



# New digestion model for starch

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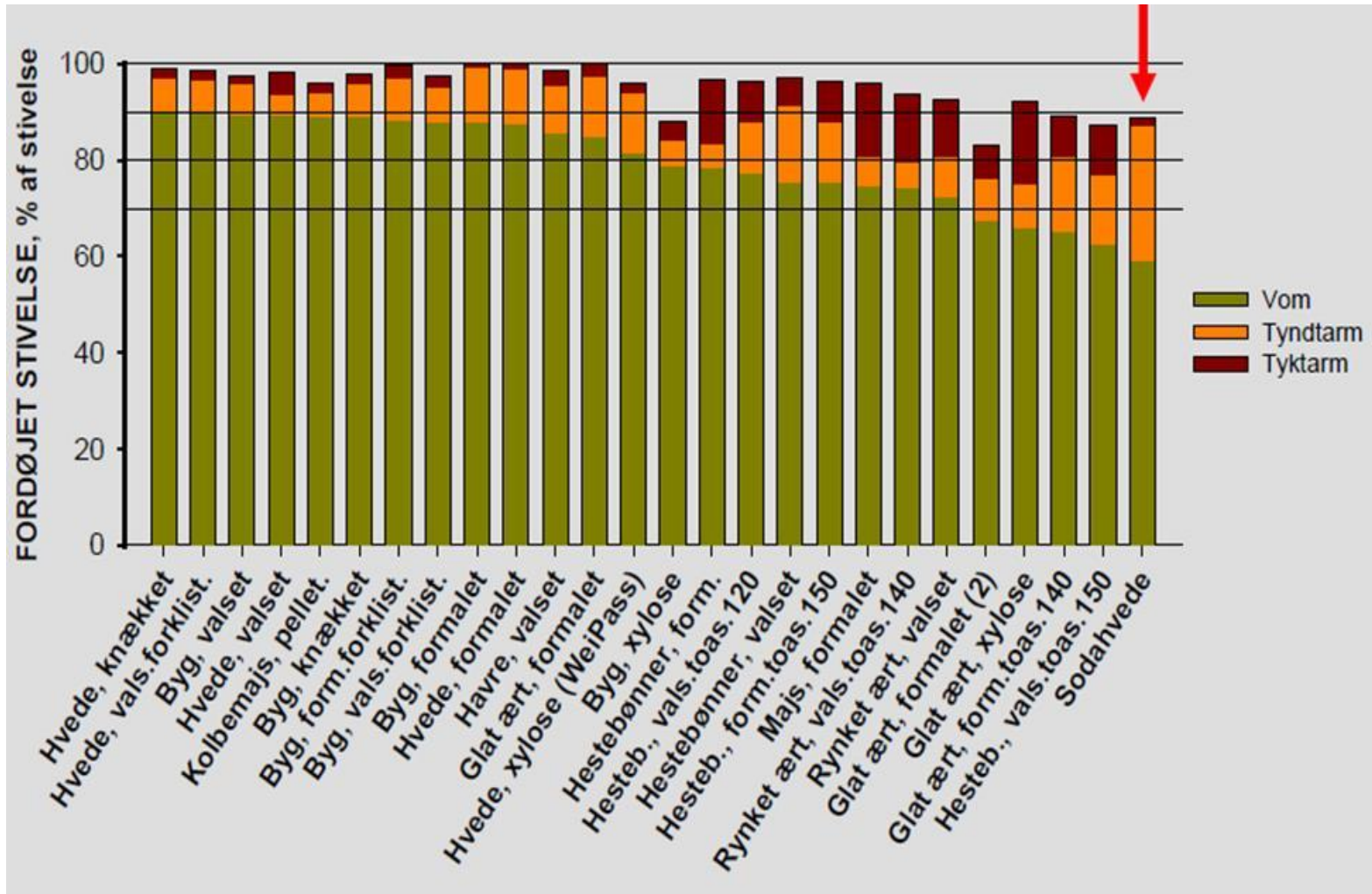


Projektet har fået tilskud fra "Grønt Udviklings- og Demonstrations Program, GUÐP under Fødevareministeriet".

## Background

- **Very high ST-digestibility in NorFor (~100%)**
- **Despite indigestible ST in the intestine (iST)**
- **Due to 90% digestibility in large intestine**
- **How high is ST-digestibility in different starch-sources ?**
- **Research project 2006-2010 about starch in Denmark**

# Starch is not always 100% digestible



(M. Larsen, 2009. M. Larsen og N.B. Kristensen, 2009, N.B. Kristensen et al, 2007)  
 Samt bidrag fra P. Lund, M. Weisbjerg og T. Hvelplund

## Digestibility of starch (dST; g/kg)

ST-source	Total			Rumen			Small intes.			Large intes.		
	n	dST	SE	n	dST	SE	n	dST	SE	n	dST	SE
Wheat	46	1002	16	29	944	43	4	675	86	4	636	100
Wheat NaOH	3	933	43	3	704	109	1	708	165	1	61	192
Barley	49	959	10	41	868	27	16	759	45	16	609	52
Maize	158	916	8	75	574	24	15	510	49	17	469	53
Faba beans	7	952	25	7	773	63	7	437	78	7	633	91
Peas	9	909	22	6	747	59	5	341	78	5	561	90
Maize silage	10	962	21	6	909	64	2	819	117	2	660	135

# Small & large intestine

ST-source	Total			Rumen			Small intes.			Large intes.		
	n	dST	SE	n	dST	SE	n	dST	SE	n	dST	SE
Wheat	46	1002	16	29	944	43	4	675	86	4	636	100
Wheat NaOH	3	933	43	3	704	109	1	708	165	1	61	192
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Maize silage	10	962	21	6	909	64	2	819	117	2	660	135

Weisbjerg & Larsen, 2012

**The more starch that is digested in the rumen,  
the more is digested in the small intestine  
relative to the large intestine**

## The new starch model

- **Total- and rumen digestibilities from Weisbjerg & Larsen (2012) are used**
- **Degradation rate (kdST) is calculated from rumen degradabilities pr feed stuff**
- **No use of soluble starch (sST=0)**
- **All starch is potentially digestible (pdST=1000)**

# Individuell degradation rates

Starch source	kdST, %/h kp <sub>r</sub> 4.48%/h	kdST, %/h kp <sub>c</sub> 6.09%/h
Wheat	75.5 <sup>2</sup>	102.6
Oat	29.7 <sup>2</sup>	40.4
Corn silage	44.7	
Barley	29.5 <sup>2</sup>	40.0
Faba beans	15.3 <sup>2</sup>	20.7
Wheat NaOH		14.5
Corn		8.2
Peas	13.2 <sup>2</sup>	18.0
Sorghum		9.8
Barley NaOH		12.4

<sup>2</sup>for roughage kdST is calculated from kp-roughage (4,48 %/h)

kdST is 25%/h for feedstuffs with low starch content (<50 g per kg DM)

# Indigestible starch is now total indigestible!

Source	Digestible g/kg ST	Indigestible g/kg ST
Wheat	1000	0
Wheat NaOH	933	67
Barley	959	41
Maize	916	84
Faba beans	952	48
Peas	909	91
Maize silage	962	38

iST = 1000-digestible starch



# Consequence for standard feed values

Source	dST/new (%)	NEL20/new MJ/kg DM	AAT20/new g/kg DM	PBV20/new g/kg DM
Hvede NaOH	100/96.3	7.86/7.12	115/108	-48/-36
Barley	99.9/95.9	7.53/7.21	104/102	-48/-45
Maize (rolled)	99.7/91.6	8.04/7.01	104/96	-63/-50
Faba beans	99.8/95.2	8.18/7.87	110/109	146/148
Maize silage	99.9/96.2	6.33/6.20	85/85	-45/-45

**Generally small changes: less energy  
less AAT  
more PBV**

# Consequence for a diet

Fodermiddel	Enhed	Øre/kg	New	Old
			Tildelt	Tildelt
NY Vårbyg	Kg TS	150,0	3,0	3,0
NY Majs	Kg TS	130,0		
NY Hvede, NaOH ludet, 80	Kg TS	80,0		
Rapskage, 10,5% fedt, DK	Kg TS	183,0	2,0	2,0
Sojaskrå, afskallet	Kg TS	300,0	2,0	2,0
Kløvergræsens., middel F	Kg TS	23,4	6,0	6,0
NY Majsensilage, høj FK	Kg TS	22,0	9,0	9,0

**3 kg DM barley &  
9 kg DM maize silage**

Rationsparameter	Enhed	Opt.	Tildelt	Tildelt
Foderoptagelse	kg TS/da	<input type="checkbox"/>	22,0	22,0
Kraftfoder	kg TS/da	<input type="checkbox"/>	7,0	7,0
Energioptagelse	MJ/dag	<input type="checkbox"/>	147,7	149,4
Energi	MJ/kg T	<input type="checkbox"/>	6,72	6,79
Energibalance	%	<input checked="" type="checkbox"/>	100,9	102,0
AAT til mælk	g/MJ	<input checked="" type="checkbox"/>	16,4	16,7
AAT i foder / NEL i foder	g/MJ	<input type="checkbox"/>	14,8	14,8
PBV	g/kg TS	<input checked="" type="checkbox"/>	20	20
Fedtsyrer	g/kg TS	<input checked="" type="checkbox"/>	24	24
NDF	g/kg TS	<input type="checkbox"/>	308	313
Vombelastning	Ingen en	<input checked="" type="checkbox"/>	0,59	0,60
Stivelse	g/kg TS	<input type="checkbox"/>	242	242
Fylde i alt	FV	<input checked="" type="checkbox"/>	8,43	8,43
Total fordøjet råprotein	g/dag	<input type="checkbox"/>	2409	2448
Total fordøjet råfedt	g/dag	<input type="checkbox"/>	377	388
Total fordøjet kulhydrat	g/dag	<input type="checkbox"/>	13077	13150
Omsættelig energi	MJ/dag	<input type="checkbox"/>	244,9	247,1
Brutto energi	MJ/dag	<input type="checkbox"/>	420	420

**Diff = -1,7 MJ NEL**

**The feed efficiency is app.  
1% unit higher then in May!**

# Consequence for a diet

Fodermiddel	Enhed	Øre/kg	New	Old
			Tildelt	Tildelt
NY Vårbyg	Kg TS	150,0		
NY Majs	Kg TS	130,0		
NY Hvede, NaOH ludet, 80	Kg TS	80,0	3,0	3,0
Rapskage, 10,5% fedt, DK	Kg TS	183,0	2,0	2,0
Sojaskrå, afskallet	Kg TS	300,0	2,0	2,0
Kløvergræsens., middel F	Kg TS	23,4	6,0	6,0
NY Majsensilage, høj FK	Kg TS	22,0	9,0	9,0

**3 kg DM NaOH wheat &  
9 kg DM maize silage**

Rationsparameter	Enhed	Opt.	Tildelt	Tildelt
Foderoptagelse	kg TS/da	<input type="checkbox"/>	22,0	22,0
Kraftfoder	kg TS/da	<input type="checkbox"/>	7,0	7,0
Energioptagelse	MJ/dag	<input type="checkbox"/>	147,4	150,5
Energi	MJ/kg T	<input type="checkbox"/>	6,70	6,84
Energibalance	%	<input checked="" type="checkbox"/>	100,7	102,8
AAT til mælk	g/MJ	<input checked="" type="checkbox"/>	16,4	16,7
AAT i foder / NEL i foder	g/MJ	<input type="checkbox"/>	14,8	14,8
PBV	g/kg TS	<input checked="" type="checkbox"/>	21	19
Fedtsyrer	g/kg TS	<input checked="" type="checkbox"/>	23	23
NDF	g/kg TS	<input type="checkbox"/>	299	301
Vombelastning	Ingen en	<input checked="" type="checkbox"/>	0,58	0,61
Stivelse	g/kg TS	<input type="checkbox"/>	249	249
Fylde i alt	FV	<input checked="" type="checkbox"/>	8,45	8,45
Total fordøjet råprotein	g/dag	<input type="checkbox"/>	2408	2452
Total fordøjet råfedt	g/dag	<input type="checkbox"/>	366	378
Total fordøjet kulhydrat	g/dag	<input type="checkbox"/>	13062	13260
Omsættelig energi	MJ/dag	<input type="checkbox"/>	244,2	248,3
Brutto energi	MJ/dag	<input type="checkbox"/>	418	417

**Diff = -3,1 MJ NEL**

**The feed efficiency is app. 2%  
units higher than in May!**

# Effect of particle size and type on starch digestibility

Maize type	PS (mm)	Digested starch (% of intake)			
		Rumen	Small intestine	Large intestine	Total
<i>Semiflint</i>	0,7	59	29	4	91
	1,8	50	32	5	86
	3,7	36	31	3	70
<i>Dent</i>	0,6	70	23	4	97
	3,5	54	32	4	89



Remond et al., 2004

## Effect of physical treatment on maize starch (Dent)

- NorFor table values

	Rolled	Ground
Starch, g/kg DM	710	710
kd_ST, %/h	7	13
Rumen degradation, %	54	68
dST, g/kg starch	890	950
NEL20 (MJ/kg DM)	7,01	7,40

- **Lower digestibility of starch than before and therefore less energy in ST-rich feedstuffs**
- **Especially NaOH treated grains and maize is reduced in energy value**
- **2 types of maize in FST depending on particle size (ground vs rolled)**
- **Energy efficiency is increased by ~1%-unit with new ST-model**
- **Check if the feedstuff industry has implemented this**