

Undegradable starch (%BZET) and protein (%BRE) in maize silage

Johan De Boever, Dorien Van Wesemael, Bart Ampe
Themamiddag Rundveevoeding CVB
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Johan.deboever@ilvo.vlaanderen.be



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Presentation overview

- Factors affecting %BZET and %BRE
- Experiments to examine the effect of ensiling time and maturity stage
- Models to predict %BZET and %BRE
- Integration in CVB Feed Table
- Conclusions and practical significance

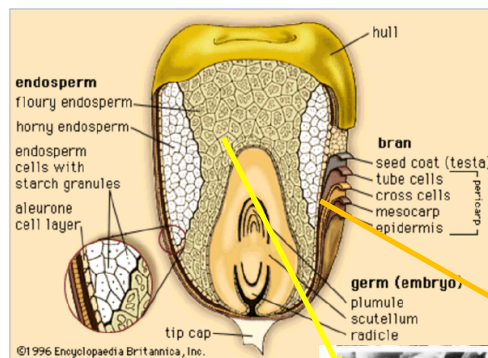
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Factors affecting %BZET & %BRE

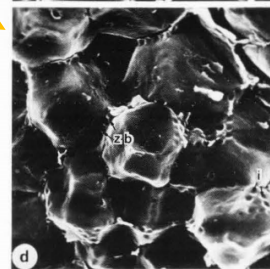
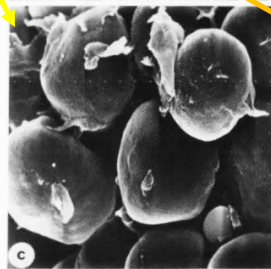
- Genotype: flint/horny/vitreous/waxy vs. dent/floury endosperm
- Maturity stage
- Chopping length/crushing rolls
- **Storage time in silo**

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Endosperm in maize



Floury vs. horny endosperm



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Effect of DM and endosperm-type

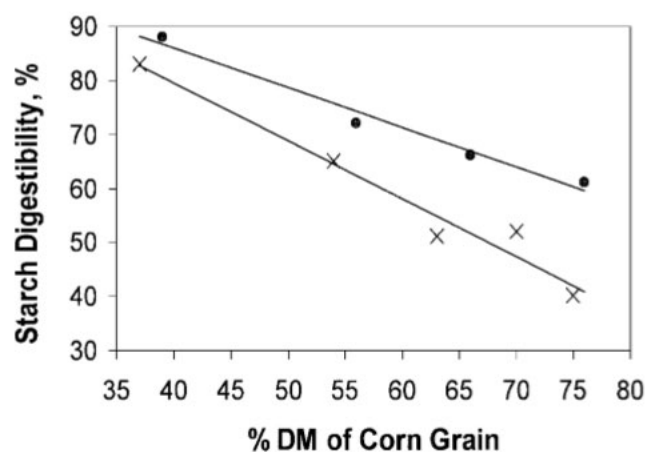
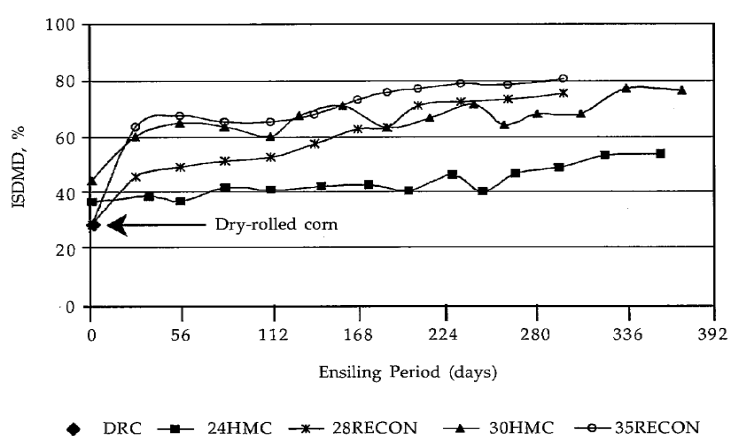


Figure 2. The effect of DM content of corn grain on in situ ruminal starch digestibility. Legend: Dent (●), and Flint (X). Equations: Dent, $Y = -0.7349x + 115.29$, $r^2 = 0.977$, Flint, $Y = -1.0768x + 122.59$, $r^2 = 0.9624$. Adapted from Philippeau and Michalet-Doreau (28).

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Effect of ensiling time on %BZET



Benton et al. (2005) : continuous increase of DM degradation in ensiled maize grain

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Continuous proteolysis of zein during ensiling (Hoffman et al., 2011)

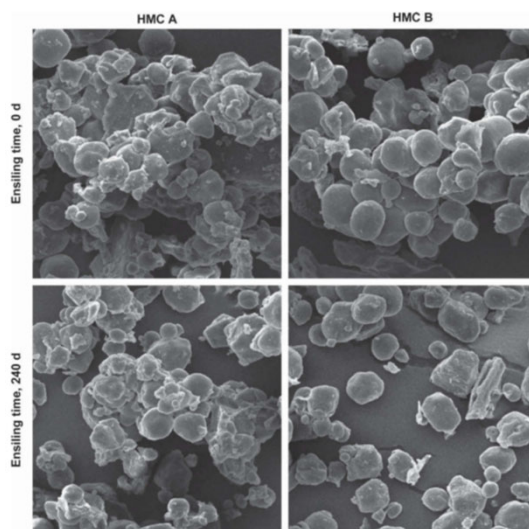


Figure 5. Scanning electron micrographs of high-moisture corn (HMC) A and B without inoculation ensiled for 0 and 240 d.

Project ILVO & HoGent (2013-2014)

- Micro-silos
 - 6 cultivars
 - harvested at 2 stages: 30 – 32% DM (ST1) and 36 – 38% DM (ST2)
 - 7 ensiling periods: 1, 2, 4, 6, 8, 10 and 12 months
- Farm silages
 - 6 cultivars
 - harvested at DM from 344 to 416 g/kg
 - sampled after ± 2, 6 and 12 months of ensiling



Micro-silo experiment

- PVC tube: 35 cm H, 10 cm Ø, 2.75 L with CO₂-valve
- Per object: 3 silos filled with pressure
- Micro-silos were stored in unheated room
- At opening: material at 5 cm on top and at bottom was discarded



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Analyses micro-silos and farm silages

- After 2, 6 and 12 months: pH, NH₃, lactic ac., acetic ac., ethanol
- All storage periods: DM, CP, STA, NDF, DC_{OM}, DC_{NDF}, NH₃
- Rumen degrad. par. with 4 cows on standard ration (CVB, 2004)
 - Frozen samples cut in mill to particles < 1 cm
 - Incubation times for starch: 0, 3, 8, 24, 48 h
 - for protein: 0, 24, 48, 336 h



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Calculation of %BZET & %BRE

$$\%BZET91 = W/10 + D \times [4.5/(4.5 + kd_D)]$$

$$\%BZET07 = W \times [8/(8 + kd_W)] + D \times [6/(6 + kd_D)]$$

$$\%BRE91 = W \times 0.05 + D \times [4.5/(4.5 + kd_D)] + U$$

$$\%BRE07 = S \times [11/(11 + 200)] + (W-S) \times [8/(8 + kd_D)] + D \times [4.5/(4.5 + kd_D)] + U$$

W = washable fraction

U = undegradable fraction (= 0 for starch)

D = degradable fraction = 100 – W – U

S = soluble fraction (= 0 for starch)

W-S = fraction of small particles

Kd_D = degradation rate of D (%/h)

Kd_W = degradation rate of W (%/h)

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Micro-silos: silage quality and chem. comp.

	Maturity stage		Ensiling time		
	ST1	ST2	2M	6M	12M
DM (g/kg)	319 ^b	391 ^a	357	355	349
pH	3.89 ^b	3.99 ^a	3.96	3.90	3.96
Lactic acid (g/kg DM)	50 ^a	42 ^b	44	47	47
Acetic acid (g/kg DM)	19	20	15 ^c	20 ^b	24 ^a
Ethanol (g/kg DM)	15	18	15	17	16
NH ₃ -N/N (%)	8.6 ^b	10.2 ^a	6.8 ^c	9.8 ^b	11.6 ^a
Starch (g/kg DM)	351 ^b	400 ^a	383	378	370
NDF (g/kg DM)	368 ^a	353 ^b	357	353	362
CP (g/kg DM)	71	71	72	70	72
DC _{NDF} (%)	54.9 ^a	53.1 ^b	52.6	53.6	53.6
DC _{OM} (%)	76.0 ^b	76.6 ^a	76.7	76.7	76.5

Linear mixed model: $Y_{ijk} = \mu + MS_i + ST_j + VAR_k + MS \times ST_{ij} + e_{ijk}$

When significant effect of MS or ST → Tukey test for comparison of means (p<0.05)

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Micro-silos: rumen degradation of starch and protein

	Maturity stage		Ensiling time		
	ST1	ST2	2M	6M	12M
W_{ZET} (%)	61.0 ^a	41.0 ^b	39.7 ^b	51.4 ^b	67.3 ^a
kd_{ZET} (%/h)	9.2	10.3	8.1 ^b	9.2 ^b	14.1 ^a
BZET07 (%)	24.3^a	28.6^b	31.1^a	25.7^b	17.3^c
W_{RE} (%)	60.1 ^a	52.8 ^b	50.0 ^c	58.8 ^b	70.8 ^a
U_{RE} (%)	20.9 ^a	18.7 ^b	18.2	20.5	20.3
kd_{RE} (%/h)	3.9	3.8	2.8 ^b	6.3 ^a	4.7 ^{ab}
BRE07 (%)	42.1	43.2	44.7^a	38.1^b	38.7^b

Means with unlike superscript letters differ ($p < 0.05$)

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Farm silages: effect ensiling time on %BZET & %BRE

	2M	6M	12M
BZET07 (%)	23.6 ^a	20.3 ^{ab}	18.1 ^b
BRE07 (%)	43.3	41.7	40.1

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Model to predict %BZET & %BRE based on DM & ET

➤ Data:

- 1) micro-silo experiment with 6 var. in 2013
 - harvested at 2 stages and 7 storage periods → **84 obs.**
- 2) farm silages with 6 var. in 2013
 - sampled 3 times during ensiling → **17 obs.**
- 3) silages from feeding experiments at ILVO from 1991 to 2016
 - harvested at DM from 285 to 427 g/kg
 - estimated storage time from 54 to 562 d → **43 obs.**

➤ Model: in R-software

- decrease of %BZET/BRE to a min. value after x days ensiled
- decrease dependent on DM-content

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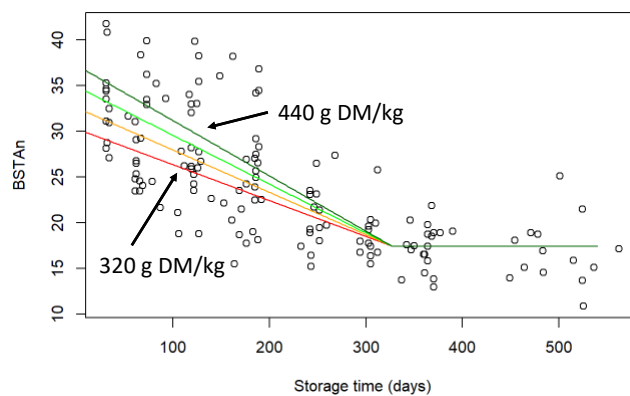
Correlation matrix (n=144)

	%BZET91	%BZET07	%BRE91	%BRE07
Dry matter	0.19	0.18	0.33	0.26
Starch	ns	ns	ns	ns
NDF	ns	ns	ns	ns
Ensiling period (d)	-0.70	-0.72	-0.67	-0.33
Endosperm-type*	ns	ns	ns	ns
Ammonia-fraction	-0.54	-0.55	-0.70	-0.55
W_{ZET}/W_{RE}	-0.77	-0.74	-0.93	-0.42

* Flint = 1, flint/flint-dent = 2, flint-dent = 3, flin-dent/dent = 4, dent = 5

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Prediction of %BZET07



$$\%BZET07 = 17.43 + (-0.0175 + 0.000177 \times DM) \times (327 - STd)$$

($R^2 = 0.59$; RMSEcv = 4.83%)

Models to predict rumen degradation characteristics

DM 360 g/kg	3M	After 327 d	Slope/M	R ²	RMSEcv
W _{ZET} (%)	52.4	70.5	2.23	0.44	9.9
kd _{ZET} (%/h)	7.52	12.67	0.65	0.29	3.55
BZET91 (%)	23.5	14.6	1.13	0.58	4.1
BZET07 (%)	28.5	17.4	1.40	0.59	4.8
W _{RE} (%)	56.3	70.6	1.80	0.69	5.7
S _{RE} (%)	46.0	54.5	1.08	0.52	4.5
U _{RE} (%)	19.2	19.2			
kd _{RE} (%/h)	2.62	2.62			
BRE91 (%)	37.7	29.0	1.11	0.66	3.2
BRE07 (%)	45.5	40.2	0.67	0.28	3.5

LVO



DM g/kg	Old	New
Class 1	< 240	300 – 340
Class 2	240 – 280	340 – 380
Class 3	280 – 320	380 – 420
Class 4	> 320	420 - 460

Snijmais, kuil-DS 340 - 380 g/kg 5008.602/2/0																			
Wende analyse en koeltydgraaf (g/kg DS)																			
	DS	PAS	REIN	RE	RVET	RVETH	RG	OKI	OKH										
gem.	361	74	72	67	32	-	174	681	-										
std.	11	4	-	5	3	-	14	-	-										
Wende analyse en koeltydgraaf (g/kg DS)																			
	ZETwe	ZETam	GOS	SUL	NOP	ADF	ADL	NIP	ENSP										
gem.	-	363	-	13	362	202	16	429	67										
std.	-	-	-	2	24	15	2	-	-										
Mineralen (g/kg DS)																			
	Ca	P	IP	Mg	K	Na	Cl	S											
gem.	1.6	1.9	-	1.3	15.2	0.1	2.1	1.0											
std.	0.3	0.2	-	0.2	1.0	0.1	0.5	0.1											
Spoorelementen (mg/kg DS)																			
	Mn	Zn	Cu	Mo	J	Co													
gem.	104	23	34	4	0.5	0.2													
std.	33	10	9	1	0.2	0.1													
Vetstoffen (g/kg DS)																			
	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS							
gem.	33	10	9	1	0.2	0.1													
std.	33	10	9	1	0.2	0.1													
Vetstoffen (g/kg DS)																			
	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS							
gem.	33	10	9	1	0.2	0.1													
std.	33	10	9	1	0.2	0.1													
Vetstoffen (g/kg DS)																			
	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS							
gem.	33	10	9	1	0.2	0.1													
std.	33	10	9	1	0.2	0.1													
Vetstoffen (g/kg DS)																			
	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS							
gem.	33	10	9	1	0.2	0.1													
std.	33	10	9	1	0.2	0.1													
Vetstoffen (g/kg DS)																			
	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS	g/kg DS							
gem.	33	10	9	1	0.2	0.1													
std.	33	10	9	1	0.2	0.1													

Snijmais, kuil-DS 340 - 380 g/kg:

2. Het %BRE en %BZET zijn afhankelijk van het DS gehalte en de inkuilduur. Voor dit productblad is als inkuilduur een periode van 90 dagen aangenomen.

Feeding value calculator

<http://vddb.cvbdiervoeding.nl/Manage/Tools/VwCalc.aspx>

Rekenmachine

NL / EN

Product

Klasse

Subklasse

Productcode	5008.602
Naam NL	Snijmais, kuil
Naam EN	Maize silage
Producttype NL	ruwvoerders
Producttype EN	roughages and related products

Overig

IP/P		% - -
CF_DI	0.97	0.97 - -
EB (meq/kg)	208	208 meq/kg - in DS
KAV (meq/kg)	147	147 meq/kg - in DS
Glycerol		g/kg - in DS
VOS_herk	719.9	719.9 g/kg - in DS
Inkuilduur snijmais 90	270	270 dag - -

Effect of ensiling time on FOM, DVE & OEB

DM		300-340	340-380	380-420	420-460
FOSp	3M	531	528	521	515
	9M	+26	+34	+40	+47
FOSp2	3M	264	259	247	236
	9M	+35	+46	+58	+71
DVE07	3M	51	53	55	57
	9M	+2	+1	0	0
OEB07	3M	-38	-43	-46	-49
	9M	-3	-1	-1	0

DVE = DVBE ↘ + DVME ↗ – DVMFE

OEB = MREN ↗ – MREE ↗

Conclusions and practical significance

- %BZET and %BRE decrease continuously during the ensiling period to a min. after 11 months; the effect is more pronounced with higher DM content.
- As a result, FOSp increases, with a minor effect on DVE and OEB.
- Shortly after ensiling, maize contains relatively a lot of bypass starch, which is mainly digested in the small intestine and absorbed as glucose, but the amount may exceed the digestive capacity → addition of amylase?
- With longer ensiling of maize, more starch becomes rumen degradable, which promotes microbial protein synthesis, but increases the risk for acidosis → max. level of sugars and degradable starch in the ration?
- In rations with a high amount of maize silage, the ensiling time could affect performances, but more research is needed to take concrete measures.

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Thank you!
Questions?



Flanders Research Institute for
Agriculture, Fisheries and Food
Scheldeweg 68
9090 Melle – Belgium
T + 32 (0)9 272 26 00
F +32 (0)9 272 26 01

dier@ilvo.vlaanderen.be
www.ilvo.vlaanderen.be

ILVO