest starch. Amylolytic organisms are found in larger percentages of the total microbial population when rations high in starch are fed. Kotarski et al. (1992) Reported 15 strains of amylolytic bacteria and characterized eight amylolytic enzymes produced by those bacteria. At least some of these bacteria adhere to and colonize feed particles in the rumen and produce endo- and exo-enzymes that hydrolyze the α-1-4 and α-1-6 bonds of amylose and amylopectin. The fragmentation by alpha-amylase initially leads to a rapid reduction in the molecular size of the starch with formation of water soluble dextrins and oligosaccharides. The final products from amylose are maltose, maltotriose and sometimes small amounts of free glucose. Maltotriose is generally stable to the action of both alpha and beta-amylases, unless massive quantities of enzyme are added. The final products from amylopectin are maltose, maltotriose, a little glucose and a mixture of alpha-limit dextrins. These latter oligosaccharides consist of 4 - 8 glucose moieties and still contain α-1-6 linkage which cannot be hydrolyzed by amylases. Debranching enzymes (R-enzyme, pullulanase, iso-amylase, or alpha limit dextrinase) are necessary to break these bonds (Clark and Bauchop, 1977). However, not all bacteria are equipped with a complete array of digestive enzymes; therefore, maximal digestion of starch to monosaccharide's requires integration among bacterial species. Coculture of Streptoccocus bovis, Butyrivibrio fibrisolvens, Bacteriodes ruminicola, and Selenomonas ruminatium demonstrated the importance of cross feeding among bacterial species in attaining greatest bacterial growth rates and complete digestion of starch (Cotta, 1992). Protozoa can exert an influence on ruminal starch hydrolysis rates in at least two respects: 1) by ingesting bacteria in numbers sufficient to decrease ruminal fermentation rates (Eadie and Hobson, 1962; Clark and Bauchop, 1977; Kurihara et al., 1978) and 2) by ingesting starch granules and soluble sugars, thus decreasing the accessibility of these substrates to fermentation by the faster growing bacteria (Coleman, 1986; Coleman, 1992). The presence of ciliates influences the site of starch digestion. It has been reported that protozoa reduce rate of starch digestion and ruminal starch digestibility, shifting the site of starch digestion to the small intestine (Mendoza et al., 1993). Therefore, rate and extent of ruminal starch digestion were greater when protozoa were eliminated from the rumen of sheep fed high moisture corn and dry rolled sorghum (Mendoza et al., 1993). The hyphae of fungi may play an important role in bacterial attachment by creating lesions in the surface of plant tissue (McAllister et al., 1994).

Owens et al. (1986) stated that starch of cereal grains is almost completely digested in the total tract (rumen and intestine). Philippeau et al. (1999b) looked at rumen starch digestibility of wheat and corn based diets. Wheat based diet increased ruminal starch digestion when compared to maize based diets (86.6 versus 47.8%). Research conducted by McCarthy et al. (1989) and Casper et al. (1990) showed that barley based diets have a higher ruminal starch digestibility than maize based diets. Herrera-Saldana et al. (1990) also demonstrated that some cereal grains are more available for rumen degradation than others. They compared five cereal grains using in vitro and in situ methods for analyzing digestibility of starch. They found that oats are more available for starch digestion in rumen, followed by wheat, barley, maize and then milo. This means that starch of maize and milo is significantly lower in ruminal degradability in comparison to starch of wheat, barley and oat grain. Sorghum-based diets were found to have a significantly lower ruminal starch digestion (75.0%) when compared to maize (84.0%) or barley (88.0%) based diet (Spicer et al., 1986). The apparent digestibility of starch and protein are greatest for barley and least for sorghum, with maize being intermediate (Theurer, 1986).

4.3 Methods of feed evaluation for ruminants

Estimation of feed nutritive values is very important to maximize the efficiency of feed utilization in ruminant feeding,. Several techniques have been established to estimate the contribution of feed to the rumen in the process of efficient digestion and animal performance. In this study we will describe only two methods of them.

4.3.1 Analytical procedures

The proximate principles system is the historical method of feed analysis. Since the mid of the nineteen centary this principle has been used to evaluate forage (Undersander et al., 1995). This system depends on partition of carbohydrate into crude fiber and nitrogen free extract. Disadvantages of this system are low precision and part of hemicellulose and soluble lignin dissolved and lost into the nitrogen free extract fraction therefore, crude fiber does not recover all the fiber content.

In the 1970s the proximate system of fiber analysis was replaced by the more meaningful detergent system which measures more basic components of plant structure and relates them to animal digestion and production according to their availability to both rumen microorganism and animal (Abeysekara, 2003). This system depends on using detergents to separate feed stuff dry matter into cell contents (soluble carbohydrate including pectic substances, protein and other soluble compounds) and cell wall fiber fractions (cellulose, hemicellulose and lignin). The neutral detergent fiber (NDF) method (Van Soest et al., 1991) dissolves cell contents and provides a measure of the total cell wall material as insoluble residue. NDF has proven of value providing a robust measure of the cell wall content of forages and enables to distinguish cellular differences between forage and concentrates (Mertens, 1997). Therefore, NDF is a valuable method that rank all feed stuffs in a continuum from feeds containing no fiber, low fiber concentrates, to high fiber straws and cellulose. On the other hand the acid detergent fiber (ADF) method dissolves part of protein and hemicellulose, leaving cellulose, lignin and insoluble ash which is mainly silica as insoluble residue (Van Soest et al., 1963). Therefore, acid detergent fiber (ADF) mainly consists of the insoluble hemicelluloses, and lignin and cellulose. Hemicellulose can be calculating as the difference between NDF and ADF values. ADF is relatively low in digestibility and hence ADF content can be used to predict the energy content of forage (Beauchemin, 1997). ADF residues can be separated into lignin and cellulose contents either through removal of lignin by potassium permanganate oxidation, or removal of cellulose by sulphuric acid hydrolysis (Goering and Van Soest, 1970).

4.3.2 In situ degradability method

The dacron bag technique for measuring the in situ rumen degradability of feeds has received widespread attention partially because it is a relatively simple, low cost method compared with methods involving intestinally cannulated animals. This technique is very old, and was used for the first time by Quin et al. (1938). They used silk bags which were introduced in the rumen via a cannula. The technique involves suspending bags containing the feedstuff in the rumen and measuring nutrient disappearance at various time intervals. Zeller (2009) in situ technique provides an advantage compared with laboratory methods because it involves digestive processes that occur in the rumen of a living animal. In situ degradability method with rumen fistulated animals are limited to the determination of the degradability of feeds in the rumen. Through the use of live animals, this method is considerably more complex than laboratory methods. But in general the in situ method is considered as a reference method for the description of degradation processes in the rumen, especially as regards the determination of the degradation kinetics of fiber rich feedstuffs (De Boever et al., 2002). Huhtanen et al. (1995) have shown that 94 - 96% of the fiber degradation occurs in the rumen. This is also the reason why this method was chosen as the reference method in the present study. It is one of the few techniques that describe the kinetics of feed degradation in the rumen. Moreover, one can calculate the effective degradability of the feed by a mathematical analysis of the results. The effective degradability represents a value that refers to a particular assumed passage rate of feed through the rumen (Zeller, 2009). The extent of degradation of each nutrient fraction is determined from the difference of the amount of nutrient in the nylon bags before and after removal of the nylon bags from the rumen. By incubation in defined intervals time, it is possible with the nylon bag technique to create typical ruminal degradation curves for a feed. In the interpretation of losses from the nylon bags, it is assumed that they correspond to the ruminal degradation of nutrients (Kurtz 2006). Dewhurst et al. (1995) found in a study with fifteen different feedstuffs that in situ technique is a good and suitable method to determine the rumen degradability of the feed stuffs with high fiber content. Also

Verbic et al. (1995) stated that in situ method is a good method for differentiation of the feeding value of various maize varieties. The technique has also provided relatively good predictions of forage digestibility (Ørskov, 2000). Yet the technique is plagued by low reproducibility and repeatability (Noziere and Michalet-Doreau, 2000) and it is notoriously difficult to standardize despite repeated attempts (Madsen and Hvelplund, 1994).

Several factors affect estimates of nutrient digestion and need to be controlled for the in situ technique to be standardized. These factors include porosity of bag material and size, bag pore size, ratio of sample weight to bag surface area, particle size of sample, method of bag placement in the rumen, washing and drying procedure, extend and nature of particulate losses, host animal species and diet of the animal, frequency of animal feeding, and degree of bacterial attachment to feed residues remaining in the bag (Stern et al., 1997). In this work we tried to overcome these disadvantages as fixing the type of the bags, particle size of the sample (3 mm), sample weight (4.0 g) in all bags, using the same six cows and using elastic wire for placing the bags inside the rumen with attachment of the three replicates at different levels on the wire. Also we tried to fixing the washing (using the same washing machine) and the drying procedures (using freeze drying machine).

4.4 Factors affecting rumen dry matter degradability of maize stover

Recently, agronomists, nutritionists, and dairy producers have placed increased emphasis on factors affecting the nutritive value of maize stover like maize variety and stage of maturity at harvest (Flachowsky et al., 1993; Akbar et al., 2002; Gruber and Hein, 2006). These two factors can be managed and controlled and this will be discussed in details in this work. Also secondarily environmental factor such as soil type, day length, temperature during plant growth are important. It is generally assumed that cell wall content increases with increasing maturity and it is negatively correlated with plant digestibility. Plant cell wall lignifications depend on the environmental temperature and plant maturity. Low temperature increase stem diameter, plant height, leaf stem ratio, digestibility, decrease lignifications and delaye maturity. Light and photoperiod promote photosynthesis and the production of sugars and metabolites that dilute the structural matter, hence a negative association between light and cell wall components (Van Soest et al., 1978). Struik et al. (1985)

investigated the influence of temperature on the proportions of several maize plant fractions and found that the dry matter proportion of stems ranged from 18.4% (low temperatures) to 41.7% (high temperatures) during growing period. Similar variations were measured for leaves (16.4 to 20.3%) and cobs (36.0 to 64.0%). Furthermore, the plant weight varied between 136.0 g DM (low temperatures) and 202.6 g DM (high temperature). Abeysekara (2003) cited that low moisture levels in soil delay plant maturity, decrease plant height, increase leaf stem ratio and can decrease NDF percentage. Generally stress factors promote digestibility through retardation of plant development.

4.4.1 Effect of maturity stage on rumen dry matter degradability of maize stover

Compared to other crops, maize produces the largest proportion of crop residues (stover) which serve as an important source of feed for ruminant. The quantity and quality of maize stover are very variable. Stage of maturity at the time of harvest for silage making is considered as one of the most important factors that influencing the nutritive value of maize stover (Tolera et al.,1998). Masoero et al. (2006) stated that during maturation phases of maize plant there is a progressive lignification of the vegetative part which tends to reduce digestibility of maize stover. Mtimuni (1976) and Masoero et al. (2006) stated that the stage of maturity affect the content of structural polysaccharides and lignin; generally these increase in concentration with advancing stage of maturity and the digestibility being related inversely to the composition of lignin carbohydrate complexes. Thus increased percentage of fibrous components with increasing maturity of maize stover mainly results from increasing dilution effect of the grain with increasing grain to leaf and stem ratio. However, this is not applicable to all forage plant species because age and the physiological maturity are not identical. Depending on growth conditions plant may reach physiological maturity at early or late chronological maturity (Steacy, 1980; Abeysekara, 2003).

As said before, in this study harvesting of maize plant occurred at different harvest dates and the second harvest date was designed to simulate the normal harvest time of maize plant such as farmers practice in the field. The early and late harvest dates were harvested two weeks early and two weeks late than the second one respectively. Rumen dry matter degradability of maize stover at the different incubation times in the first three experiments is presented in Figure 11. This Figure indicated that rumen DM degradability increased with increasing the incubation hours. Mean of stover DM washing losses (0 h) at Exp 1 decreased with increasing plant maturity and it decreased from 33.0% at early to 30.0% at late harvest. But the decrease in stover DM washing losses with increasing maturity became more pronounced at Exp 2 as it decreased from 29.0% at early to 21.0 at late harvest as well as in Exp 3 as it decreased from 35.0 at early to 24.0 at late harvest. The decreased in DM washing losses accompanied with decreasing in the rapidly soluble fraction and it decreased from 33.0% at early to 30.0% at late harvest in Exp 1 and decreased from 29.0% at early to 22.0 at late harvest in Exp 2 as well as it decrease from 35.0 at early to 24.0 at late harvest in Exp3 (Figure 12). These results are in agreement with the finding of Zeller (2009) as she studied the effect of stage of maturity on the in situ DM degradability of maize stover of six varieties over a period of three years (2004, 2005 and 2006) at four stages of maturity and found that mean of DM washing losses of maize stover decreased with increasing plant maturity from 33.0% at early to 27.0% at late harvest. In the same time mean of the rapidly soluble fraction of maize stover decreased from 33.0% at early to 27.0% at late harvest. Regarding slowly degradable fraction of maize stover it increased from 38.5% at early to 40.0% at late harvest in Exp 1 and increased from 45.0% at early to 51.0 at late harvest in Exp 2 as well as it increased from 41.0 at early to 48.0 at late harvest in Exp3 (Figure 12). These results are compatible with Zeller (2009) who found that slowly degradable fraction of maize stover increased from 40.0% at early to 43.0% at late harvest.

The highest mean of stover DM degradability was after 96 h of incubation in which it reached more than 70.0%. Mean of stover DM degradability after 96 h of incubation decreased with increasing plant maturity from 73.0% at early to 71.0% at late harvest in Exp 1 and decreased from 73.0% at early to 70.0 at late harvest in Exp 2 as well as it decreased from 75.0 at early to 71.0 at late harvest in Exp3. This is in harmony with the finding of Zeller (2009) who found that DM degradability of maize stover at 96 h decreased from 73.0% at early to 69.0% at late harvest. The non degradable part increased with increasing plant maturity, and it increased from 29.0% at early to 30.0% at late harvest in Exp 1 and increased from 26.0% at early to 28.0 at late harvest in Exp 2 and this increase became more pronounced at Exp 3 as it increased from 24.0 at early to 27.0 at late harvest. Also Zeller (2009) found that the non degradable fraction of maize stover increased from 27.0% at early to 30.5% at late harvest. DM degradability and degradability parameters of the present work (Figure 11 and 12) agreed with the findings of Ørskov (2000) which highlighted some similarities in DM degradability of roughage in the rumen using the in situ method.

The difference in DM degradability of maize stover between first and last harvest stage decreased with increasing incubation hours. For example, in Exp 3 after 2 h of incubation DM degradability of maize stover decreased from 35.0% at early to 25.0% at late harvest with a difference of 10.0%, but after 96 h of incubation DM degradability of maize stover decreased from 75.0% at early to 71.0% at late harvest with a difference of 4.0%. This proved that the problem however, is not the digestibility of stover, but rather, the length time needed for the degradation process. This is because of long retention time of fiber in rumen, or the length of time that fiber is exposed to the fibrolytic process. Thus with long incubation hours decrease the difference in degradability between the maturity stages (Zinn and Ware, 2007).

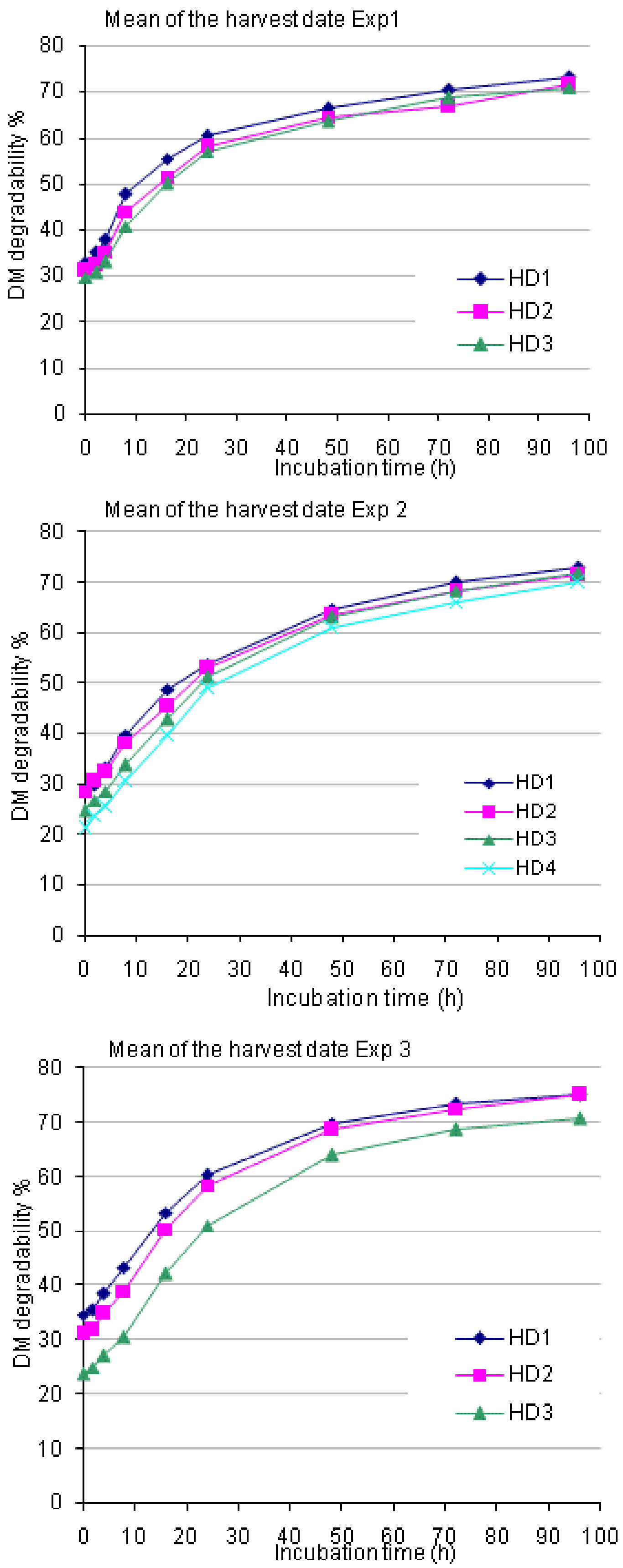
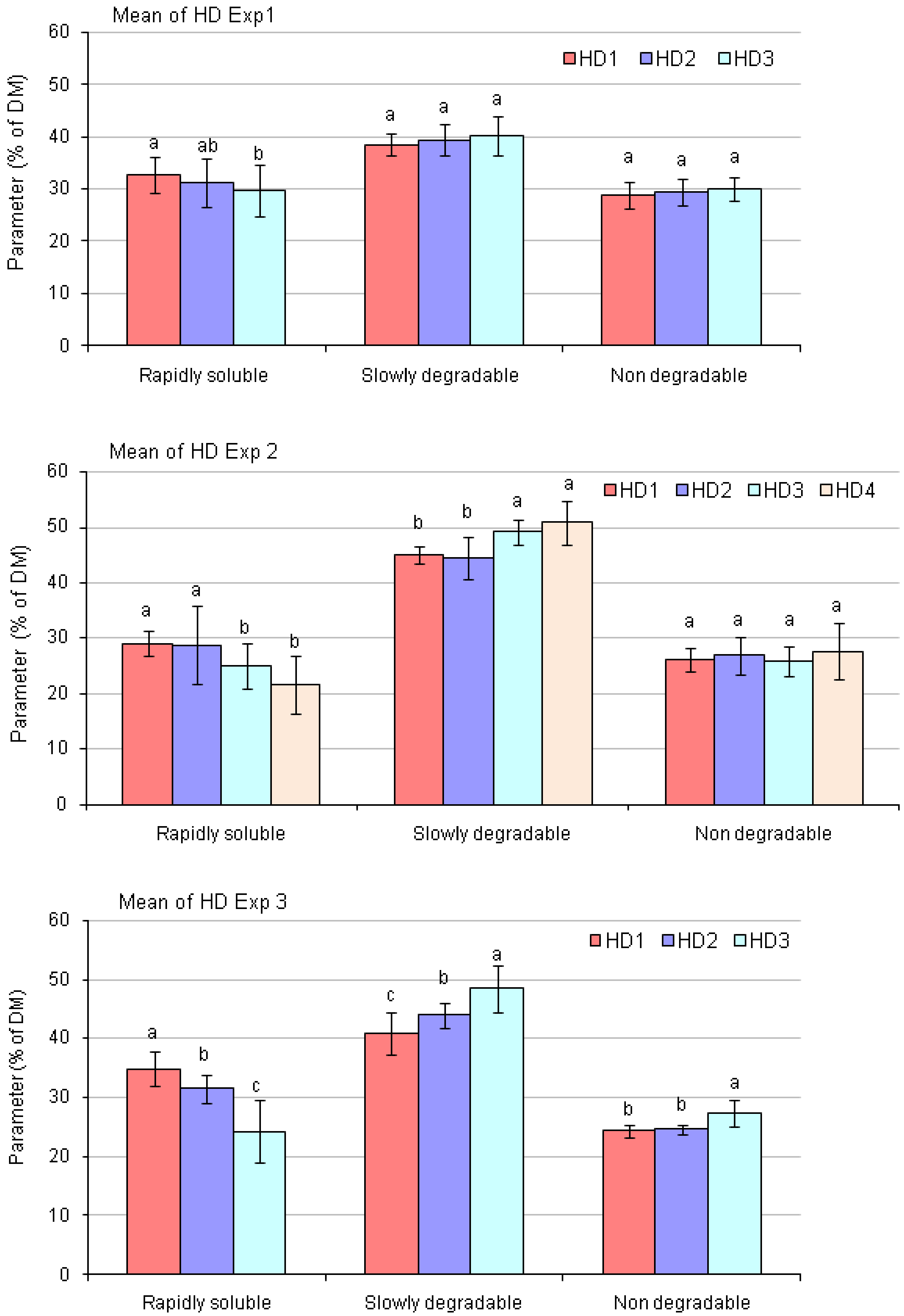


Figure 11. Effect of maturity stage on rumen dry matter degradability of maize stover at the different incubation times at the first three experiments



For each parameter, different letters are significantly different

Figure 12. Effect of maturity stage on the parameters of rumen dry matter degradability of maize stover at the first three experiments

Table 45. Effect of maturity stage on the effective rumen dry matter degradability (%) of maize stover by passage rate of 6%h^{-1}

	Mean of harvest date			
Exp No	***HD1 (02.09.-08.09.)***	***HD2 (18.09.-25.09.)***	***HD3 (02.10.-09.10.)***	***HD4 (17.10.)***
Exp 1	50.8	47.6	46.0	-
Exp 2	44.9	43.6	40.7	37.8
Exp 3	50.0	47.0	39.7	-
Zeller (2009)	48.2	46.6	44.2	41.1

Results of the effect of maturity stage on effective rumen DM degradability of maize stover of the present work and the work of Zeller (2009) by passage rate of 6%h^{-1} are illustrated in Table 45. This table indicated that the effective rumen DM degradability of maize stover decreased with increasing plant maturity and the results of the present work are consistent with the work of Zeller (2009). During maize plant maturity there is a strong changes in chemical composition of maize stover and the proportion of maize stover fractions (steam, leaf and husk) occur. But which chemical components can affect the degradability and can be improved through plant breeder is also an important question. The decrease in DM degradability with increasing stage of maturity could be attributed to translocation of cell soluble substances towards grain with increased fibre content (cellulose, hemicelluloses and lignin) in stover and to a decrease in digestibility of cell wall constituents. Therefore, Figure 13 indicates that there is a negative correlation of R^2 = 0.834 between crude fiber and effective rumen dry matter degradability of maize stover by passage rate of 6%h^{-1}. Russell (1986) harvested maize stover from a single hybrid across 3 years at three maturities ranging from 3 weeks pre- to 5 weeks post physiological maturity. He stated that non structural carbohydrates and in vitro DM digestibility decreased and fiber concentration increased with advancing maturity. The reduction in DM degradability results from both changes in the proportion of stover fractions and changes in chemical composition of these fractions. As he found that the concentrations of NDF, ADF and ADL (lignin) increased linearly with later harvest but the lignin to NDF ratio did not affected by harvest dates. The increased ADL concentration in the DM, therefore, would seem to be due to the increased cell wall concentration and not to increased lignifications of the cell wall. This indicates that the lignin content of maize stover cell walls is not a reliable indicator of the availability of cell wall carbohydrates to microbial enzymes. Therefore, he attributed the decline in the digestibility of maize stover with increasing maturity to the increase in the concentration of NDF caused by a loss of water soluble carbohydrates and is not due to increased ligninfication of the cell walls. But Russell et al. (1992) reported that in vitro DM digestibility of maize stover decreased with advancing maturity and was highly correlated with ADF and lignin contents. Also Andrea et al. (2001) studied the effect of stage of maturity on intake and in vivo digestibility of maize stover and stated that maize stover similar to other grasses, declines in digestibility as the plant matures. Decreased digestibility of NDF and ADF in mature forage is presumably the result of increased lignification which interfering with enzymatic access to cell wall polysaccharides. Other studies in situ (Flachowsky et al., 1993) and in vivo in beef cattle (Brown et al., 1999) have shown reductions in NDF digestibility with increasing maturity of maize at harvest. In agreement with Russell (1986) Tolera et al. (1998) studied the in situ DM degradability and degradability characteristics of maize stover harvested at three stages of grain maturity and concluded that there was a decreasing trend in DM degradability with increasing stage of maturity. Reduction in the nutritive value of stover with increasing stage of maturity was characterised by increasing concentration of fibrous constituents. These were a reflection of changes in the morphological composition of stover and losses of nutrients within the morphological fractions with increasing stage of maturity. At early stage of maturity stover has higher leaf to stem ratio and leaf has higher potential degradability and higher degradation rate than stem, and in turn DM degradability of maize stover at early stage of maturity is higher than late one. Also Akbar et al. (2002) studied the effect of stage of maturity of maize stover on in situ dry mater degradability and found that later harvested plants showed lower DM degradability of maize stover than early harvest. They concluded that loss of sugars from the stem and the increase in fibre constituents with maturity of plants are the causes for decreased DM degradability with increasing plant maturity. Also they stated that longer lag time could be a reflection of their relatively high lignin and cellulose content in the stover. Zeller (2009) stated that physiological maturity plays a major role in the determination of the feeding value of maize. It appeared that ruminal degradability reduced substantially with advancing maturities of the plants. She also found a strong negative interaction between NDF content and ruminal degradability of maize stover (r = - 0.81). Also in contrast to Akbar et al. (2002), Zeller (2009) found that there is no significant relationship between lignin contents and ruminal DM degradability of maize stover.

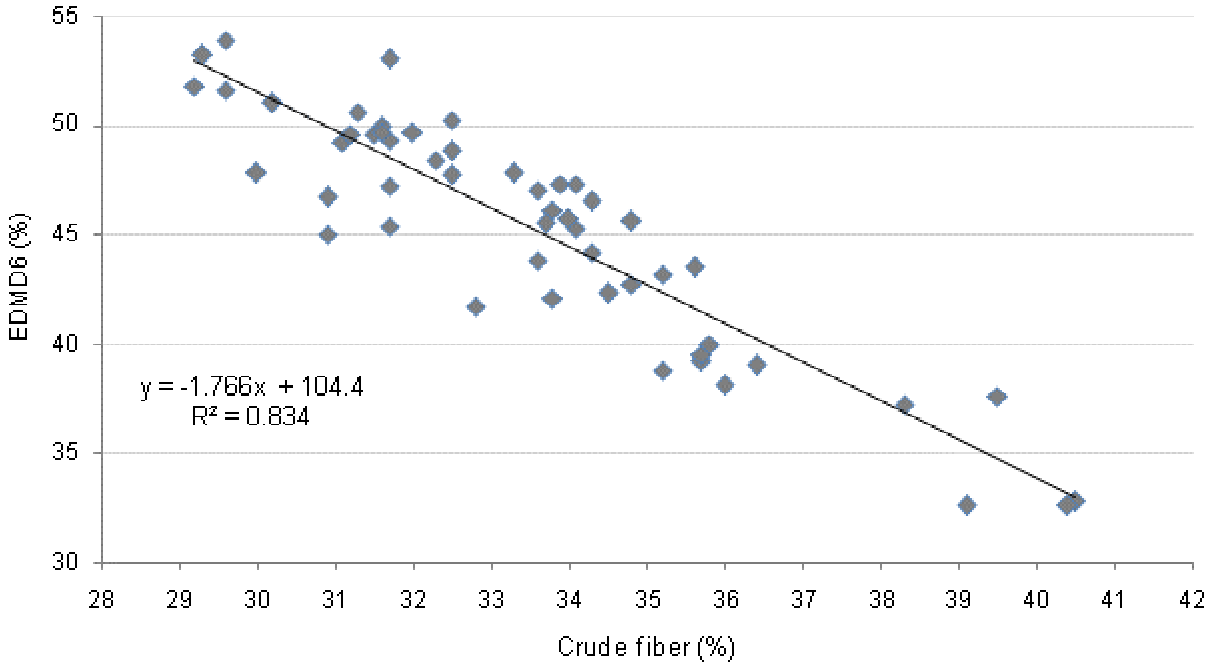


Figure 13. Relationship between maize stover crude fiber content and effective dry matter degradability by passage rate of 6%h^{-1}as affected by maturity stage

4.4.2 Effect of maize variety on rumen dry matter degradability of maize stover

In the seventies of the previous century, plant breeder and animal nutritionist found significant difference in digestibility of maize silage hybrids with the same physiological maturity, which could not be explained by the cob portion at this time (Bunting 1975; Hunter, 1978). Barriere et al. (1992) attribute less than 40% of genetic variation in the in vivo digestibility of organic matter to the grain portion. This strengthened the need to investigate the effect of maize stover (crude fiber) digestibility on the feeding value of maize plant. Later on genetic variation for fiber concentration and dry matter digestibility of maize stover was observed by Albrecht et al., 1986; Dhillon et al., 1990; Hunt et al., 1992. Decreased in fiber concentration are commonly correlated with increased digestibility of maize stover (Dhillon et al., 1990; Hunt et al., 1992). Development of elite maize hybrids specifically for forage has had low priority, although some attention has paid to hybrids for forage quality traits. Because grain is highly digestible, maize hybrids for silage production are generally chosen based on their grain yield. However, the stover portion of the maize plant contains 50% or more of the whole plant biomass and most of the fiber which is much less digestible than fiber in grain (Hunt et al., 1992). For these reasons stover is the plant structure most commonly identified as a potential target for genetic improvement. This is because usually the best varieties for grain production are not the best varieties for silage maize production (Galleis et al., 1976; Fairey, 1980a and b). In contrast White et al. (1981) and Flachowsky et al. (1991) showed that cultivars with higher straw quality were not consistently associated with lower grain yields, and this gives a potential to select for a high grain yield without sacrificing stover degradability. Jung et al. (1998) stated that the use of maize silage by ruminant livestock may be improved through genetic selection for decreased concentration or increased rate or extent of fiber digestion.

Due to the unequal maturity of cobs and stover, maize varieties classified into two major categories, maize varieties whose cobs mature faster than stover (stay green) and maize varieties whose stover mature faster than cobs (dry down). In accordance with the FAO nomenclature all maize varieties fall within numbers 100 - 900 (Zscheischler et al., 1990). Maize varieties are divided into maturity groups according to the length of time required from sowing to maturity. These groups are labelled as early, mid early, mid late and late. Within each group varieties are once more subdivided with the help of number 10. Early maturity group: S180 – S220, mid early maturity group: S230 – S250 and mid late maturity group: S260 – S280. In the present work the three experiments divided according to this classification into:

1. In Exp 1 varieties EXP99FN and NX0601 were classified as early maturity group and varieties NK Magitop, NX1494, NX1485 and NX1064 were classified as mid early maturity group.
2. In Exp 2 varieties NK Magitop, NX1775 and Winn were classified as mid early maturity group and variety NK Lemoro was classified as mid late maturity group.
3. In Exp 3 varieties NK Magitop, NX1485, NX10126 and NX04016 were classified as mid early maturity group and varieties NX20026 and NX17066 were classified as mid late maturity group.

The obtained results indicated that there was a difference in DM degradability between the two maturity groups at the three experiments (Figure 14). The mid early maturity group was highly degradable than early maturity group at Exp 1, but in Exp 2 and Exp 3 mid early maturity group was highly degradable than mid late maturity group. Zeller (2009) studied the effect of genetic variation (maturity group) on the in situ DM degradability of maize stover and she found that early maturing group had higher DM degradability than mid late maturity and mid early maturity group.

At Exp 1 DM degradability of mid early maturity group after 96 h of incubation (73.0%) was higher than that of early maturity group (70.0%). Also at Exp 2 after 96h of incubation mid early maturity group was higher in DM degradability (73.0%) than mid late maturity group. The same for Exp 3 DM degradability of mid early maturity group after 96h (74.0%) was higher than that of mid late maturity group (73.0%). Zeller (2009) found that after 96h of incubation DM degradability for early maturity group (73.0%) and mid late maturity group (72.0%) were significantly higher than mid late maturity group (70.0%) which disagree with the present work.

The effect of maize variety (maturity group) on parameters of the effective rumen dry matter degradability of maize stover is showed in Figure 15. At Exp 1 mid early maturity group was higher in the rapidly soluble fraction (32.0%) than early maturity group (29.5%), also the slowly degradable fraction of mid early maturity group (40.0%) and early maturity group (39.0%) were nearly equal in values, but the non degradable part of early maturity group (32.0%) was higher than that of mid early maturity group (28.0%). For Exp 2 the rapidly soluble fraction of mid early maturity group (27.0%) was higher than that of mid late maturity group (22.0%) and the non degradable part of mid late maturity group (31.0%) was higher than that of mid early maturity group (25.0%). In Exp 3 also the rapidly soluble fraction of mid early maturity group (32.0%) was higher than that of mid late maturity group (27.0%), but the slowly degradable fraction of mid late maturity group (47.0%) was higher than that of mid early maturity group (43.0%). Zeller (2009) found that the rapidly soluble fraction of early maturity group (30.0%) was higher than that of mid early maturity group (28.0%), and the slowly degradable fraction of early maturity group (43.0%) was nearly equal to that of mid early and mid late maturity group (42.0%).

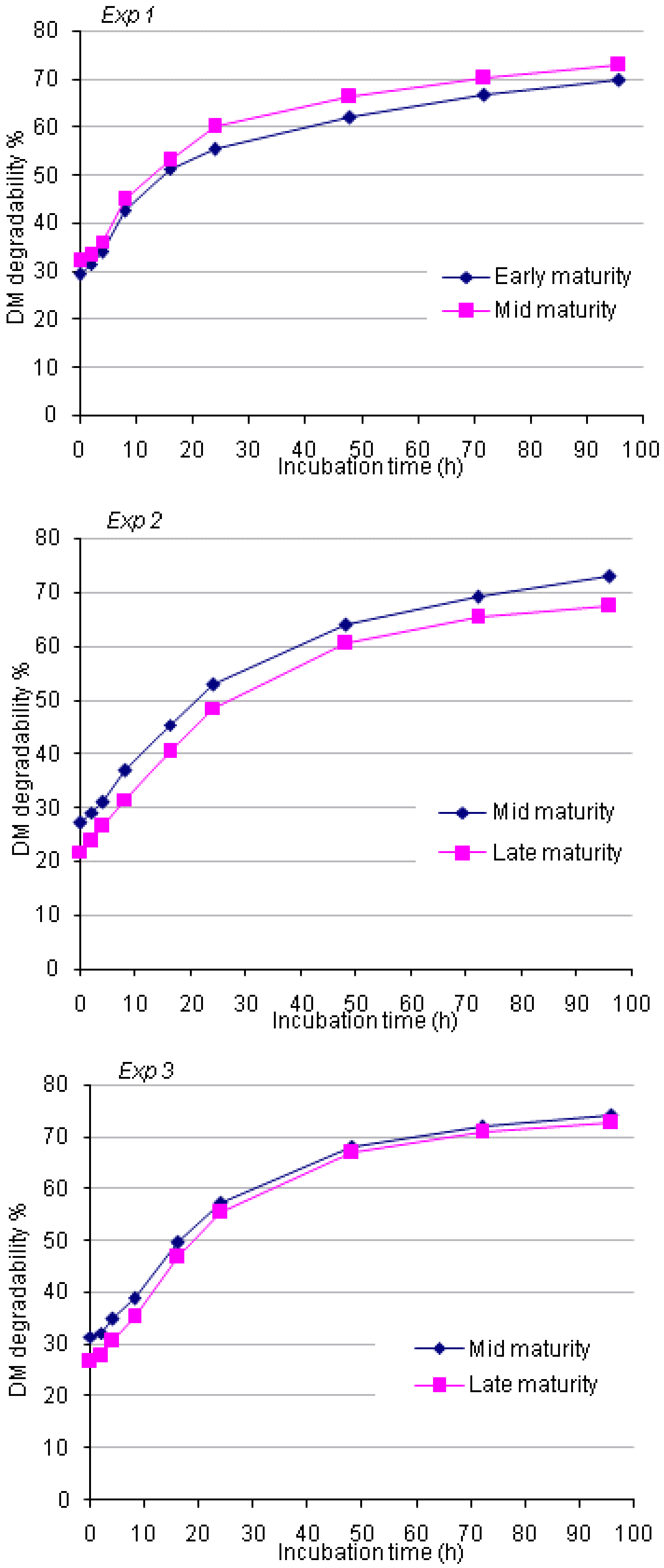
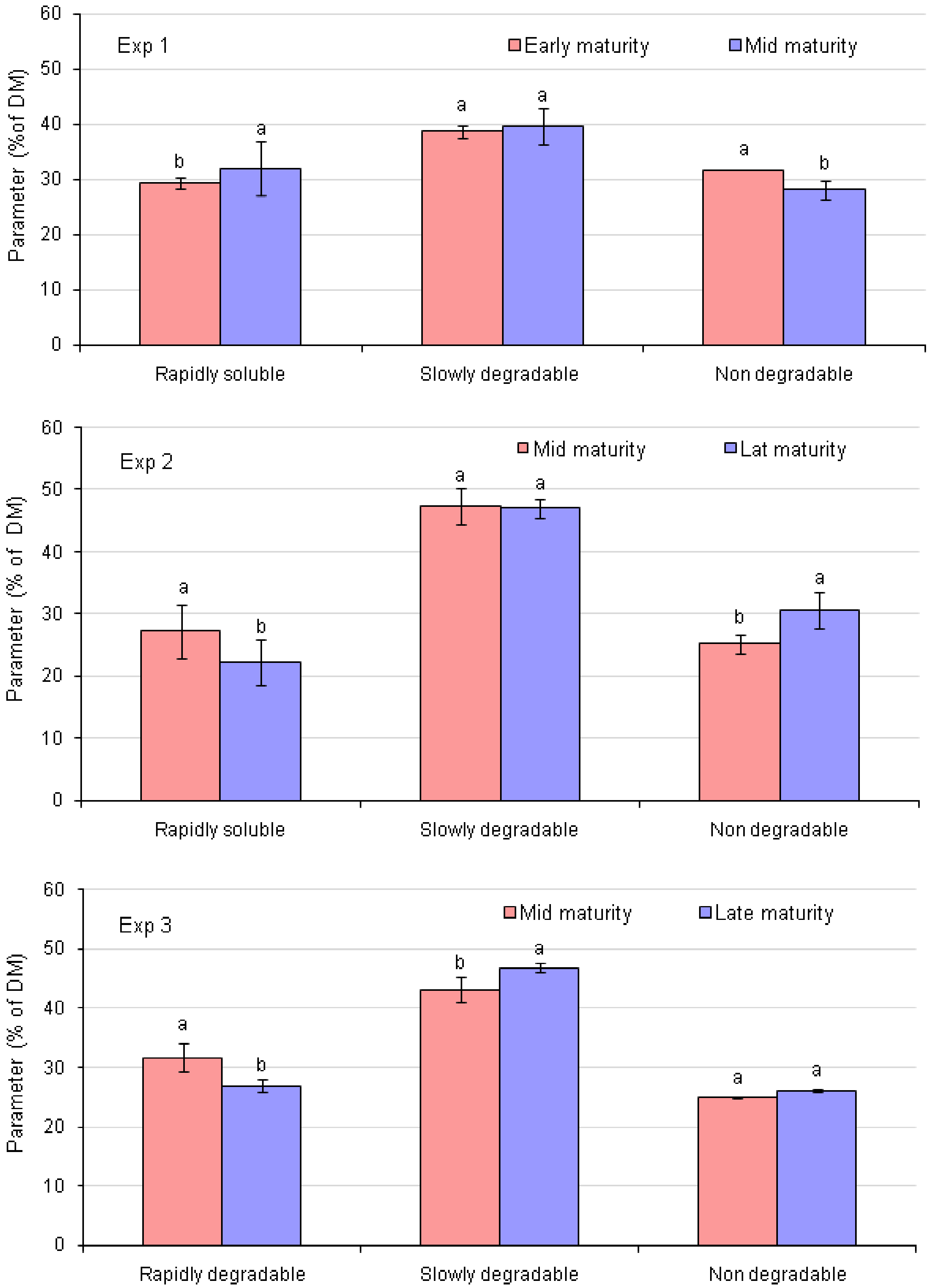


Figure 14. Effect of maize variety (maturity group) on the in situ rumen dry matter degradability (%) of maize stover at the different incubation times at the first three experiments



For each parameter, different letters are significantly different

Figure 15. Effect of maize variety (maturity group) on parameters of rumen dry matter degradability of maize stover at the first three experiments

Deinum (1988) showed that a high proportion of the genotypic variability in forage maize digestibility was due to differences in cell wall digestibility. Also Tovar-Gomez et al. (1997) concluded that much of the response in animal performance associated with different maize genotypes was due to differences in the extent of cell wall degradability in the rumen. The influence of the genotype became particularly apparent in the chemical composition of the plants. Previous research has demonstrated that the chemical composition and in turn the ruminal degradability of maize stover can be improved through using of early maturing varieties (Zeller, 2009), brown midrib varieties (Barrière and Argillier, 1993) or multi leafy varieties (Hartnell et al., 2005).

Table 46. Effect of maize variety (maturity group) on effective rumen dry matter degradability (%) of maize stover by passage rate of 6%h^{-1}

Exp No	***Early maturity***	***Mid early maturity***	***Mid late maturity***
Exp 1	46.2	49.1	-
Exp 2	-	43.0	38.2
Exp 3	-	46.5	43.7
Zeller (2009)	46.1	44.2	45.1

The effect of maize variety (maturity group) on EDMD of maize stover in the present work and the work of Zeller (2009) by passage rate of 6%h^{-1} are illustrated in Table 46. It is obvious that EDMD of mid early maturity group was higher than that of early maturity group in Exp 1 as well as mid early maturity group at Exp 2 and at Exp 3 was higher than that of mid late maturity group. But Zeller (2009) found that the EDMD of the early maturity group (46.1%) was higher than that of mid early maturity group (44.2%) and mid late maturity group (45.1%). The apparent results of Zeller (2009) seem to be disagreeing with the present work but on contrast it is compatible with the present work. As Zeller (2009) choose the harvesting time of maize plant according to the dry matter of the grain at the four harvest stages, this mean that the three groups have the same grain DM during harvest and not rely on special date. But in the present work harvesting occurs at fixed dates without pay attention to the grain DM. This resemble which usually happen in the field, because farmers underestimate the maturity of plants and so the exact time for harvesting maize plant is lost. But also in the present work the higher EDMD of the mid early maturity group attributed to the lower crude fiber content than that of early maturity group and mid late maturity group. Additionally, there is a correlation of R^2 = 0.800 between crude fiber and the effective dry matter content (Figure 16). This is the same results recorded by Zeller (2009) as she found that maturity groups affect the chemical composition of maize stover and in turn affect the ruminal degradability. Therefore she found that early maturing varieties had significantly lower content of crude fiber and NDF and higher degradability in comparison to the later maturing varieties. Furthermore the difference between the maturity groups became clearer with later harvest date. Ettle and Schwarz (2003) compared the chemical composition and DM degradability of maize stover of two varieties (one early maturing variety and the other mid early maturing variety). They stated that early maturity variety had lower concentrations of crude fibre and higher degradability than mid early maturing variety. Therefore they concluded that the feeding value and digestibility of maize stover are significantly affected by maize variety. In the same direction Russel (1992) found that late maturing variety has high concentration of NDF than early maturing variety in spite of lower DM content.

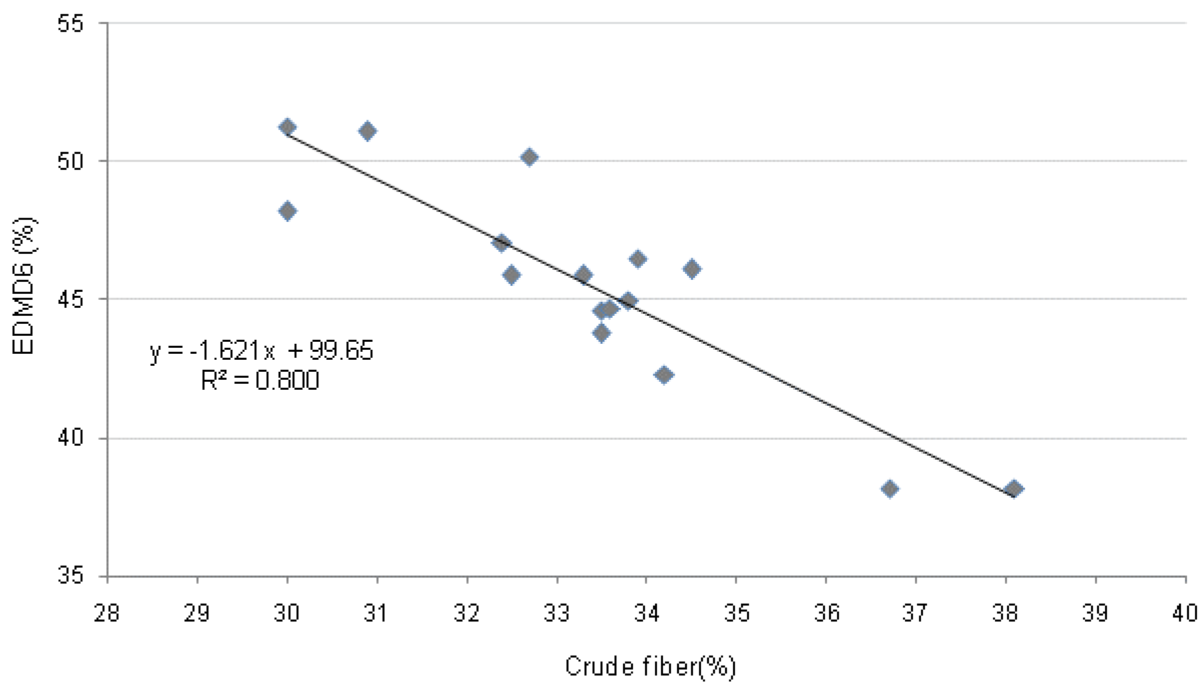


Figure 16. Relationship between maize stover crude fiber content and effective dry matter degradability by passage rate of 6%h^{-1} as affected by maize variety

The second trait which assumed to be improves the chemical composition and in turn the ruminal degradability is brown midrib (bm). It was first reported in dent maize at St. Paul, MN in 1924. It first appears at the 4-6 leaf stage as a reddish orange coloration down the underside of the leaf mid vein or midrib. The colour is associated with lignified rind and vascular bundles. Colouring eventually disappears on the leaves, but remains in the stalk (Lauer and Coors, 1997). Brown midrib maize is an example of a natural mutation that caused a “knock out” of one of the lignin biosynthetic enzymes. The bm3 hybrid, consistently decreased the lignin content of the maize plant by approximately 40% because the activity of the enzyme, O-methyltransferase, is reduced, which increased in vitro NDF degradability (Barriere and Argillier, 1993). Regardless of consistently greater NDF digestibility in vitro for brown midrib forages compared with control forages, responses to brown midrib forages in apparent total tract NDF digestibility vary among experiments. Wedig (1988) reported that total tract digestibility was not improved by brown midrib forages. On the other hand, Oba and Allen (1999) reported a 9% increase in DM intake and a 7% increase in milk yield when diets fed to dairy cows contained bm3 over those fed isogeneic normal maize silage. Oba and Allen (2000) found that although in vitro NDF digestibility of bm maize silage was higher than for normal maize silage, enhanced in vitro NDF digestibility does not necessarily translate to increased NDF digestibility either in the rumen or in the total tract. However, bm maize silage may possibly increase DM intake and rate of passage, thus improving efficiency of microbial protein production. Tjardes et al. (2000) studied the effect of bm3 maize silage on digestion and performance of growing beef steers and stated that although feeding bm maize silage in growth phase diets resulted in increased daily DM intake and improved digestibility of DM and fiber, but it did not result in improved steer feedlot average daily gain compared with control silage. On the other hand Kurtz et al. (2004) reported higher feed intake and a trend for better average daily gain for bulls fed whole plant maize silage of bm hybrid compared to control one.

Verbic et al. (1995) studied the EDMD of the different morphological fractions of maize stover (stalk, leaves, husk and cob) of eight varieties and stated that effective DM degradability of the stover varied considerably between maize hybrids. Differences were mainly due to variation of EDMD within the morphological fractions and not to differences in their distribution. Therefore, when selecting hybrids for maize silage production, the nutritive value cannot simply be improved by manipulating the morphological proportions. They concluded also that the differences in stover quality between hybrids were mainly due to large differences in the degradability of stalks which also represented the main proportion of the stover. On the other hand Hartnell et al. (2005) stated that using multi leafy hybrid (hybrids which having extra leaves above the ear) often results in increased forage digestibility because of the increased leaf to stem ratio. Ørskov et al. (1990) said that leaf to stem ratio, solubility of leaf and stem and the degradation of the insoluble parts are important parameters to be recorded if the nutritive value of the stover is to be improved by selection. In general, the agronomic and plant morphological characteristics that are strongly correlated with improved stover yield and quality need to be clearly defined for successful incorporation of stover yield and quality attributes in maize breeding programmes.

4.4.3 Effect of conservation method (fresh, oven dried (at 60 ℃) or ensiling) on rumen dry matter degradability of maize stover

During the in situ studies of maize stover usually it is dried either by freeze drying or oven drying method and we want to know the effect of the two methods on stover degradability. Also the suggested question is the ensiling conservation has an effect on rumen degradability of maize stover or not. Ensiling is a common preservation method for most forage crops. It is based on lactic acid bacteria converting water soluble carbohydrates (WSC) into organic acids, mainly lactic acid, under anaerobic conditions. As a result, pH decreased and the forage can preserve from spoilage by microorganisms for long time (McDonald et al., 2002).

Results of present study indicate that stover DM degradability after freeze drying and oven drying (at 60 ℃) was higher than t hat after ensiling (Figure 17). Also stover DM degradability after freeze dried was higher than that of oven dried at 0, 2, 4 and 8 h of incubation. Dry matter washing losses of stover after freeze dried (33.0%) was higher than that after oven dried (31.0%) and ensiling (26.0%). Higher DM washing losses of freeze dried stover accompanied in Figure 18 with higher rapidly soluble fraction (33.0%) than that after oven dried (31.0%) and ensiled stover (26.0%). On the opposite side slowly degradable fraction of ensiled stover (46.5 %) was higher than that of freeze dried stover (40.3%) and oven dried one (43.0%).

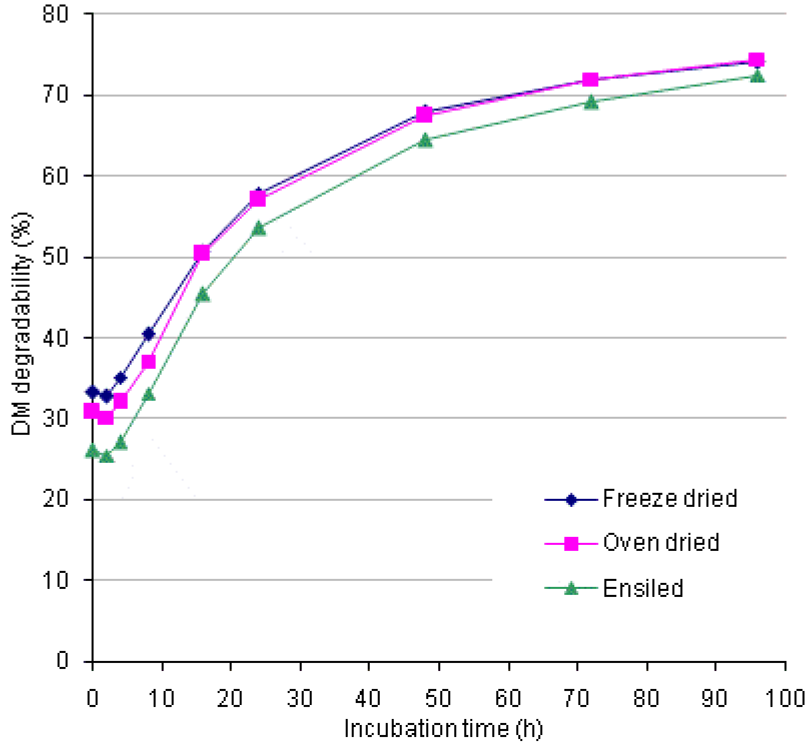
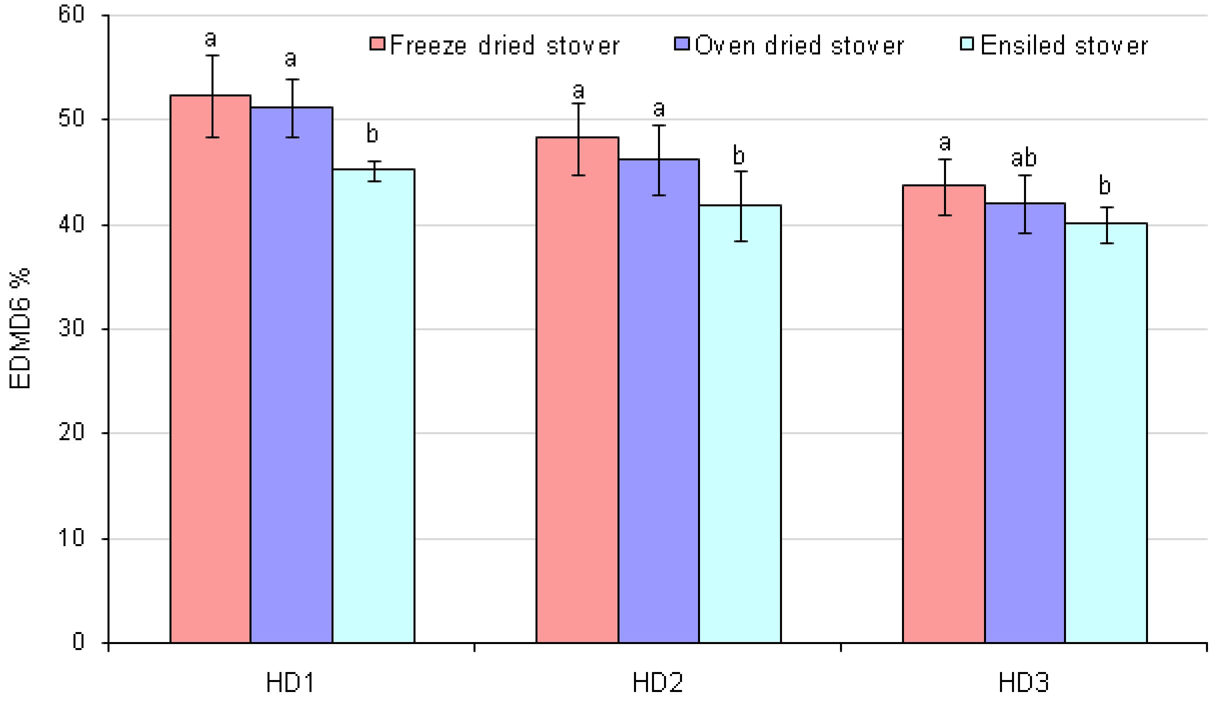


Figure 17. Effect of conservation methods (fresh, oven dried (at 60 ℃) or ensiling) on in situ rumen dry matter degradability of maize stover (in %) at different incubation

For each parameter, different letters are significantly different

Figure 18. Effect of conservation method (fresh, oven dried (at 60 ℃), or ensiling) on parameters of rumen dry matter degradability (%) of maize stover



For each harvest date, different letters are significantly different

Figure 19. Effect of conservation method (fresh, oven dried (at 60 °C), or ensiling) and maturity stage on effective rumen dry matter degradability (%) of maize stover by passage rate of 6%h^{-1}

Stover effective rumen DM degradability after freeze dried (fresh stover) and oven dried (at 60 °C) were higher than that of ensi led stover (Figure 19). This attributed to converting of maize stover WSC into organic acids during conservation which leads to increase the proportion of the cell wall (crude fiber and NDF) in relation to the cell content, and this has a direct effect on reducing stover DM degradability. Increases in concentration of the cell wall constituents due to soluble carbohydrate losses during fermentation have been reported previously (Phipps et al., 1979). Russell et al. (1992) stated that losses of WSC during silage fermentation and their effects on silage nutritive value are inconsistent. Maize silage produced from plants containing a low proportion of grain has contained greater concentration of ADF and ADL, and lesser concentrations of digestible organic matter. A large proportion of total non structure carbohydrate in maize stalks water soluble (Phipps and Waller, 1979) and it is lost during fermentation of maize silage (Wilkinsom and Phipps, 1979). Because a large proportion of the total non structure carbohydrate in maize whole silage is starch, however fermentation losses of water soluble carbohydrates from maize whole silage have little effect on the IVDMD of maize whole silage (Wilkinsom and Phipps, 1979; Russell et al., 1992). In contrast, fermentation losses of total non structure carbohydrate during ensiling of stover result in significant reductions in IVDMD of stover silage (Russell, 1986). Also the EDMD of maize stover after freeze drying (48.0%) was to some extent higher than that after oven drying conservation (46.5%). These results are in agreement with Lopez et al. (1995) as they said that freeze drying method leads to fine grinding and so increase the particulate losses through the bags pores during washing. This lead to overestimate effective rumen DM degradability but it is better than over drying method for silage materials and this is why the ensiled stover of the present study was dried with freeze drying method. As well as they stated that oven drying reduces nitrogen degradability and solubility.

4.5 Factors affecting rumen dry matter degradability of maize grain

Starch is quantitatively important nutrient for high yielding dairy cows, and for microbial protein production in the rumen. The variability in ruminal starch digestion of maize holds promise for manipulating the site and extent of starch digestion in ruminants. The site of starch digestion alters the nature of the end products of digestion (i.e volatile fatty acids in the rumen and hind gut and glucose in the small intestine) and, in this respect, the efficiency of their metabolic utilization by the ruminant. Owens et al. (1986) concluded that starch digested in small intestine provided 42% more energy than ruminally digested starch. It is generally assumed that starch digested in small intestine (glucose) is more efficiently used to support milk production than starch digested in rumen (McDonald et al., 2002). However, this assumes that rumen escape starch is digested in small intestine (Oba and Allen, 2003). Theurer (1986) reported that sorghum, maize, and barley had ruminal starch escape values of 34.0, 27.0, and 7.00%, respectively, with the total tract starch digestion of sorghum, maize, and barley reported to be 92.0, 96.0, and 99.0%, respectively, thereby illustrating the inverse relationship between starch ruminal escape and total tract starch utilization. Shifting starch digestion from rumen to small intestine has potential benefits. First, starch digestion in small intestine is energetically more efficient than ruminally fermented starch (Harmon and McLeod, 2001). Second, a decrease in rumen starch digestion may help to limit the incidence of bloat, acidosis, and laminitis (Owens et al., 1998).

Digestibility of maize DM and starch is highly variable. Various factors such as stage of maturity, maize endosperm type (dent or flint), particle size (fine versus coarse grind), grain processing (steam flaked versus dry rolled), and maize grain conservation (fresh, oven drying or ensiling) influence DM and starch ruminal degradability of maize grain. The aim of this study was to examine the effect of stage of maize maturity, maize variety and method of conservation on in situ rumen DM degradability of maize grain.

The in situ degradation measurements for maize grain using the nylon bag technique enable a wider insight to know the extent and dynamics of DM and starch degradability in the rumen of dairy cows. Philippeau et al. (1999a) stated that the DM degradation traits and effective degradability were strongly linked to the starch degradation traits and effective degradability. Loose (1999) found a correlation of r = 0.97 between the in situ grain dry matter degradability and ruminal starch degradation. In the same time Correa et al. (2002) found correlations of r = 0.98. The rumen dry matter degradability of maize grain therefore seems to be a good prediction for rumen starch degradability. Based on this relationship, it is possible to predict the starch degradability from rumen dry matter degradability without analysis of starch in the bag residues.

4.5.1 Effect of maturity stage on rumen dry matter degradability of maize grain

This section and the next one will discuss the effect of maize maturity stage and maize variety on rumen dry matter degradability of maize grain. Fresh (freeze dried) will be used such as a model which will be useful for plant breeder. Later on the other conservation methods (ensiling and practical oven drying at high temperature) will be discussed which will be useful for animal nutritionist and farm practice.

The relationship between DM and starch degradability of maize grain and physiological maturity of the maize plant at the time of harvest is considering one of the most important factor that determine the degradability of maize grain. Dry matter and starch degradability of maize grain decreasing with increasing plant maturity. Figure 20 and 21 showed that there is variation in DM degradability and in parameters of degradability between the three harvest dates. Dry matter degradability of maize grain increased with increasing the incubation hours. Mean of

DM washing losses (0 h) of the fresh (freeze dried) maize grain decreased significantly with increasing plant maturity (53.0, 43.0 and 36.0% for early, middle and late harvest respectively). These results are in agreement with the work of Kurtz (2006) as he found that mean of dry matter washing losses of freeze dried maize grain decreased progressively from early (50.0%) to late (28.0%) maturity. Also Höner (2001) found that dry matter washing losses decreased from 53.0% at early to 45.0% at late maturity.

Fresh maize grains were completely degradable after 48 h of incubation (98.0, 98.0 and 97.0% for early, middle and late harvest respectively). These results are in agreement with the results of Kurtz (2006) in which he found that DM degradability of fresh maize grain after 48 h of incubation was 99.0 and 94.0% for early and late harvest respectively. Höner (2001) found that DM degradability after 48 h of incubation was 95.0% for early and 92.0% for late maturity.

Figure 21 revealed that the rapidly soluble fraction of freeze dried maize grain decreased with increasing grain maturity (55.0, 44.0 and 35.0% for early, middle and late harvest respectively). In the opposite side the slowly degradable fraction of fresh maize grain increased with increasing grain maturity (45.0, 56.0 and 65.0% for early, middle and late harvest respectively). Maize grain completely disappeared in the rumen and the non degradable fraction was zero. These results are in agreement with the work of Kurtz (2006) who found that the rapidly soluble fraction of maize grain decreased with increasing maize grain maturity (51.0 and 29.0% for early and late harvest respectively). Also he found that slowly degradable fraction of maize grain increased with increasing grain maturity (49.0 and 71.0% for early and late harvest respectively). Höner (2001) found that the rapidly soluble fraction of maize grain decreased from 52.0 to 48.0% from early to late maturity. Also she found that the slowly degradable fraction of maize grain increased from early (44.0%) to late maturity (46.0%).

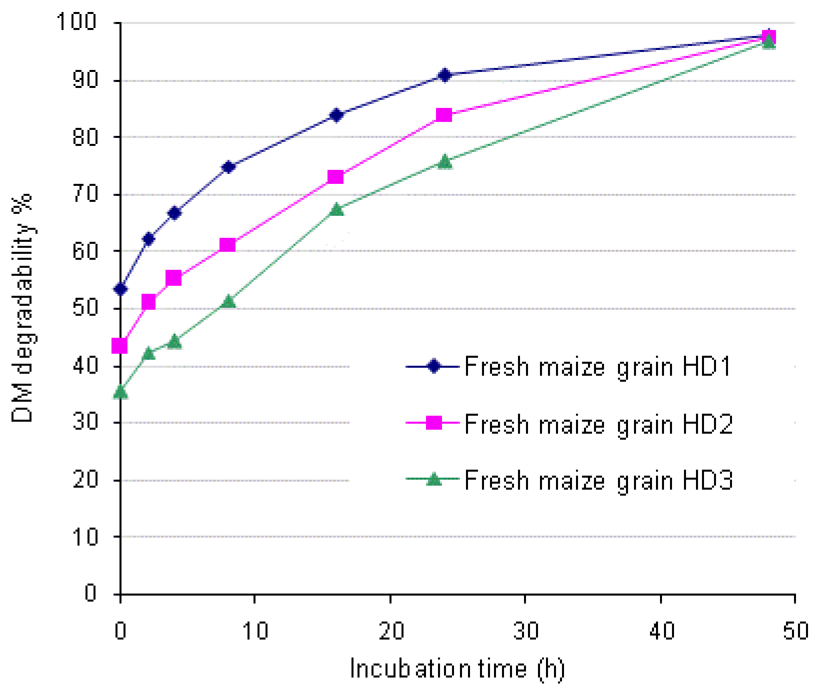
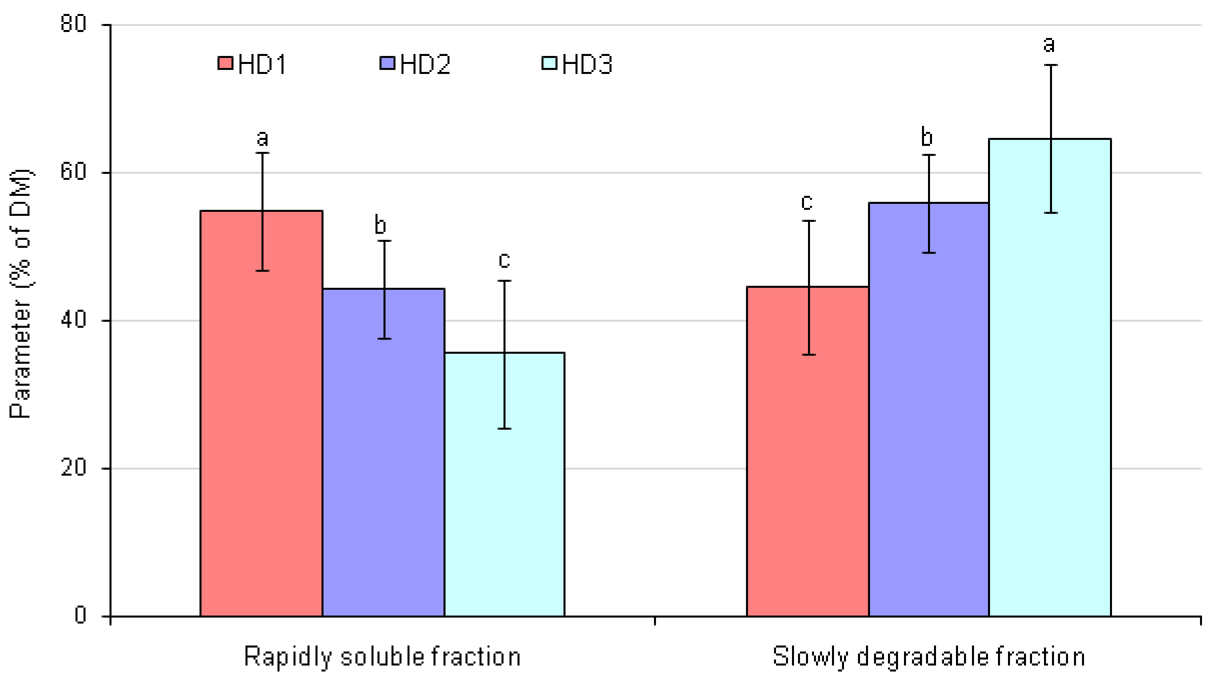


Figure 20. Effect of maize maturity stage on rumen DM degradation curve of fresh maize grain as mean of the harvest date



For each parameter, different letters are significantly different

Figure 21. Effect of maturity stage on parameters of rumen dry matter degradability of maize grain after fresh (freeze dried) maize grain as mean of the harvest date

The decrease in DM washing losses and the rapidly soluble fraction with increasing maturity attributed to increased grain dry matte and vitreousness and hence during preparation for the in situ technique grinding (3 mm) increased the course particles. Therefore low proportion of fine particles can escape through the bag pores during washing and so decreasing the washing losses. Also Philippeau et al. (1998) found that there is a significant negative correlation between the ruminal starch degradability and the proportion of coarse particles in the ground grain. Thus, the proportion of small particles in the ground material which decreased with increasing grain particle size has a big influence on the starch degradability (Remond et al., 2004). The proportion of coarse particles was commonly used as a predictor of grain hardness. Shull et al. (1991) and Li et al. (1996) found a strong relationship between these two parameters (coarse particles and grain hardness).

Table 47. Effect of maturity stage on the effective rumen dry matter degradability (%) of maize grain by passage rate of 6%h^{-1}

	Mean of harvest date			
	HD1 (02.09.)	***HD2 (19.09.)***	***HD3 (07.10.)***	***HD4 (17.10.)***
Present work	79.0	69.7	62.4	-
Höner (2001)	76.2	74.5	71.6	-
Kurtz (2006)	79.1	67.7	63.6	59.6

The effect of maturity stage on the EDMD of fresh maize grain by passage rate of 6%h^{-1} is presented in Table 47. From this table it is conspicuous that EDMD of fresh (freeze dried) grain decreased with increasing grain maturity. Also Figure 22 showed a negative correlation (R^2 = 0.848) between EDMD by passage rate of 6%h^{-1} and maize grain DM content. This means continuous decrease in EDMD of maize grain with increasing DM of maize grain. These results are in agreement with Höner (2001) as she found that the EDMD decreased with increasing maturity (76.2, 74.5 and 71.6% for early, middle and late maturity respectively. Also Kurtz (2006) stated that the EDMD of fresh maize grain decreased with increasing grain maturity and found a negative correlation of (r = - 0.91) between DM of fresh maize grain and the effective DM degradability by passage rate of 8%h^{-1}. Furthermore, Philippeau and Michalet-Doreau (1997) proved that starch degradation decreased with increasing grain maturity and the decreased in starch degradability with increasing grain maturation is closely coupled with increasing endosperm vitreousness (r = - 0.93). Also Szasz et al. (2007) stated that DM and starch ruminal degradation of maize grain decreased as plant age progressed and a marked decrease in ruminal degradability occurred when the hybrid progressed from half milk line to black layer stage. Therefore, from this section it can be concluded that the EDMD of maize grain decreases with increasing maturity because of increasing in grain dry matter and vitreousness.

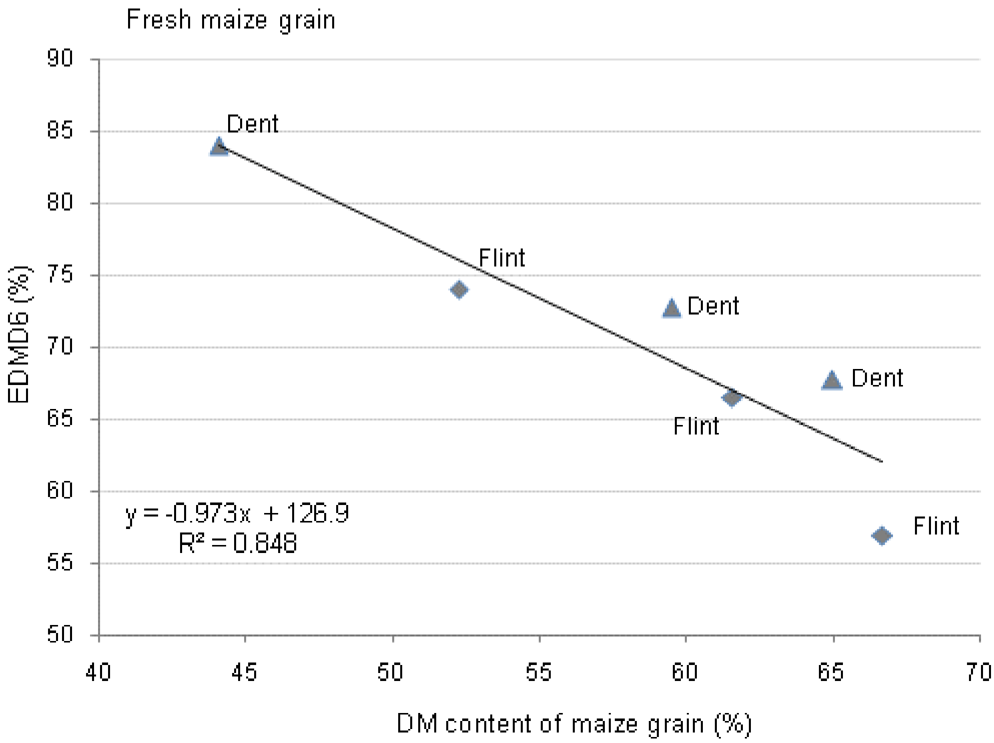


Figure 22. Relationship between EDMD6 and DM content of fresh maize grain

4.5.2 Effect of maize variety (flint or dent) on rumen dry matter degradability of maize grain

Understanding the relationship between kernel vitreousness due to maize variety (flint or dent) and starch digestibility may allow for improved selection of corn hybrids for silage and grain production resulting in improvements in the utilization of maize based diets by ruminants. As descried before the dent grain characterized by a lower vitreousness than flint grain, i.e a lower ratio of vitreous to floury endosperm. Starch granules in vitreous or flinty endosperm are surrounded by an insoluble protein matrix that resists digestion; in contrast, floury or opaque endosperm has a soluble protein matrix that is easily digested by rumen microorganisms. Those two endosperms had specific protein distributions: the ratio of zein to salt soluble protein was higher in vitreous than in floury endosperm. Digestibility of starch from maize grain is limited by the protein matrix that encapsulates starch granules and by the compact nature of starch itself, particularly in the hard endosperm portion of kernels that prevents microbial colonization and retards penetration by amylolytic enzymes (McAllister et al., 1990; Huntington, 1997; Huntington et al., 2006). This protein matrix in particular, is less dense in barley and wheat starch than maize starch and so barley and wheat are higher than maize in starch degradability (Ørskov, 1986; Michalet-Doreau et al., 1997). However, difference in rumen starch degradability didn’t found only between different starch sources, it also exists between different varieties of the same starch source (Streeter et al., 1990a and 1990b).

The effect of endosperm structure (flint or dent) on rumen DM degradability of fresh (freeze dried) maize grain is presented in Figure 23. This figure revealed that DM degradability increased with increasing the incubation hours. Mean of DM washing losses of the fresh dent maize grain (50.1%) was significantly higher than that of fresh flint grain (38.0%). These results are in agreement with that obtained by Kurtz (2006) as he found that mean of DM washing losses of fresh dent maize grain (41.3%) was significantly higher than that of fresh flint grain (34.3%). The results of Kurtz (2006) was to some extent lower than that obtained in the present work, this is may be because he used the mean of four harvest dates but in the present work only the mean of three harvest dates were used.

Figure 24 revealed that the rapidly soluble fraction of fresh maize grain of dent type (50.5%) was significantly higher than that of flint grain type (39.0%). On the other hand the slowly degradable fraction of fresh flint grain (61.0%) was significantly higher than that of dent one (49.9%). This is in agreement with Kurtz (2006) as he found that the rapidly soluble fraction of fresh maize grain of dent type (42.4%) was higher than that of dent one (36.6%). Also he found that the slowly degradable fraction of fresh grain of flint type (63.2%) was higher than that of dent one (57.2%). Philippeau et al. (1997) stated that the variation in the rapidly degradable fraction of maize grain between flint and dent might be related to the difference in the proportion of particulate starch losses which higher for dent than for flint maize.

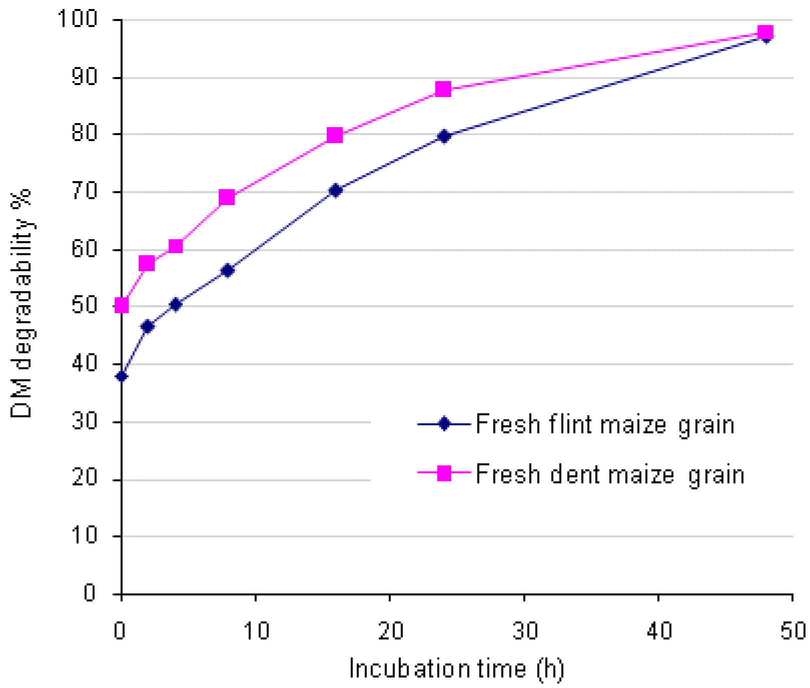
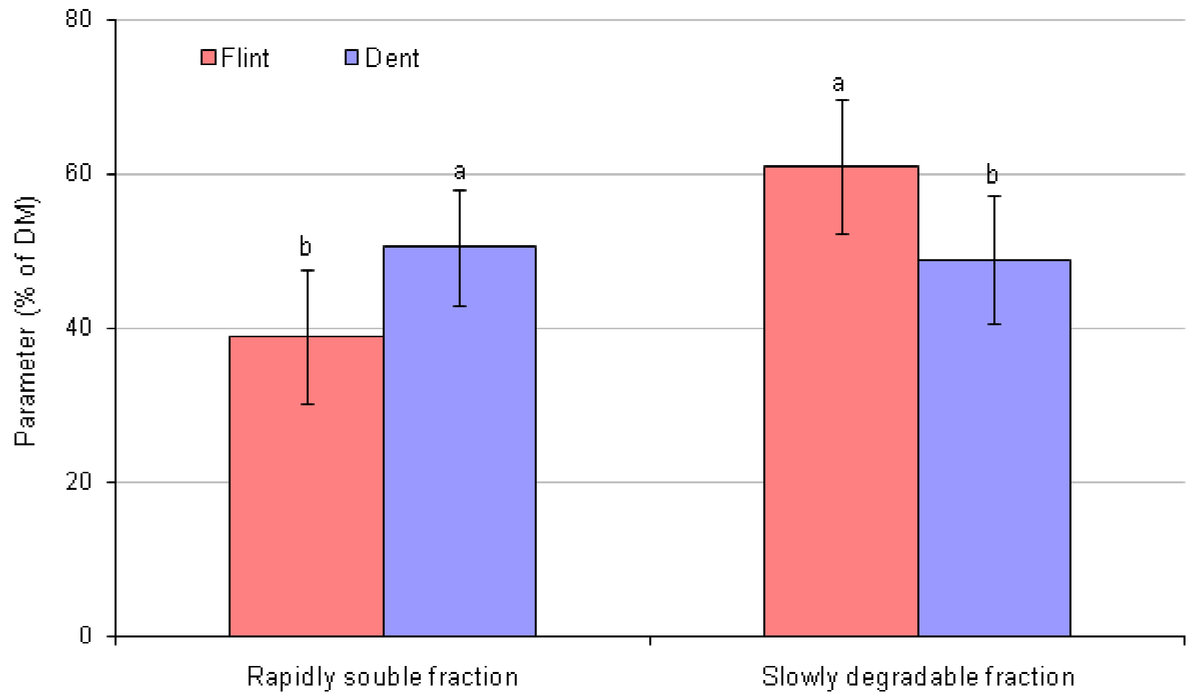


Figure 23. Effect of maize variety (flint or dent) on rumen DM degradation curve of fresh (freeze dried) maize grain as mean of the variety



For each parameter, different letters are significantly different

Figure 24. Effect of maize variety (flint or dent) on parameters of rumen dry matter degradability of fresh (freeze dried) maize grain as mean of variety

The effective DM degradability of fresh (freeze dried) maize grain was higher for dent than for flint maize grain (75.0 and 66.0%, respectively). Lower DM degradability of flint maize attributed to lower proportion of the rapidly soluble fraction, lower constant rate of degradation, or both. These results are compatible with the work of Kurtz (2006) who found that the effective DM degradability of fresh maize grain of dent type (72.0%) was significantly higher than that of flint type (66.0%). Philippeau et al. (1999a) found that dent and flint maize grain differed markedly in the proportion of coarse particles, apparent density and specific surface area. The dent type had smaller proportion of coarse particles than flint type (61.9 vs 69.6%) and inversely had higher proportion of fine particles (15.6 vs 9.0%). They found also that the apparent density was lower for dent than for flint maize (1.29 vs 1.36 g/cm^3), and was strongly correlated with the grain vitreousness (R^2 = 0.71). Also the specific surface area was higher for dent than for flint type 0.13 and 0.07m^2/g respectively, and it was negatively correlated to vitreousness (R^2 = 0.63). Also they concluded that ruminal starch degradability could be predicted accurately by vitreousness (R^2 = 0.89) or by the combination of apparent density and 1,000 grain weight (R^2 = 0.91), a measurement faster than the vitreousness determination. Correa et al. (2002) stated that kernel hardness is an index of the relative proportion of vitreous to floury endosperm. Increased kernel vitreousness has been associated with decreased in situ ruminal starch degradation. They concluded also that with advancing maturity in dent maize hybrids, kernel vitreousness and density increased with a correlation of r = 0.87, while ruminal starch digestibility decreased. Kernel vitreousness may be a useful parameter for selecting maize hybrids with high ruminal starch availability.

Philippeau et al. (1999b) evaluated the effect of vitreousness of maize grain on ruminal starch digestibility in steers fed a 67.0% maize grain diet. Ruminal starch digestibility was greater for dent maize based diets (60.8% in vivo and 74.5% in situ) than flint maize based diets (34.8% in vivo and 70.9% in situ), and vitreousness of dent maize grain (51.7%) was lower than flint maize grain (66.8%). Also in anther study Philippeau and Michalet- Doureau (1998) found that ruminal starch degradability for dent grain (72.3%) was higher than that of flint one (61.6%). They stated that the difference in ruminal starch degradability could be related to the difference in the proportion of vitreous endosperm in the grain. The difference in ruminal starch degradability between these two grains also could be explained by the difference in grain DM content (46.4 and 52.3% for dent and flint, respectively). However, it is not possible to differentiate between the effects of these two factors, because vitreousness and DM content of grain are strongly correlated. This is with the decreasing of maize grain EDMD with increasing DM as in the previous section (Figure 22) is a good explanation for the results of the present work as DM of flint grain was higher than that of dent grain (60.2 vs 56.2% respectively). On the other hand Philippeau et al. (2000) found that variations in ruminal starch degradation of maize grain differing in vitreousness were closely related to the protein distribution in the endosperm and the type of protein composition in the endosperm (Zein versus glutelin). Therefore, the chemical composition of maize endosperm may affect starch availability for enzymatic hydrolysis in the rumen. From this section we can conclude that dent maize grain is higher in rumen degradability than flint maize grain. The difference in degradability attributed to the difference in grain dry matter and grain vitreousness and it is difficult to differentiate between the effects of these two factors.

4.5.3 Effect of conservation method (ensiling, fresh or oven dried at 85 °C) on rumen dry matter degradability of maize grain

As described before the starch granules in the peripheral and comeous endosperm are surrounded by protein storage bodies and are embedded in a dense matrix of dried endosperm cells. Various processing and preservation techniques disrupt this protein matrix, making the starch more available for rumen fermentation and digestibility. Processing methods include both physical and chemical modifications. Physical processes include breaking, cracking, grinding, or rolling grains. Chemical modification processes involve water, heat, and pressure (Nocek and Tamminga, 1991). Kurtz (2006) stated that any modification in the protein layer which surrounds the starch granule in the endosperm can lead either to increase or decrease in starch degradability.

Farmers usually used maize grain either in form of maize grain in maize whole plant silage or used it alone in the concentrate mixture. If maize grain will be used in the concentrate mixture, it must be dried to be preserved and prevent mould growth and mycotoxins production. Farmers usually harvest these grains when it contain dry matter content between 65 to 70% therefore, it must be dried to obtain maize grain with moisture content not more than 12 to 13 % to be safe for storage. In Europe, drying the grain usually occurs in hot oven at high temperature. On the other hand, because of intense solar radiation that prevails in hot climate lands like Egypt; maize grain that harvested soon after attaining physiological maturity (65 to 70% DM) could be effectively dried in the sun to the point of safe storage. Drying in the sun is not expensive and it is less complicated compared to oven drying. Thus, nowadays in Europe they started to use the grain such as ensiled maize grain because it is less expensive than oven dried grain. Therefore, the present study aimed to study the effect of conservation method (ensiling, fresh and oven dried at 85 ℃) on rumen dry matter degradability of maize grain.

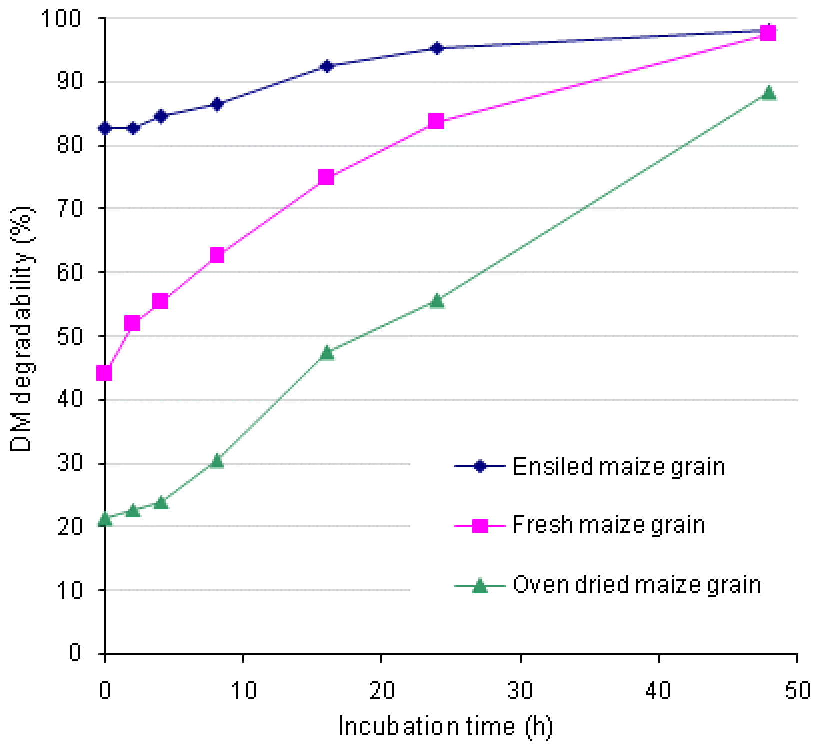
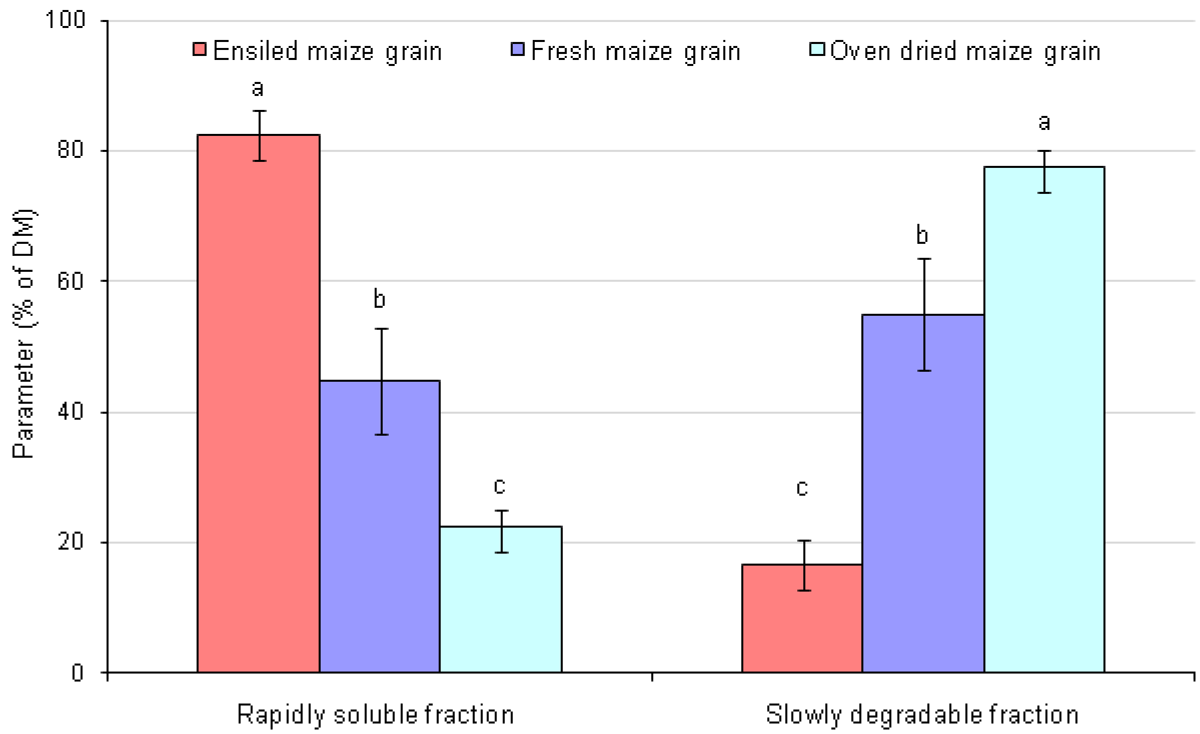


Figure 25. Effect of conservation method (fresh, oven dried (85℃) or ensiling) on rumen DM degradability of maize grain after the different incubation times

Rumen DM degradability of maize grain after the different conservation methods as a mean of harvest date and variety is showed in Figure 25. It is evident that DM washing losses of ensiled grain (83.0%) was nearly double that of fresh grain (44.0%) and nearly four times that of oven dried grain (21.0%). These results are in agreement with the work of Kurtz (2006) as he found that DM washing losses of ensiled grain (82.0%) was much higher than that of fresh grain (36.0%). Also Kurtz (2002) found that DM washing of oven dried (at 85 °C) maize grain was 19.0% which is compatible with the results of the present work. Dry matter of fresh and ensiled maize grain disappeared completely after 48 h of incubation (98.6 and 98.4% for fresh and ensiled maize grain respectively) but only about 88.5% from oven dried maize grain DM disappeared after 48 h of incubation. The obtained results confirm the finding of Kurtz (2006) as he found that DM of fresh and ensiled grain was nearly completely degradable after 48 h (96.3 and 97.8% for fresh and ensiling maize grain respectively). Also Kurtz (2002) found that about 94.6 from oven dried (at 85 ℃) maize grain was degradable after 48 h of incubation. It is obvious that DM degradability of fresh, oven dried and ensiled maize grain after 48 h of incubation is much higher than that of maize stover in the present study (only from 70.0 to 73.0% after 96 h of incubation).



For each parameter, different letters are significantly different

Figure 26. Effect of conservation method (ensiling, fresh or oven dried at 85 ℃) on parameters of rumen dry matter degradability of maize grain

The effect of conservation method (ensiling, fresh or oven dried at 85 ℃) on parameters of rumen DM degradability of maize grain is illustrated in Figure 26. It is evident that the rapidly soluble fraction of ensiled maize grain (82.5%) was nearly double from that of fresh grain (45.0%) and four times from that of oven dried (at 85℃) maize grain (22.0%). On the opposite side the slowly degradable fraction was higher for oven dried maize grain (78.0%) than fresh grain (55.0%) and ensiled grain

(17.0%). These results are in agreement with the finding of Kurtz (2006) who found that the rapidly soluble fraction of ensiled maize grain (80.0%) was higher than that of fresh grain (37.0%), on the other hand the slowly degradable fraction of fresh grain (63.0%) was much higher than that of ensiled maize grain (19.0%). Also Kurtz (2002) found that the rapidly soluble fraction and the slowly degradable fraction of oven dried (at 85 ℃) maize grains were 20.0 and 80.0% r espectively.

Table 48. Effect of conservation method (ensiling, fresh or oven dried) on rumen dry matter degradability (%) of maize grain by passage rate of 6%h^{-1}

	Conservation method		
	Ensiled grain	***Fresh grain***	***Oven dried grain at 85 ℃***
Present work	90.5	70.4	43.8
Kurtz (2002)	-	79.6	54.5
Kurtz (2006)	85.7	67.5	-

The effective DM degradability of ensiled grain was higher than that of fresh (freeze dried) and oven dried (at 85 ℃) maize grai n (Table 48). These results are in agreement with Kurtz (2006) and Kurtz (2002). Ensiling increase ruminal DM and starch degradability. The increase in DM and starch degradability was mainly due to the increase in the rapidly soluble fraction. Because ensiling induces a partial solubilization of the endosperm proteins of maize grains, and accessibility of starch granules to ruminal microorganisms could be determined mainly by the proteins of the endosperm. Philippeau and Michalet Doureau (1998) stated that the increase in ruminal starch degradability after ensiling could be partly derived from solubilisation of endosperm proteins during silage fermentation.

Philippeau and Michalet Doureau (1997) found that drying and conservation method strongly influence the extent of starch lost from the nylon bags. Freeze drying led to much greater starch losses than oven drying for immature maize; respectively, on average, 66.0 and 16.0% of starch initially introduced in the bags. The starch losses were greater for freeze dried than oven dried maize grain, but it is impossible to differentiate the effect of freezing and that of grinding. Therefore, in the present work fresh and ensiling maize grains were dried with freeze drying method to eliminate this difference. Ould-Bah (1989) found no differences between freeze drying and oven drying but the grinding fineness differed according to the drying method. There is thus an interaction between drying method and physical form of the samples. Freezing could induce disruption of plant structures and this may become more obvious after grinding and so higher washing losses. On the other hand Philippeau and Michalet Doureau (1997) cited that oven drying between 45 and 60℃ decreased in situ and enzymatic degradability of soluble nitrogen, and this decrease was essentially due to a smaller rapidly degradable fraction and so decrease the effective DM degradability. But oven drying at 40 ℃ limits the extent of starch lost through the bag pores without being degraded and low heating induces no changes in starch granule structure. This is in agreement with the present study as the rapidly soluble fraction of oven dried (at 85 °C) maize grain was only about 22.0%. Kurtz (2006) stated that there is a very little difference in the effective ruminal degradability between freeze dried material and gentle oven drying material at 40 ℃. But oven drying at high temperature (85 ℃) signifi cantly reduce the effective ruminal degradability to reach about 50% from freeze drying materials. He stated that excessive heat leads to protection of the starch granules from ruminal degradation. The physical reason for this might be the protective effect of heat which modified the protein matrix that surrounds the starch granules. Kurtz (2006) cited that drying of maize grain under practical condition at hot air oven at high temperatures provides high yielding dairy cow with ruminal starch about 20.0 and 36.0% less compared to that provided from the fresh and ensiling material respectively. Therefore, we can conclude that ensiling significantly improves the effective dry matter degradability of maize grain through solubilization of the starch granules. On the other hand practical oven drying of maize grain at high temperature impair the effective dry matter degradability of maize grain.

4.5.3.1 Interaction between effect of conservation method and maturity stage on rumen dry matter degradability of maize grain

The present study revealed that there was interaction between effect of conservation method and maturity stage on rumen dry matter degradability of maize grain. However the effective rumen dry matter degradability of fresh (freeze dried) and oven dried maize grain (at 85 ℃) decreased gre atly with increasing maturity, EDMD6 of ensiled maize grain decreased with increasing maturity, but there was no big difference between the three harvest dates (Table 49). Therefore, there was a week correlation of R^2 = 0.390 between the EDMD6 and DM content of ensiled maize grain (Figure 27). These results are in agreement of Kurtz (2006) as he found the effective rumen DM degradability of ensiled maize grain decreased with increasing maturity. Furthermore, he found a week correlation of only r = - 0.54 between DM of ensiled maize grain and the effective DM degradability by passage rate of 8%h^{-1}. About oven dried maize grain (at 85 ℃) there was a negative correlation R^2 = 0.970 between EDMD6 and DM content of maize grain (Figure 27). Kurtz (2002) proved that the EDMD of oven dried maize grain (at 85℃) d ecreased with increasing plant maturity and found a negative correlation of r = 0.79 between DM of oven dried grain at 85 ℃ and the EDMD by passage rate of 8%h^{-1}. Therefore, it can be concluded that the EDMD of maize grain decreases with increasing plant maturity because of increasing in grain vitreousness. Also ensiling solublizes the protein matrix which surrounds the starch granule and this can eliminates the endosperm vitreousness with increasing grain maturity. Therefore, ensiling can reduces or eliminates the decrease in the EDMD with increasing plant maturity.

Table 49. Effect of conservation method and maturity stage on effective rumen dry matter degradability (%) of maize grain by passage rate of 6%h^{-1}

	Mean of harvest date			
	HD1 (02.09.)	***HD2 (19.09.)***	***HD3 (07.10.)***	***HD4 (17.10.)***
Fresh maize grain	79.0	69.7	62.4	-
Oven dried maize grain at 85 ℃	48.7	43.2	39.4	-
Ensiled maize grain	91.9	90.2	89.3	-
Kurtz (2006) Fresh maize grain	79.1	67.7	63.6	59.6
Kurtz (2002) Oven dried maize grain at 85 ℃	60.4	57.1	50.6	49.8
Kurtz (2006) Ensiled maize grain	87.8	87.9	84.9	82.0

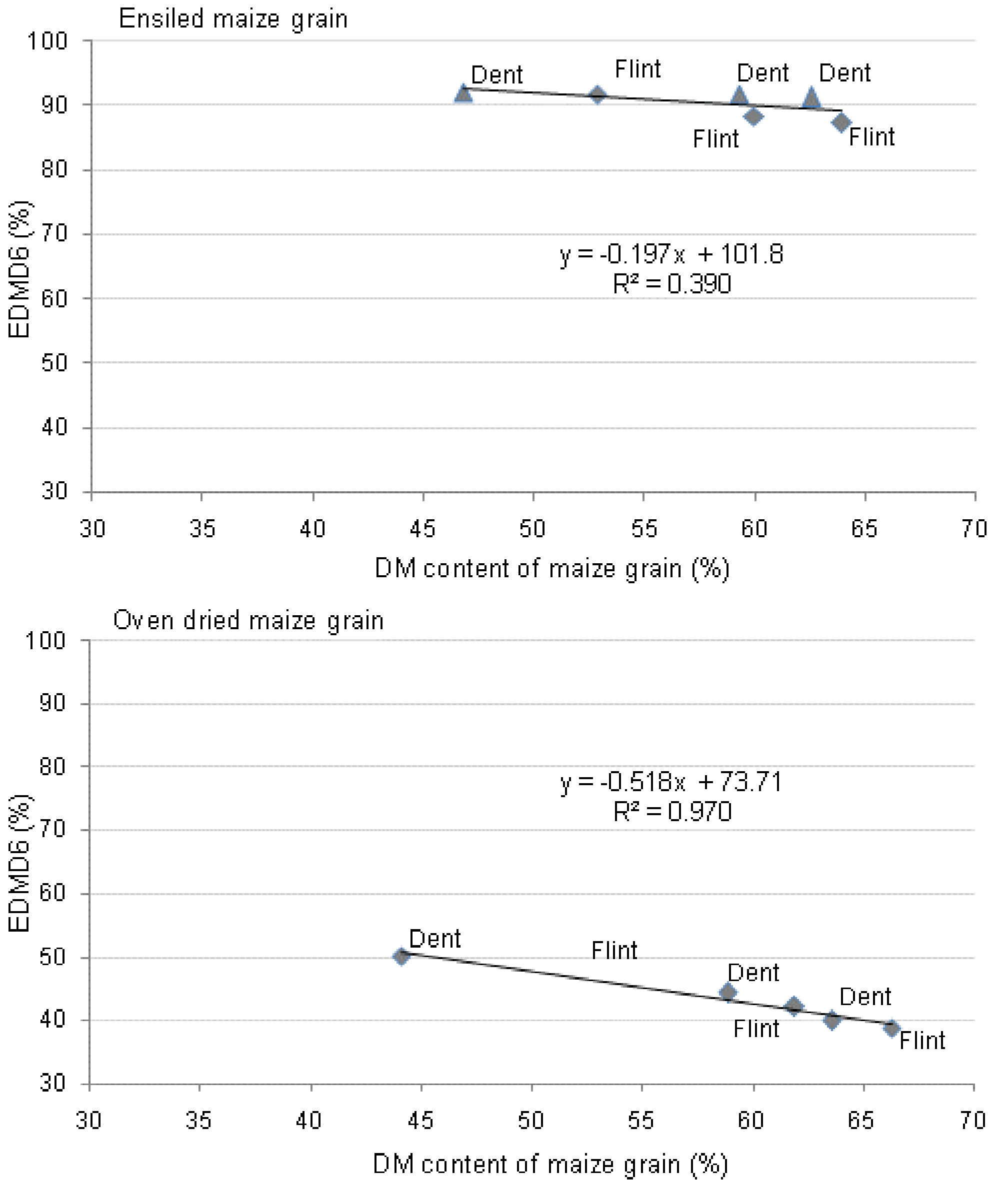


Figure 27. Relationship between EDMD6 and DM content of maize grain after ensiling and oven dried (at 85 ℃) conservation.

4.5.3.2 Interaction between effect of conservation method and maize variety on rumen dry matter degradability of maize grain

The present study indicated that there was interaction between effect of conservation method and maize variety on rumen dry matter degradability of maize grain. However the EDMD of fresh dent maize grain was much higher than that of fresh flint maize grain, there is no big difference between the two varieties after ensiling and oven dried at 85 ℃ conservation (Tabl e 50). The effective rumen DM degradability of ensiled maize grain was 89.2 and 91.8% for flint and dent type respectively, which indicates that the difference between dent and flint type reduces after ensiling. These results are in agreement with Kurtz (2006) as he found that the effective DM degradability of ensiling maize grain by passage rate of 6%h^{-1} is 84.2 and 87.3% for flint and dent respectively. But these results disagree with Philippeau and Michalet Doureau (1998) as they found that ruminal starch degradability of flint and dent grain before ensiling were (73.7 vs 84.4% respectively) and after ensiling were (82.0 vs 91.1% respectively) and stated that the difference between flint or dent genotypes remained constant before (10.7%) and after ensiling (11.6%). They concluded that the extent of increase in ruminal starch degradability after ensiling was the same regardless of maize genotype (dent or flint maize grain), and the increase in ruminal starch degradability after ensiling could be partly derived from the solubilization of endosperm proteins during silage fermentation.

Table 50. Effect of conservation method and maize variety (flint or dent) on effective rumen DM degradability of maize grain (%) by passage rate of 6%h^{-1}

	Endosperm type	
	Flint	***Dent***
Fresh maize grain	65.8	74.9
Oven dried maize grain at 85 ℃	42.7	44.8
Ensiled maize grain	89.2	91.8
Kurtz (2006) Fresh maize grain	65.8	72.1
Kurtz (2002) Oven dried maize grain at 85 ℃	53.8	58.2
Kurtz (2006) Ensiled maize grain	84.2	87.3

Kurtz (2002) studied the effect of oven dried at 85 ℃ on DM degradability of maize grain (flint and dent type) and found that the effective DM degradability of maize grain by passage rate of 6%h^{-1} was 53.8 and 58.2% for flint and dent respectively. This indicates that oven drying of maize grain decreases the difference in the effective DM degradability between flint and dent maize type. Therefore, it can be concluded that the effect of endosperm structure (flint vs dent) on maize grain rumen dry matter degradability reduced after ensiling and oven dried at 85 ℃ in comparison with fresh maize grain.

4.6 Factors affecting rumen dry matter degradability of maize whole plant

The previous sections indicate that degradability of maize whole plant affected by the factors which affect its components (maize cob and stover) as well as the proportion of those components in whole maize plant. Therefore, this section will be such a conclusion of previous sections. The relationships between maize whole plant composition, digestibility and feed intake are complicated. As maturity advances, the fibrous portion of the stalk increased and its digestibility declines, however proportion of grain and consequently of starch, increased with advancing maturity and this can lead to a higher digestibility of whole plant and to an improvement of dry matter intake.

Johnson et al. (1999) reported that the largest changes in nutritive components in the maize plant occurred in the early stages of maturity. At the early dent stage, DM content was low and water soluble carbohydrate was high, but with no decrease in digestibility. At the blackline stage, dry matter yields are the highest, but the WSC decrease sharply owing to starch accumulation, and this had an impact on the ensiling quality of the maize plant. Russell (1986); Russell et al. (1992); Hunt et al. (1989) stated that stover NDF and lignin contents increase and NDF digestibility decrease with progressive maturity, while whole plant NDF and lignin contents are constant or decline as grain proportion increase. Also Adams (1995) reported that concentrations of NDF and ADF in whole crop maize silage decreased as maturity proceeded from early dent to two-thirds milkline stage, but did not change from two-thirds milkline to the blackline stage. Delaying harvest of whole plant maize to black layer stage of maturity resulted in higher starch content and lower NDF content as grain comprises a higher proportion of the maize plant.

Dry matter degradation curve of fresh maize whole plant and maize whole plant silage is illustrated in Figure 28. Dry matter washing losses of fresh maize whole plant decreased significantly with increasing maturity (40.0, 37.0 and 28.0% for early, middle and late harvest date respectively). On the other hand dry matter washing losses of maize whole plant silage at middle (56.0%) and late harvest (56.0%) was significantly higher than that at early harvest date (53.0%). Mean of DM washing losses of maize whole plant silage (55.0%) was significantly higher than that of maize whole plant (35.0%). Jurjanz and Monteils (2005) studied the degradability of maize whole plant and maize whole plant silage when maize whole plant DM was 34.0% and they found that DM washing losses of maize whole plant silage (57.0%) was higher than that of maize whole plant (38.0%).

In the present study there was no big difference in DM degradability between early and middle harvest of fresh maize whole plant at the different incubation times. At short incubation time (until 24 h of incubation) DM degradability of early and middle harvest date of fresh maize whole plant was higher than that of late harvest date. The difference in DM degradability between the three harvest dates of maize whole plant silage disappeared after 24 h of incubation. As well as the difference in DM degradability between fresh maize whole plant and maize whole plant silage disappeared after 72 h of incubation. Mean of DM degradability of maize whole plant silage and fresh maize whole plant at 96 h of incubation was nearly equal in values (83.7 and 83.6%, respectively).

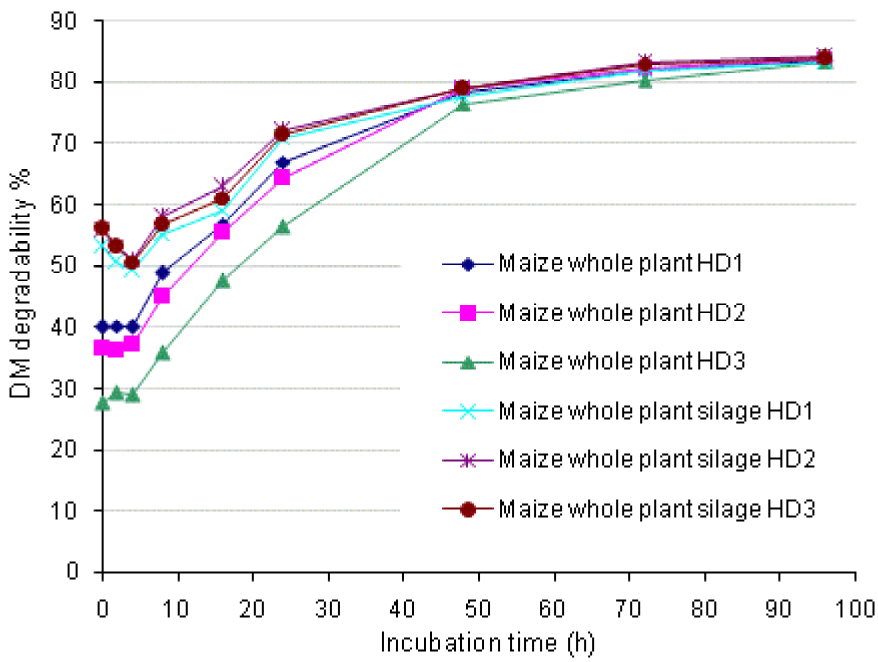
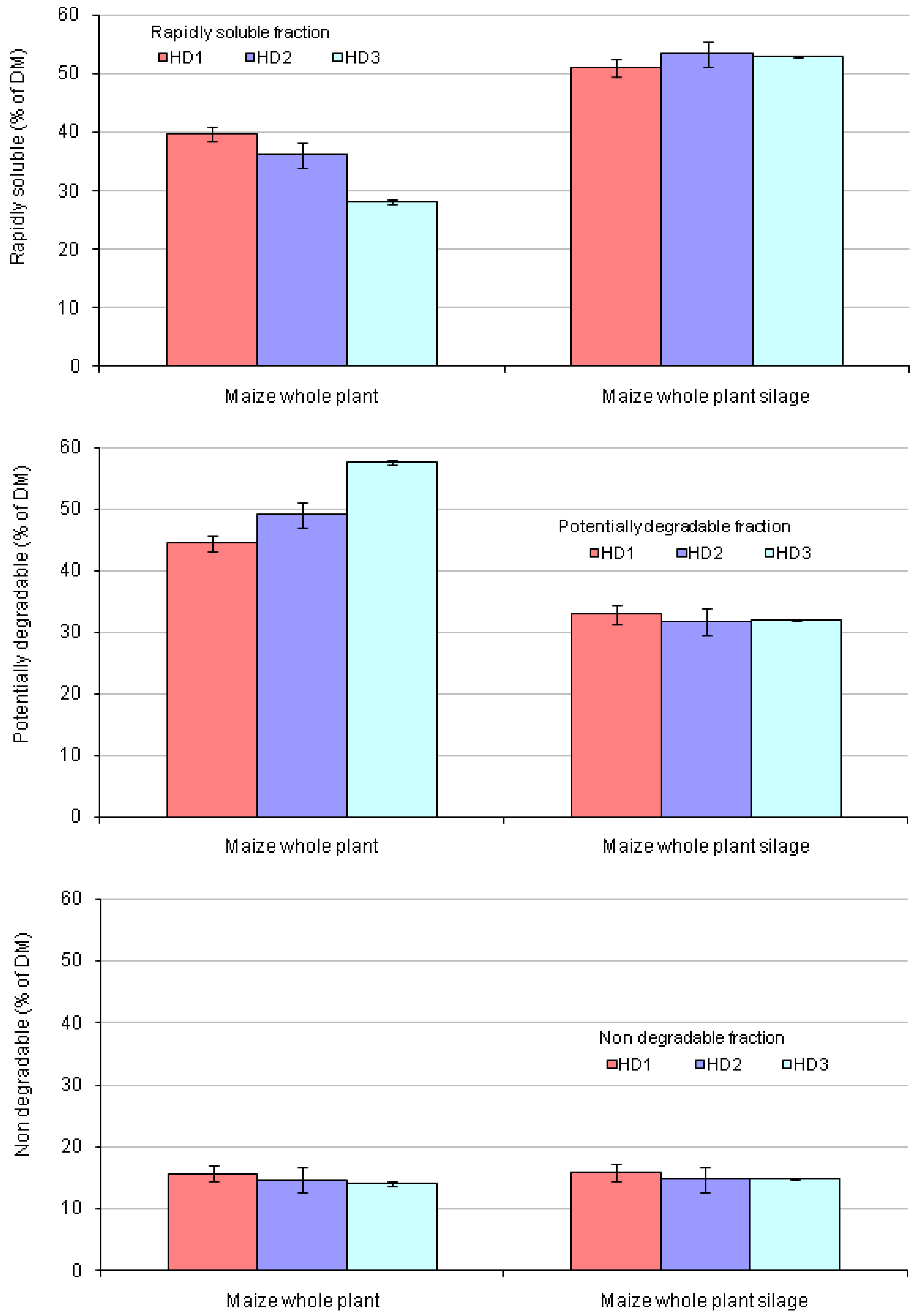


Figure 28. Effect of stage of maturity on rumen DM degradability of maize whole plant and maize whole plant silage after the different incubation times

Parameters of rumen DM degradability of fresh maize whole plant and maize whole plant silage are presented in Figure 29. The rapidly soluble fraction of fresh maize whole plant decreased significantly with increasing plant maturity (40.0, 36.0 and 28.8% for early, middle and late harvest respectively). On the other hand the rapidly soluble fraction of maize whole plant silage at middle (53.5%) and late harvest dates (53.0%) was significantly higher than that at early harvest date (51.0%). This accompanied with higher mean of the rapidly degradable fraction for maize whole plant silage (53.0%) than maize whole plant (38.0%). This is in agreement with the work of Jurjanz and Monteils (2005) as they found that the rapidly soluble fraction of maize whole plant silage (56.0%) was higher than that of maize whole plant (39.0%). As disused before ensiling solubilizes the endosperm protein in maize grains which involved a reduction in the protective aptitude of the protein matrix and so increase starch availability. Therefore, maize whole plant silage has higher rapidly soluble fraction than maize whole plant as well as ensiling reduces the differences between the three harvest dates.

The slowly degradable fraction of fresh maize whole plant increased significantly with increasing maturity (45.0, 49.0 and 58.0% for early, middle and late harvest respectively). On the other hand no significant difference in the slowly degradable fraction between the three harvest dates of maize whole plant silage was noticed (33.0, 32.0 and 32.0 for early, middle and late harvest date respectively). Mean of the slowly degradable fraction of maize whole plant (51.0%) was significantly higher than that of maize whole plant silage (32.5%). Jurjanz and Monteils (2005) found that the slowly degradable fraction of maize whole plant (42.0%) was higher than that of maize whole plant silage (27.0%).

The non degradable fraction of fresh maize whole plant and maize whole plant silage was nearly equal in value (15.0 and 15.5% respectively). These results are in agreement with Jurjanz and Monteils (2005) as they found that the non degradable fraction of maize whole plant and maize whole plant silage was 19.4 and 17.2% respectively.



For each parameter, different letters are significantly different

Figure 29. Effect of stage of maturity on parameters of rumen dry matter degradability of maize whole plant and maize whole plant silage

Maize whole plant has higher DM washing losses and rapidly degradable fraction (Table 37 and 41) than maize cob (Table 36 and 40). Since the same plants and the maturity stage at harvest were used, an explanation due to differences in variety or maturity can be excluded. Jurjanz and Monteils (2005) suggested two hypotheses which may be responsible for the increase of the rapidly soluble fraction of maize whole plant than maize cob. They stated that starch in the maize whole plant is nearly identical with starch in the grains based on low starch content in maize stover (2.0% of DM, Flachowsky (1994)). The first hypothesis suggested that the more rapidly degradable fraction in maize whole plant could be due to the chopping of the plant at harvest site (1-2 cm) and then grinding prior to ruminal incubation (3 mm). On the other hand maize cob was ground directly (3 mm) without chopping. The double mechanical treatment for maize whole plant during harvest and grinding could have weakened the protective layers of starch granules and the fine grinding (3 mm) could amplify this effect by increased particulate losses. The second hypothesis based on the higher moisture level of the whole plant (about 35.0%) when compared to dry cob (about 60.0%). Starch structure would be softened by moisture and therefore favors enzymatic hydrolysis, even if the forages were dried during sample preparation prior to incubation. Thus, double cracking and/or a softened starch structure lead to a higher rapidly degradable starch fraction in the whole fresh plant when compared to the starch in maize cob.

Table 51. Effect of stage of maturity on effective rumen dry matter degradability of maize whole plan and maize whole plant silage by passage rate of 6%h^{-1}

Component	*Mean of harvest date*			*Mean*
	HD1 (03.09.07)	*HD2 (18.09.07)*	*HD3 (15.10.07)*	
Maize whole plant	55.0	52.5	45.1	50.9
Maize whole plant silage	60.6	63.0	62.2	61.9

The effective rumen DM degradability of fresh maize whole plant decreased with increasing plant maturity (Table 51). However effective rumen DM degradability of maize whole plant silage increased from early (60.6%) to middle harvest (63.0%) but did not change from middle to late (62.2%) harvest stage. Moreover, the effective

DM degradability of maize silage (62.0%) was higher than that of fresh maize plant (51.0%); this is in agreement with the finding of (Jurjanz and Monteils, 2005). In the same time the effective DM degradability of maize silage didn't decrease with increasing plant maturity. Ettle and Schwarz (2003) stated that crude fibre digestibility declined with increasing maize maturity whereas the digestibility of nitrogen free extract rose slightly. Shifts in the carbohydrate fractions and their digestibility during the ripening process explain the fact that the digestibility of the organic matter of the maize silages was largely unaffected by the maturity stage. In disagree with Andrae et al. (2001) as they stated that harvesting maize silage at physiological maturity had a lower rate and extent of starch and fiber in situ rumen degradability than maize silage harvested at half milkline. From the present work ensiling has a dramatic effect on the effective DM degradability of maize stover (Exp 4) and maize grain (Exp 5), and the extent of the decrease depending on the maturity stage. Whereas the ensiling seems to impair the effective DM degradability of stover, the effective DM degradability of the ensiling grain is much higher than the fresh grain. Also the decrease in the effective DM degradability of the ensiled stover and grain with later harvesting is only small. These data together with alternation of the proportions of the stover and cob during maturity explain why the effective DM degradability of the whole plant silage didn't decrease during maturity. Therefore, the effective DM degradability of whole plant silage shows a broad window for harvesting of maize plant. But still the relation of grain to stover will highly affect the extent of effective DM degradability of maize whole plant silage.

5. Conclusions

In situ technique proved to be sufficiently precise in distinguishing between the degradability of the different dietary maize components (maize stover, maize grain, maize whole plant and maize whole plant silage). Furthermore, this technique advanced the knowledge about kinetic of maize degradation significantly. Therefore, plant breeder and animal nutritionist can use this technique as a useful tool for evaluating the feeding value of maize plant. Special precaution should be taken during using the in situ technique related to sample preparation, bag characteristics, incubation procedures, animal used and washing and drying method. Therefore, the exact description of the in situ method with the standard condition is necessary.

As study the degradability of different maize varieties at different harvest dates was the key research area of our interest. In situ rumen degradability of maize stover, maize grain and maize whole plant of different varieties at different harvest dates was studied. Additionally, maize grain was used as fresh grain (freeze dried) or conserved either by ensiling or oven dried at 85 ℃, as well as maize whole plant was used either in form of fresh or ensiling materials. While fresh materials will be helpful to plant breeder, practical oven dried and ensiled materials will be helpful to animal nutritionist and farm.

<u>Maize stover</u>

The obtained data of the present work indicate that maturity stage during maize silage making has a marked effect on chemical composition and in situ rumen degradation kinetics of maize stover. Chemical composition is the prime cause which affects DM degradability of maize stover, as stover crude fiber content increases with increasing plant maturity with a positive correlation of R^2 = 0.45. The higher in situ rumen dry matter degradability of maize stover at early maturity compared to later one is related to lower content of crude fiber. Therefore, there is a negative correlation of R^2 = 0.834 between crude fiber and effective rumen dry matter degradability of maize stover. Also there is difference in maize stover rumen dry matter degradability between maize varieties. As maize varieties vary in their chemical composition especially crude fiber and there is a correlation of R^2 = 0.523 between dry matter and crude fiber content. They vary also in their rumen dry matter degradability and there is a correlation of R^2 = 0.80 between crude fiber and effective rumen dry matter degradability. The decrease in effective rumen dry matter degradability between early and late harvest dates is different between varieties. When this decrease has a small range this indicates a wide window for harvesting those varieties without decreasing in their degradability. Thus those traits which affecting maize stover nutritive value should receive priority from plant breeder in the quest for improved maize silage. Furthermore, ensiling has adverse effect on rumen dry matter degradability of maize stover as dry matter degradability of maize stover after freeze drying and oven drying is higher than that after ensiling. This is because of conversion of maize stover water soluble carbohydrate into organic acids during ensiling. This leads to increase the proportion of the cell wall (crude fiber and neutral detergent fiber) in relation to the cell content, which has a direct effect on reducing stover rumen dry matter degradability after ensiling.

Maize grain

Maize grains are highly energetic feedstuff as it contains high concentration of starch (65 to 70%). Because starch in cereal grains is embedded in a protein matrix inside the endosperm, disruption of this protein matrix is required for starch digestion by microbes in the rumen. This protein matrix in particular, is less dense in barley and wheat starch than maize starch and so barley and wheat are higher than maize in starch degradability. Starch content of maize grain increased with increasing plant maturity and there was a correlation of R^2 = 0.598 between starch and dry matter content of maize grain. Rumen dry matter degradability decreased significantly with advanced maturity and this accompanied with a negative correlation of R^2 = 0.848 between dry matter and the effective rumen dry matter degradability of maize grain. This is because the protein matrix of the endosperm became denser with increasing maturity. Therefore, rumen dry matter degradability of maize grain can be predicted from its dry matter content. Furthermore, maize variety (endosperm structure) affect rumen dry matter degradability of maize grain and variety NX20026 (dent type) was significantly higher in degradability than variety NX1485 (flint type). This attributed to the difference in dry matter content of maize grain as it is lower in dent than flint grain. Maize grain used either in maize whole plant silage such as ensiling grain or used in the concentrate feed such as oven dried maize grain. While ensiling improve maize grain dry matter degradability greatly, practical oven dried at 85 ℃ impair it.

The increase in rumen degradability of maize grain after ensiling could be partly derived from solubilization of endosperm proteins during silage fermentation. Furthermore, DM degradability of the ensiled maize grain does not affected greatly with increasing maturity as there is a week negative correlation of R^2 = 0.390 between dry matter and effective rumen dry matter degradability of ensiled grain. On contrast to ensiling, practical oven drying at 85 °C shows a negative correlation of R^2 = 0.970 between dry matter and effective rumen dry matter degradability. Moreover, ensiling and practical oven drying at 85 °C can reduce or eliminate the difference in rumen dry matter degradability between the two maize varieties (dent and flint one). Thus the site of maize starch degradability (rumen vs. intestine) can be modified by conservation method and to some extend by genetic selection of maize variety.

<u>Maize whole plant</u>

Degradability of maize whole plant is affected by factors which affect its components (maize grain and maize stover) as well as the proportion of those components. The relationship between maize whole plant composition and degradability is complicated. As maturity advanced, stover crude fiber increased and its degradability decreased, on the other hand proportion of grain and consequently starch increased and its degradability decreased. Therefore rumen dry matter degradability of fresh maize whole plant decreased significantly with increasing plant maturity. On contrast to fresh material, ensiling has a dramatic effect on the effective dry matter degradability of maize stover and maize grain and in turn maize whole plant silage. Whereas ensiling impairs the effective dry matter degradability of stover, it improves the effective dry matter degradability of maize grain greatly. Also the decrease in the effective dry matter degradability of the ensiled stover and grain with later harvesting is only small. Moreover, the proportion of the grain increased with increasing maturity. Therefore, the effective rumen dry matter degradability of the whole plant silage didn’t decrease with increasing maturity. Furthermore, ensiling improved the dry matter degradability of maize whole plant in comparison to fresh material. Therefore, effective rumen dry matter degradability of whole plant silage shows a broad window for harvesting of maize plant. But still the relationship of grain to stover will highly affect the extent of degradability of maize whole plant silage.

6. Summary

The aim of this work was to study the effect of maturity stage at harvest, maize variety and the effect of conservation methods (oven drying and ensilage in comparison to the fresh material) on the in situ rumen degradability of maize plant components (stover, cob, grain and whole plant). Results were sought to clarify the effect and contribution of each component on degradability and feeding value of maize whole plant and which component and trait are important for the plant breeder to improve the feeding value of maize hybrids.

For determination of the ruminal degradability of the maize plant components a total of six experiments were done over a period of three years (2006, 2007 and 2008). The first three experiments were allotted to fresh maize stover in which six maize varieties (NK Magitop, EXP99FN, NX1064, NX1494, NX1485 and NX0601) in Exp 1, four maize varieties (NK Magitop, Winn, NX1775 and NK lemoro) in Exp 2 and six maize varieties (NK Magitop, NX17066, NX10126, NX20026, NX04016 and NX1485) in Exp 3 were used. The fourth experiment was allotted to maize stover in which two maize varieties (NX1485 and NX20026) were used such as fresh (freeze dried), oven dried at 60 ℃ or ensiling. The fifth experiment was allotted to maize grain in which two maize varieties, one from flint endosperm (NX1485) and the other from dent endosperm (NX20026) were used such as fresh (freeze dried), oven dried at 85 ℃ or ensiled grain. The sixth experiment was allotted to maize stover, maize cob, maize whole plant and maize whole plant silage in which two maize varieties from flint endosperm (NK Magitop and NX1485) were used. The different varieties of maize plant designated for measuring the ruminal dry matter degradability of the different maize plant components were harvested simultaneously at three different harvest dates (early, middle and late harvest dates) which were proceeded with plant maturity.

The chemical analysis of the different maize components was divided up into the measurement of the crude nutrients (crude ash, CP, EE and CF) with the Weender analysis method as well as the determination of the structural cell wall components (NDF, ADF and ADL) and starch content.

Rumen DM degradability was estimated using the in situ technique. Thereby four gram on DM basis from the ground feed material (3 mm) were placed in nylon bags and incubated for 0, 2, 4, 8, 16, 24, 48, 72 and 96 hours in the rumen of six non lactating dairy cows fitted with ruminal cannulae but for maize grain it incubated only until 48 hours. Thus it is possible to generate characteristic ruminal degradation curves. Then ruminal degradation parameters were fitted to an exponential model and the following parameters were estimated: a = rapidly soluble fraction, b = insoluble, but ruminally degradable fraction, c = degradation rate of fraction b, and lag time (t_0), which describes the delay between the beginning of rumen incubation and microbial degradation. Additionally, the effective dry matter degradability was estimated based on these parameters assuming a passage rate of 6 $\%h^{-1}$.

The first three experiments indicated that maturity stage at harvest plays a major role in the determination of the chemical composition and hence ruminal dry matter degradability of maize stover. Rumen dry matter degradability of maize stover reduced strongly with advancing maturities of the plants. Therefore, maize stover at early maturity stage showed an effective rumen dry matter degradability of about 50.0% which significantly decreased to about 47.0% at middle maturity stage and to about 40.0% at late maturity stage. There was a strong negative correlation between crude fiber content and effective rumen dry matter degradability of maize stover R^2 = 0.834. Also maize variety affect the chemical composition of maize plant clearly; in turn there was a different in rumen dry matter degradability between varieties. Maize varieties can be classified according to dry matter degradability into three categories, in which varieties NK Magitop, NX1494, NX1485 and NX1775 have high dry matter degradability, varieties NX0601, EXP99FN, NX10126, NX20026 and NX04016 have intermediate dry matter degradability and varieties NX1064, Winn, NK Lemoro and NX17066 have low dry matter degradability.

Moreover, results of Exp 4 indicated that conservation method greatly affect rumen dry matter degradability of maize stover. Thus, the effective rumen dry matter degradability of maize stover after ensiling (42.0%) was lower than that after oven dried at 60 ℃ (47.0%) and freeze dried (48.0%).

Results of Exp 5 revealed that the effective rumen dry matter degradability of fresh maize grain as mean of the two varieties decreased with increasing maturity (79.0, 70.0 and 63.0% for early, middle and late harvest respectively). This is accompanied with a strong negative correlation of R^2 = 0.848 between dry matter and effective dry matter degradability of fresh maize grain. Ensiling improved rumen degradability of maize grain clearly than fresh maize grain and the effective rumen dry matter degradability of the ensiled maize grain as mean of the two varieties was 92.0, 90.0 and 89.0 for early, middle and late harvest respectively. This is accompanied with a weak negative correlation of R^2 = 0.390 between dry matter and effective dry matter degradability of ensiled maize grain. This correlation indicates that rumen degradability of ensiled maize grain did not affected greatly with increasing maturity. On the other hand, oven dried at 85 ℃ impaired rumen degradability of the grain and the effective rumen dry matter degradability was 49.0, 43.0 and 39.0% for early, middle and late harvest respectively. This accompanied with a strong negative correlation of R^2 = 0.970 between dry matter and the effective rumen dry matter degradability of oven dried maize grain. Furthermore, maize variety (endosperm type) plays a role in determining rumen dry matter degradability of maize grain. Dent endosperm variety was higher in effective rumen dry matter degradability than flint endosperm variety after freeze drying (75.0 vs 66.0%). This is may be attributed to the difference in grain vitreousness and dry matter between the two varieties, as flint grain dry matter (60.0%) was higher than dent one (56.0%). The difference in effective rumen dry matter degradability between dent and flint maize grain decreased after oven drying (45.0 vs 43.0%) and ensiling conservation (92.0 vs 89.0%).

The obtained results of Exp 6 were such as a summary of the previous experiments, where the effective dry matter degradability of fresh maize whole plant followed the same direction like fresh stover and fresh grain as it decreased with increasing plant maturity (55.0, 52.5 and 45.0% for early, middle and late harvest respectively). However, the effective rumen dry matter degradability of maize whole plant silage at the three harvest date was nearly equal in value (61.0, 63.0 and 62.0%.for early, middle and late harvest respectively). Thus, the result of maize whole plant silage shows a broad window for harvesting of maize plant during silage making

7. Zusammenfassung

Das Ziel dieser Untersuchung war es, den Einfluss des physiologischen Reifestatus zum Erntezeitpunkt, der Maissorte sowie der Konservierungsverfahren (Ofentrocknung und Silierung im Vergleich zum frischen Material) auf die in situ-Abbaubarkeit der Bestandteile der Maispflanze (Restpflanze, Kolben, Korn und Ganzpflanze). Es sollte geklärt werden, welchen Einfluss in welchem Ausmaß die einzelnen Pflanzenbestandteile auf die Abbaubarkeit und den Futterwert der Maisganzpflanze haben und welche Komponenten und Eigenschaften möglicherweise wichtig für die Pflanzenzüchtung sind, um den Gesamtfutterwert von Maishybriden zu verbessern.

Zur Bestimmung der ruminalen Abbaubarkeit der Pflanzenbestandteile wurden sechs Experimente (Exp) über einen Zeitraum von drei Jahren (2006, 2007 und 2008) durchgeführt. In den ersten drei Versuchen wurden frische Maisrestpflanzen untersucht. In Exp 1 wurden sechs Maissorten (NK Magitop, EXP99FN, NX1064, NX1494, NX1485 und NX0601), in Exp 2 vier (NK Magitop, Winn, NX1775, NK lemoro) und in Exp 3 sechs Sorten (NK Magitop, NX17066, NX10126, NX20026, NX04016 und NX1485) verwendet. Im vierten Experiment wurden die Restpflanzen zweier Sorten (NX1485 und NX20026) als frisches Material (gefriergetrocknet), nach Ofentrocknung bei 60 °C oder siliert untersucht. Im fünften Experiment wurden die Maiskörner zweier Sorten mit flint-Typ-Endosperm (NX1485) bzw. dent-Typ-Endosperm (NX20026) in frischer (gefriergetrockneter), bei 85 °C ofengetrockneter sowie silierter Form betrachtet, während der sechste Versuch Maisrestpflanzen, Maiskolben, Maisganzpflanzen sowie Maisganzpflanzensilage zweier Sorten mit flint-Typ-Endosperm (NK Magitop und NX1485) untersuchte. Die verschiedenen Sorten, die zur Bestimmung der ruminalen Abbaubarkeit der Trockenmasse (TM) der Maispflanzenbestandteile bestimmt waren, wurden gleichzeitig zu drei verschiedenen Erntezeitpunkten (früher, mittlerer und später Erntezeitpunkt) bei zunehmender Reife der Pflanze geerntet.

Die chemischen Analysen der Maispflanzenbestandteile gliederten sich in die Bestimmung der Rohnährstoffe (Rohasche, Rohprotein, Rohfett und Rohfaser) durch die Weender-Analyse sowie der pflanzlichen Gerüstsubstanzen NDF, ADF und ADL nach Van Soest und des Stärkegehalts.

Die ruminale Abbaubarkeit der Trockenmasse wurde anhand der in situ-Technik bestimmt. Hierfür wurden 4 g TM des gemahlenen Futtermittels (3 mm) in Nylonbeutel abgewogen und diese für 0, 2, 4, 8, 16, 24, 48, 72 und 96 Stunden im Pansen von sechs trockenstehenden pansenfistulierten Milchkühen inkubiert (Maiskörner nur bis 48 Stunden). Somit können typische ruminale Abbaukurven dargestellt werden. Es erfolgte die Schätzung folgender Parameter des ruminalen Abbaus: a=schnell abbaubare bzw. lösliche Fraktion, b=unlösliche aber abbaubare Fraktion, c=Abbaurate von Fraktion b sowie die lag time (t_0), die die Verzögerung zwischen Inkubationsbeginn und dem Beginn des mikrobiellen Abbaus beschreibt. Zusätzlich wurde aus diesen Parametern die effektive ruminale TM-Abbaubarkeit bei einer angenommenen Passagerate von $6\%h^{-1}$.

Die ersten drei Untersuchungen zeigten für Maisrestpflanzen einen großen Einfluss der physiologischen Reife zum Erntezeitpunkt auf die chemische Zusammensetzung und somit auf die ruminale Abbaubarkeit der TM – diese nimmt deutlich ab mit dem Fortschreiten der physiologischen Reife der Pflanzen. Die Restpflanzen im jungen Reifestadium wiesen eine effektive ruminale TM-Abbaubarkeit von etwa 50,0% auf, die im mittleren Reifestadium auf etwa 47,0% und im späten Reifestadium auf etwa 40,0% signifikant abfiel. Es ergab sich eine starke negative Korrelation zwischen dem Rohfasergehalt und der effektiven ruminalen TM-Abbaubarkeit der Restpflanze mit R^2 = 0,834. Die Maissorte beeinflusst die chemische Zusammensetzung der Maispflanze ebenfalls deutlich, so dass sich die ruminale TM-Abbaubarkeit der Sorten unterscheidet. Anhand ihrer TM-Abbaubarkeit können sie in drei Klassen unterteilt werden: NK Magitop, NX1494, NX1485 und NX1775 zeigen eine hohe TM-Abbaubarkeit, NX0601, EXP99FN, NX10126, NX20026 und NX04016 eine mittlere sowie NX1064, Winn, NK Lemoro und NX17066 eine geringe TM-Abbaubarkeit.

Ferner lassen die Ergebnisse des vierten Versuchs einen großen Einfluss des Konservierungsverfahrens auf die ruminale TM-Abbaubarkeit der Restpflanze erkennen. Bei der Silierung war sie geringer (42,0%) als nach Ofentrocknung bei 60 °C (47,0%) oder Gefriertrocknung (48,0%).

Exp 5 konnte aufzeigen, dass die effektive ruminale TM-Abbaubarkeit frischer Maiskörner mit zunehmender physiologischer Reife abnimmt (79,0, 70,0 und 63,0% bei früher, mittlerer und später Ernte). Eine starke negative Korrelation von R^2 = 0,848 zwischen dem Trockenmassegehalt und der effektiven ruminalen TM-Abbaubarkeit des frischen Maiskorns belegt dies. Die effektive ruminale TM-Abbaubarkeit silierter Maiskörner war mit 92,0, 90,0 bzw. 89,0% bei früher, mittlerer bzw. später Ernte deutlich verbessert im Vergleich zu frischem Material. Eine schwache negative Korrelation von R^2 = 0,390 zwischen dem Trockenmassegehalt und der effektiven ruminalen TM-Abbaubarkeit des silierten Maiskorns deutet auf einen geringen Einfluss der physiologischen Reife auf die ruminale Abbaubarkeit hin. Andererseits beeinträchtigt die Ofentrocknung bei 85 °C die ruminale Abbaubarkeit des Korns mit effektiven ruminalen TM-Abbaubarkeiten von 49,0, 43,0 und 39,0% bei früher, mittlerer bzw. später Ernte. Die Korrelation zwischen dem Trockenmassegehalt und der effektiven ruminalen TM-Abbaubarkeit des ofengetrockneten Maiskorns war mit R^2 = 0,970 stark negativ. Schließlich spielt auch die Maissorte (Endosperm-Typ) eine Rolle bezüglich der effektiven ruminalen TM-Abbaubarkeit des Maiskorns. Sorten mit dent-Typ-Endosperm zeigen eine höhere effektive ruminale TM-Abbaubarkeit als solche des flint-Typs (75,0 vs. 66,0%). Das kann auf Unterschiede in Vitreousness und Trockenmassegehalt zwischen den Sorten zurückgeführt werden. Der TM-Gehalt des flint-Typ-Korns lag mit 60,0% höher als der des dent-Typ-Korns mit 56,0%. Die Differenz zwischen den effektiven ruminalen TM-Abbaubarkeiten zwischen dem dent-Typ- und dem flint-Typ-Maiskorn nahm bei Ofentrocknung (45,0 vs. 43,0%) sowie Silierung (92,0 vs. 89,0%) ab.

Die Resultate des sechsten Versuchs zeigten, dass die effektive ruminale TM-Abbaubarkeit der frischen Maisganzpflanze genauso wie die der frischen Restpflanze und des frischen Maiskorns mit zunehmender physiologischer Reife der Pflanzen absinkt (55,5, 52,5 bzw. 45,0% bei früher, mittlerer bzw. später Ernte). Die effektive ruminale TM-Abbaubarkeit der silierten Maisganzpflanze unterschied sich zu den drei Erntezeitpunkten kaum (61,0, 63,0 bzw. 62,0% bei früher, mittlerer bzw. später Ernte). Dieses Ergebnis lässt auf ein großes Erntezeitfenster bei der Herstellung von Maisganzpflanzensilage schließen.

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9. Appendices

Table A1. Ruminal juice pH value of the used animals at the first experiment

Time	pH value							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	6.99	7.11	6.95	6.80	6.94	7.14	6.99	0.12
07:30	6.42	6.45	6.57	6.63	6.67	6.77	6.59	0.13
08:00	6.49	6.56	6.64	6.67	6.75	6.82	6.66	0.12
08:30	6.47	6.46	6.75	6.67	6.69	6.92	6.66	0.17
09:30	6.65	6.62	6.81	6.84	6.76	6.95	6.77	0.12
10:30	6.67	6.59	6.87	6.73	6.78	7.00	6.77	0.15
11:30	6.67	6.56	6.81	6.80	6.80	6.89	6.76	0.12

Table A2. Ruminal juice pH value of the used animals at the second experiment

Time	pH value							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	6.82	6.87	6.76	6.89	6.91	6.99	6.87	0.08
07:30	6.68	6.60	6.51	6.54	6.63	6.69	6.61	0.07
08:00	6.56	6.60	6.56	6.59	6.57	6.79	6.61	0.09
08:30	6.68	6.59	6.70	6.51	6.58	6.82	6.65	0.11
09:30	6.45	6.54	6.65	6.78	6.58	6.86	6.64	0.15
10:30	6.62	6.62	6.65	6.76	6.68	6.89	6.70	0.11
11:30	6.72	6.62	6.62	6.64	6.68	6.82	6.68	0.08

Table A3. Ruminal juice pH value of the used animals at the third experiment

Time	pH value							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	6.89	6.87	6.99	7.20	6.86	7.08	6.98	0.14
07:30	6.62	6.58	6.77	6.69	6.49	6.70	6.64	0.10
08:00	6.51	6.58	6.82	6.62	6.43	6.85	6.64	0.17
08:30	6.50	6.47	6.90	6.54	6.48	6.82	6.62	0.19
09:30	6.40	6.38	6.85	6.35	6.50	6.88	6.56	0.24
10:30	6.58	6.45	6.83	6.38	6.64	6.75	6.61	0.17
11:30	6.34	6.58	6.84	6.62	6.56	6.83	6.63	0.19

Table A4. Ruminal juice pH value of the used animals at the fourth experiment

Time	pH value							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	7.01	6.73	6.96	6.97	6.92	6.78	6.90	0.11
07:30	6.71	6.46	6.69	6.64	6.77	6.82	6.68	0.13
08:00	6.67	6.36	6.66	6.73	6.74	6.47	6.61	0.15
08:30	6.82	6.41	6.60	6.75	6.48	6.45	6.59	0.17
09:30	6.88	6.39	6.69	6.73	6.62	6.55	6.64	0.17
10:30	6.83	6.38	6.38	6.79	6.61	6.25	6.54	0.24
11:30	6.89	6.48	6.62	6.81	6.64	6.46	6.65	0.17

Table A5. Ruminal juice pH value of the used animals at the fifth and sixth experiment

Time	pH value							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	7.05	7.13	7.11	7.15	7.08	7.29	7.14	0.08
07:30	6.81	6.88	6.78	6.88	6.73	7.01	6.85	0.10
08:00	6.67	6.91	6.97	6.82	6.71	7.05	6.86	0.15
08:30	6.65	6.90	6.87	6.83	6.74	7.08	6.85	0.15
09:30	6.59	6.89	6.83	6.65	6.75	7.08	6.80	0.18
10:30	6.60	6.82	7.01	6.40	6.73	7.02	6.76	0.24
11:30	6.84	6.77	6.98	6.81	6.80	6.92	6.85	0.08

Table A6. Ruminal juice ammonia nitrogen of the used animals at the first experiment

Time	Ammonia nitrogen in mg/100 ml							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	7.9	8.5	10.8	6.8	6.8	9.9	8.5	1.6
07:30	13.6	23.1	21.8	23.5	27.5	22.5	22.0	4.6
08:00	17.0	15.3	20.1	18.7	23.3	20.4	19.1	2.8
08:30	15.0	18.4	20.1	20.1	25.2	16.4	19.2	3.6
09:30	11.6	11.3	14.2	10.5	16.4	13.6	12.9	2.2
10:30	6.5	8.2	8.5	4.8	11.6	9.9	8.3	2.4
11:30	5.1	6.8	8.2	1.7	6.8	8.2	6.1	2.5

Table A7. Ruminal juice ammonia nitrogen of the used animals at second experiment

Time	Ammonia nitrogen in mg/100 ml							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	5.1	6.5	8.2	6.2	6.2	7.7	6.7	1.1
07:30	7.9	11.9	15.6	11.6	11.6	15.9	12.4	3.0
08:00	9.4	15.0	11.9	13.6	13.3	12.2	12.6	1.9
08:30	10.8	15.3	15.3	12.5	13.3	14.2	13.6	1.7
09:30	10.5	7.9	10.8	7.7	11.1	11.3	9.9	1.6
10:30	6.2	7.1	8.7	7.2	5.5	7.9	7.1	1.1
11:30	4.8	3.7	9.9	4.8	6.0	7.7	6.2	2.3

Table A8. Ruminal juice ammonia nitrogen of the used animals at the third experiment

Time	Ammonia nitrogen in mg/100 ml							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	4.3	6.0	7.4	8.1	10.5	7.1	7.2	2.1
07:30	13.6	11.9	11.5	11.4	19.0	10.4	13.0	3.1
08:00	15.6	22.4	13.6	11.9	11.1	8.5	13.9	4.8
08:30	14.7	13.0	12.5	10.8	14.7	13.0	13.1	1.5
09:30	5.7	9.1	8.8	7.9	18.7	12.8	10.5	4.6
10:30	3.4	12.8	3.7	0.9	7.0	7.1	5.8	4.2
11:30	2.6	1.7	4.7	2.0	4.8	4.8	3.4	1.5

Table A9. Ruminal juice ammonia nitrogen of the used animals at fourth experiment

Time	Ammonia nitrogen in mg/100 ml							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	3.8	3.4	5.1	6.8	6.8	3.8	5.0	1.5
07:30	3.8	5.1	6.8	5.5	8.5	6.8	6.1	1.6
08:00	9.8	7.7	8.1	7.2	6.0	8.1	7.8	1.2
08:30	7.2	7.2	6.8	8.1	7.7	8.9	7.7	0.8
09:30	6.4	6.0	8.9	7.7	6.0	8.5	7.3	1.3
10:30	11.9	10.2	8.1	11.5	7.2	10.6	9.9	1.9
11:30	9.4	7.7	8.9	10.2	8.9	8.5	8.9	0.8

Table A10. Ruminal juice ammonia nitrogen of the used animals at fifth and sixth experiment

Time	Ammonia nitrogen in mg/100 ml							
	Eureka	Gerri	Rabina	Falke	Anke	Leisa	Mean	SD
07:00	6.4	5.5	3.8	4.7	3.4	5.5	4.9	1.1
07:30	5.1	7.2	8.5	7.2	4.7	7.2	6.7	1.5
08:00	8.1	9.8	5.5	9.4	7.2	9.4	8.2	1.7
08:30	11.5	10.3	7.2	7.7	6.8	11.5	9.2	2.2
09:30	7.2	6.8	10.6	13.6	8.9	12.3	9.9	2.8
10:30	3.0	6.8	8.1	6.0	7.7	5.1	6.1	1.9
11:30	4.3	2.1	3.8	6.8	4.7	5.5	4.5	1.6

Table A11. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at the first experiment

Animals	**Acetic acid (mmol/l)**	**Butyric acid (mmol/l)**	**Propionic acid (mmol/l)**
Eureka	65.0	13.62	14.85
Gerri	58.3	11.35	13.50
Rabina	55.0	11.35	13.50
Falke	65.0	12.48	14.85
Anke	66.7	10.21	12.15
Leisa	51.7	11.35	10.80
Mean	60.3	11.73	13.27
SD	6.2	1.17	1.58

Table A12. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at the second experiment

Animals	**Acetic acid (mmol/l)**	**Butyric acid (mmol/l)**	**Propionic acid (mmol/l)**
Eureka	55.0	11.35	13.50
Gerri	58.3	11.35	13.50
Rabina	55.0	11.35	13.50
Falke	65.0	12.48	14.85
Anke	66.7	10.21	12.15
Leisa	51.7	11.35	10.80
Mean	58.6	11.35	13.05
SD	6.0	0.72	1.39

Table A13. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at the third experiment

Animals	Acetic acid (mmol/l)	Butyric acid (mmol/l)	Propionic acid (mmol/l)
Eureka	50.0	11.35	14.85
Gerri	61.7	10.21	21.60
Rabina	38.3	10.21	13.50
Falke	53.3	11.35	12.15
Anke	46.7	9.08	12.15
Leisa	48.3	9.08	18.90
Mean	49.7	10.21	15.52
SD	7.7	1.02	3.89

Table A14. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at the fourth experiment

Animals	Acetic acid (mmol/l)	Butyric acid (mmol/l)	Propionic acid (mmol/l)
Eureka	40.0	6.81	9.45
Gerri	56.7	9.08	12.15
Rabina	60.0	9.08	12.15
Falke	41.7	7.94	10.80
Anke	55.0	7.94	12.15
Leisa	65.0	12.48	16.20
Mean	53.1	8.89	12.15
SD	6.4	1.95	2.26

Table A15. Rumen volatile fatty acids (acetic, butyric and propionic acid) of the used animals at fifth and sixth experiment

Animals	Acetic acid (mmol/l)	Butyric acid (mmol/l)	Propionic acid (mmol/l)
Eureka	48.3	7.94	12.15
Gerri	43.3	5.67	8.10
Rabina	45.0	6.81	10.80
Falke	65.0	10.21	14.85
Anke	53.3	9.08	10.80
Leisa	48.3	7.94	10.80
Mean	50.6	7.94	11.25
SD	7.9	1.61	2.20

Table A16. Dry matter of maize whole plant and maize cob at the first experiment

Component	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety
Maize whole plant DM%	**NK Magitop**	29.6	36.7	40.4	**35.5**
	EXP99FN	28.9	35.2	41.5	**35.2**
	NX1064	29.0	34.7	46.9	**36.8**
	NX1494	27.1	32.6	39.9	**33.2**
	NX1485	27.2	34.2	40.0	**33.8**
	NX0601	28.3	35.9	39.1	**34.4**
	Mean HD	**28.3[c]**	**34.9[b]**	**41.3[a]**	
Maize cob DM%	**NK Magitop**	48.9	57.3	59.9	**55.4**
	EXP99FN	53.0	60.1	63.4	**58.8**
	NX1064	51.8	60.5	64.4	**58.9**
	NX1494	53.2	59.2	63.8	**58.7**
	NX1485	52.1	60.0	64.1	**58.7**
	NX0601	52.9	57.6	60.5	**57**
	Mean HD	**52.0[c]**	**59.1[b]**	**62.7[a]**	

Means along the same row bearing different small letters are significantly different

Table A17. Maize cob and maize stover proportions from the whole plant dry matter at the first experiment

Component	Variety	HD1 (08.09.06)	HD2 (25.09.06)	HD3 (09.10.06)	Mean variety
Maize cob %	**NK Magitop**	47.5	55.5	56.7	**53.2**
	EXP99FN	48.5	55.1	56.0	**53.2**
	NX1064	50.4	53.5	57.3	**53.7**
	NX1494	45.1	50.6	55.3	**50.3**
	NX1485	49.5	57.2	60.1	**55.6**
	NX0601	53.5	57.8	60.0	**57.1**
	Mean HD	**49.1[b]**	**55.0[a]**	**57.6[a]**	
Maize stover %	**NK Magitop**	52.5	44.5	43.3	**46.8**
	EXP99FN	51.5	44.9	44.0	**46.8**
	NX1064	49.6	46.5	42.7	**46.3**
	NX1494	54.9	49.4	44.7	**49.7**
	NX1485	50.5	42.8	39.9	**44.4**
	NX0601	46.5	42.2	40.0	**42.9**
	Mean HD	**50.9[a]**	**45.0[b]**	**42.4[b]**	

Means along the same row bearing different small letters are significantly different

Table A18. Dry matter of maize whole plant and maize cob at the second experiment

Component	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety
Maize whole plant DM%	**NK Magitop**	30.1	34.2	39.9	46.6	**37.7**
	Winn	30.0	35.0	42.5	52.5	**40.0**
	NK Lemoro	24.7	33.2	36.2	48.6	**35.7**
	NX1775	28.9	32.6	39.9	46.2	**36.9**
	Mean HD	**28.5^{d}**	**33.7^{c}**	**39.6^{b}**	**48.5^{a}**	
Maize cob DM%	**NK Magitop**	50.4	55.5	56.3	60.5	**55.7**
	Winn	50.8	53.5	57.7	60.7	**55.7**
	NK Lemoro	38.5	49.9	50.8	59.0	**49.6**
	NX1775	52.6	58.2	60.5	61.4	**58.2**
	Mean HD	**48.1^{b}**	**54.3^{ab}**	**56.3^{a}**	**60.4^{a}**	

Means along the same row bearing different small letters are significantly different

Table A19. Maize cob and maize stover proportions of the whole plant dry matter at the second experiment

Component	Variety	HD1 (03.09.07)	HD2 (18.09.07)	HD3 (02.10.07)	HD4 (17.10.07)	Mean variety
Maize cob%	**NK Magitop**	48.3	53.2	53.0	62.0	**54.1**
	Winn	53.0	57.6	58.6	61.6	**57.7**
	NK Lemoro	42.7	52.7	53.8	57.6	**51.7**
	NX1775	52.6	52.0	57.0	63.5	**56.3**
	Mean HD	**49.0^{c}**	**54.0^{bc}**	**55.6^{b}**	**61.2^{a}**	
Maize stover%	**NK Magitop**	51.7	46.8	47.0	38.0	**45.9**
	Winn	47.0	42.4	41.4	38.4	**42.3**
	NK Lemoro	57.3	47.3	46.2	42.4	**48.3**
	NX1775	47.4	48.0	43.0	36.5	**43.7**
	Mean HD	**51.0^{a}**	**46.0^{ab}**	**44.4^{b}**	**38.8^{c}**	

Means along the same row bearing different small letters are significantly different

Table A20. Dry matter of maize whole plant and maize cob at the third experiment

Component	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
Maize whole plant DM%	**NK Magitop**	29.5	36.2	44.9	**36.9**
	NX17066	25.9	31.7	44.1	**33.9**
	NX20026	24.5	32.7	41.2	**32.8**
	NX10126	24.8	32.7	42.4	**33.3**
	NX 04016	27.6	35.2	42.7	**35.2**
	NX1485	25.4	33.3	41.6	**33.4**
	Mean HD	**26.3[c]**	**33.6[b]**	**42.8[a]**	
Maize cob DM%	**NK Magitop**	50.2	64.6	67.4	**60.7**
	NX17066	45.1	58.6	61.5	**55.1**
	NX20026	46.9	61.5	64.2	**57.5**
	NX10126	48.4	62	64.8	**58.5**
	NX04016	53.7	62.2	65.9	**60.6**
	NX1485	50.9	62	65	**59.3**
	Mean HD	**49.2[c]**	**61.8[b]**	**64.8[a]**	

Means along the same row bearing different small letters are significantly different

Table A21. Maize cob and maize stover proportions of the whole plant dry matter at the third experiment

Component	Variety	HD1 (02.09.08)	HD2 (19.09.08)	HD3 (07.10.08)	Mean variety
Maize cob%	**NK Magitop**	48.5	56.1	56.1	**53.6**
	NX17066	46.0	48.7	59.8	**51.5**
	NX20026	40.2	57.4	59.6	**52.4**
	NX10126	39.7	50.4	53.9	**48.0**
	NX04016	50.7	55.2	57.7	**54.6**
	NX1485	44.7	54.3	57.1	**52.0**
	Mean HD	**45.0[b]**	**53.7[a]**	**57.4[a]**	
Maize stover%	**NK Magitop**	51.5	43.9	43.9	**46.4**
	NX17066	54.0	51.3	40.2	**48.5**
	NX20026	59.8	42.6	40.4	**47.6**
	NX10126	60.3	49.6	46.1	**52.0**
	NX04016	49.3	44.8	42.3	**45.4**
	NX1485	55.3	45.7	42.9	**48.0**
	Mean HD	**55.0[a]**	**46.3[b]**	**42.6[b]**	

Means along the same row bearing different small letters are significantly different

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