Session 08

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Influence of hydrothermic processing of cereals on their nutritive value in ruminants

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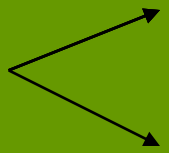
EAAP, Bratislava 2012

Introduction

- Cereal grains and maize are a source of energy and protein for animals
- Cereal proteins constitute a significant part of total dietary protein in the diet for ruminants
- High rumen degradation of protein decrease the protein nutritive value of feeds and lower their utilisation by ruminants
- Reduction of the rumen degradation increases by-pass digestible protein
- Nutritive value is possible to improve by heat processing
- Possibilities of heat treatment are steam flaking. roasting. extrudation. etc.

Effect of heat treatment

Heat treatment acts:



positively

negatively

Positive effects:

- the extent of protein degradation in the rumen is decreased
- increasing of by-pass protein with high intestinal digestibility

Negative effects:

- over protected protein (by too high temperature, long treatment time, Mailard products) with decreased intestinal digestibility of by-pass protein

Heat treatments

such as:

- steam flaking
- dry rolling
- extrusion
- autoclaving
- toasting
- pelleting

resulting to a decrease of ruminal CP degradation and

an increase of rumen escape CP fraction.

Every feed needs optimal temperature. pressure. treatment time and moisture.

Systems of feeds evaluation

Rumen degradability and intestinal digestibility of undegraded feed protein is an important parameter in modern protein evaluation systems for ruminants.

The systems for feedstufs avaluation in Europe and other countries:

- PDI – French protein evalaution system
- DVE/OEB – Duch protein evaluation system
- Nor-For™ – Nordic feeds evaluation system
- Danish feeds evaluation system
- German feeds evaluation system
- CNCPS – The Cornel Net Carbohydrate and Protein System (USA)

and other countries used some of thouse systems modificated

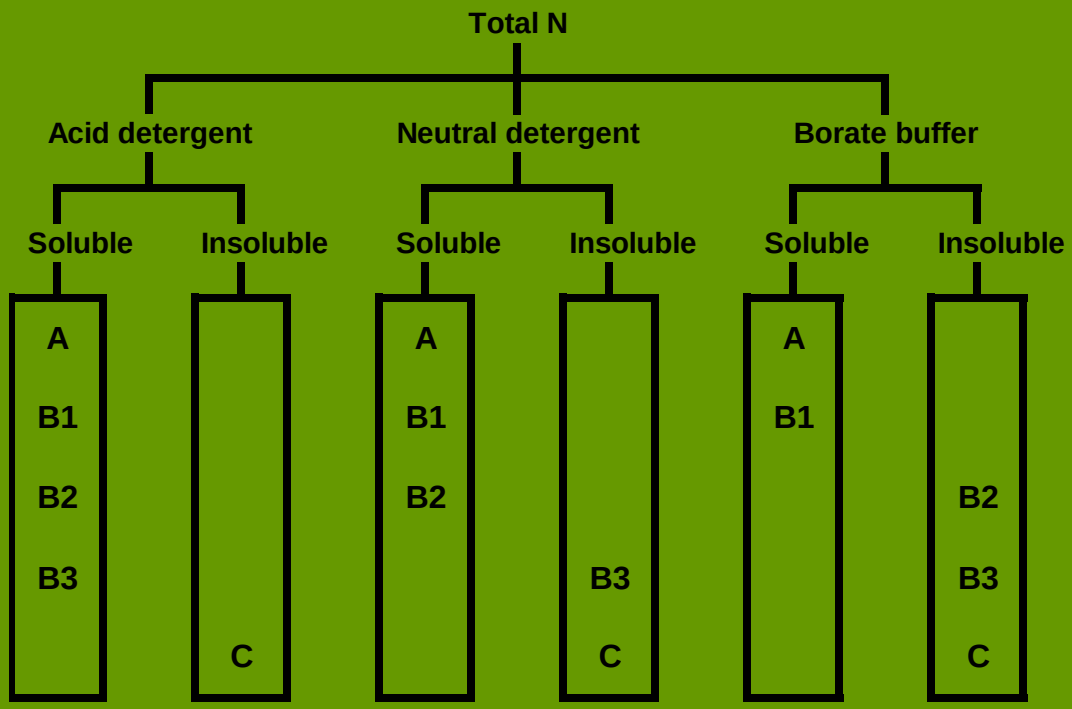
The Cornel Net Carbohydrate and Protein System

New knowledges about quality of feed protein help to increase precision of the informations about nutritive quality of feeds for ruminants and this provides

The Cornel Net Carbohydrate and Protein System

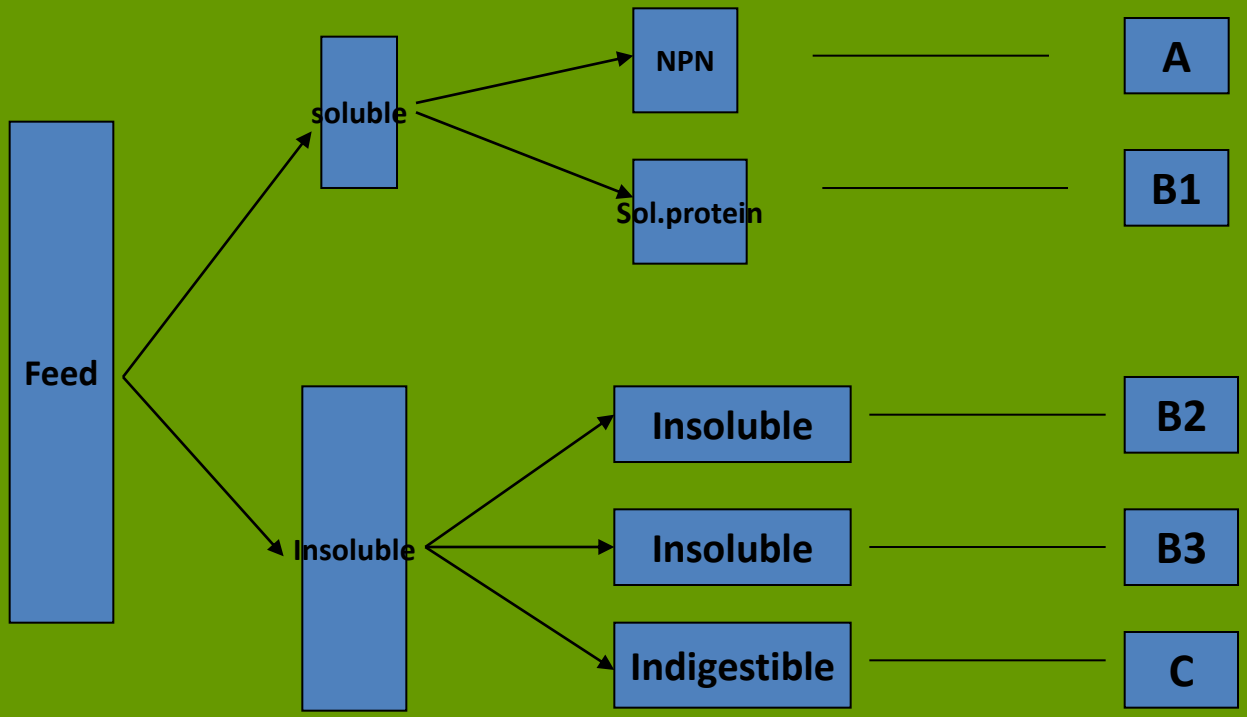
This system divides feed protein by chemical composition, physical characteristics, characteristics of rumen degradation and intestinal digestibility

Protein fractions
according to solubility



Fraction A – protein soluble in buffer
Fraction B1 – protein soluble in buffer and precipitable by TA
Fraction B2 – protein insoluble in buffer but soluble in neutral and acid detergent solutions
Fraction B3 – protein insoluble in buffer and neutral detergent solution but soluble in acid detergent solution
Fraction C is the protein that is insoluble in acid detergent

Feed protein fractions



Fraction C

- Protein in complexes with tannin, and Maillard products
- They are highly resistant to breakdown by microbial and mammalian enzymes
- Is assumed to be unavailable for the animals
- Is protein assotiated with the cell wall mainly with lignin (ADIP)

Also common feedstuffs may contain significant amount of the Fraction C

The objectives of this presentation are:

- to assess the effect of steam flaking of wheat, barley and maize on their nutritive value for ruminants
- to determine the content of nutrients and N subfractions in treated and untreated cereals
- to determine rumen degradation of CP by in situ method
- to determine intestinal digestibility of rumen undegraded protein (RUP) by mobile bag method

Flaking wheat

Flaking barley

Flaking maize

Flaking cereals at 120°C and 30 min

Chemical methods

- Chemical composition of feeds was determined according to the Decree of the Ministry of Agriculture of the Slovak Republic No. 1497/4/1997-100.
- Method for acid-insoluble nitrogen (ADIN and/or N-ADF) determination is described in **Licitra et al. (1996)**

Feed protein fractions according CNCPS

Individual protein fractions were determined according the methods published by Licitra et al. (1996)

- NPN = Not precipitable using TCA = **Fraction A**
- True protein = precipitate wit TCA (TP)
- Insoluble protein = insoluble in buffer (IP)
- True soluble protein = buffer soluble but precipitable protein (TP-IP) = **Fraction B_1**
- Neutral detergent soluble protein = differnce betwen IP and protein insoluble in neutral detergent (ND) (IP-NDIP) = Fraction B_2
- Protein insoluble in ND but soluble in acid detregent (AD) = Fraction B_3
- Protein insoluble in acid detergent (AD) = Fraction C

In situ method

Animals for in situ experiment

- 3 rumen fistulated Holstein-Friesian cows with T cannulae in distal duoudenum
- non lactating cows at maintainace level (live weight 680 ±30 kg)
- pH of rumen fluid 6.3±0.243 (n=6)

Diet of experimental animals

- meals at 6:30 and 18:30 h
- Daily ration contained: maize silage
  lucerne hay
  wheat and barley meal (1:1)
  Vitamix S1
- water ad libitum

In situ and mobile bag methods

Effective degradation of cereals CP and degradation parameters (a,b,c) were determined by in situ method, intestinal digestibility of RUP by mobile bag method

- incubation time of pea samples: 3, 6, 9,16,24, 48 & 96 h
- minimum of three bags per animal, incubation time and feed

Conditions of in situ technique

- Bags size: 9 x 15 cm
- Pore size: 42 μm (Uhelon 130 T)
- 3.5 g DM of sample / bag
- grinding of sample 3 mm
- Macerate the bags 10 min in 37 ° C warm water before inserting them into the rumen
- Bags were inserted in the rumen just before morning feeding (every incubation separately); for 16 h incubation inserted in the rumen just before evening feeding
- 0 h incubation (only 3 x 5 min washing without spinning)

after incubation followed:

- Rinsing (cold tap water)
- Washing (3 x 5 min in domestic washing machine) and drying (24 h, 55 ° C)
- Weighing, pooling, grinding
- Analysis (dry matter, nitrogen. ash)
- Correction of dry matter of residues
- Computing according Ørskov&McDonald (1979)

Experimental procedure of intestinal digestibility determination

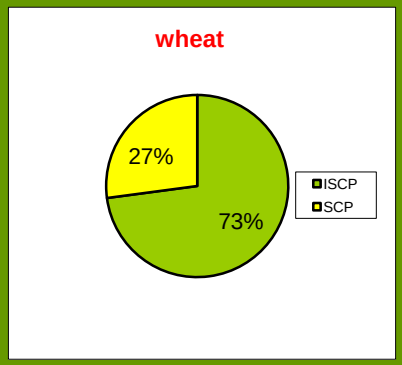
- Lyophilysed undegraded feed residues after 16 h incubation in the rumen
- Nylon bags from UHELON 130T (42 µm) of size 4 x 2 cm
- From every residue 0.3 – 0.5 g was weighed into small bags (10 pcs/animal)
- Befor inserting the bags into duodenum they were incubated during 1 h at 37˚ C in pepsin/HCl –solution (5 bags during 10 minutes)
- The bags were collected from faeces 20 hours after inserting.
- Faeces were rinsed with cold ranning water and disstiled water
- After washing clean bags were stored at -20 ˚ C until they were lyophilysed and analysed for N

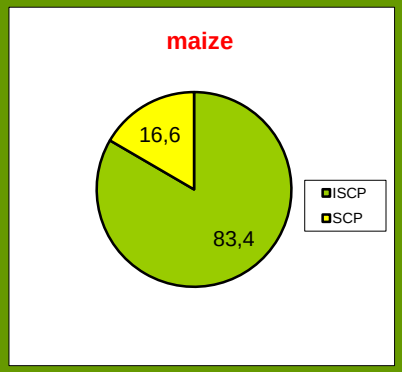
Chemical composition of untreated and treated cereals (mean ± SEM)

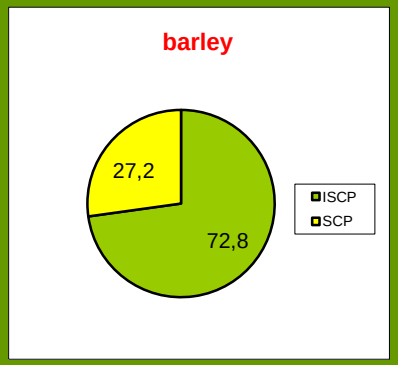
Feeds	n	Content of nutrients (g.kg^{-1} DM)			
		CP	Starch	NDF	ADF
Wheat	3	137.0±3.42	671.5±10.01	143.2±23.27	36.9±4.02
Flaking Wheat (90 °C 30 min.)	2	128.9±1.33	689.7±2.27	120.2±9.7	45.2±1.54
Maize	5	94.6±6.47	726.7±6.22	129.2±11.34	35.8±1.78
Flaking maize (90 °C 30 min.)	2	88.2±0.88	787.4±0.38	82.1±0.90	27.8±1.26
Barley	2	120.4±0.65	594.6±0.85	177.6±0.4	60.2±1.85
Flaking barley(90 °C 30 min.)	2	120.6±2.60	587.5±2.0	168.2±2.95	68.1±1.10

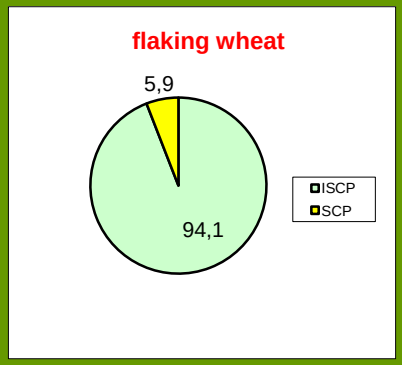
Effect of flaking on changes in the proportion of in buffer soluble and insoluble protein (% of total protein)

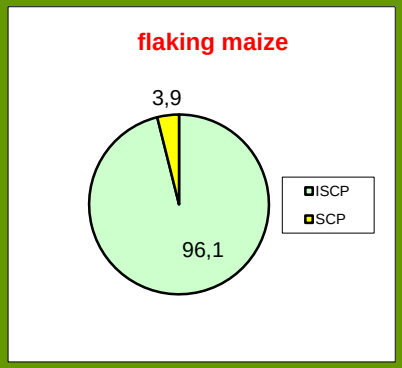
the means between untreated and treated cereals are signifficantly different at P<0.01

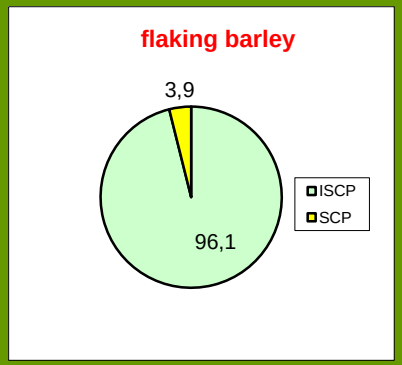












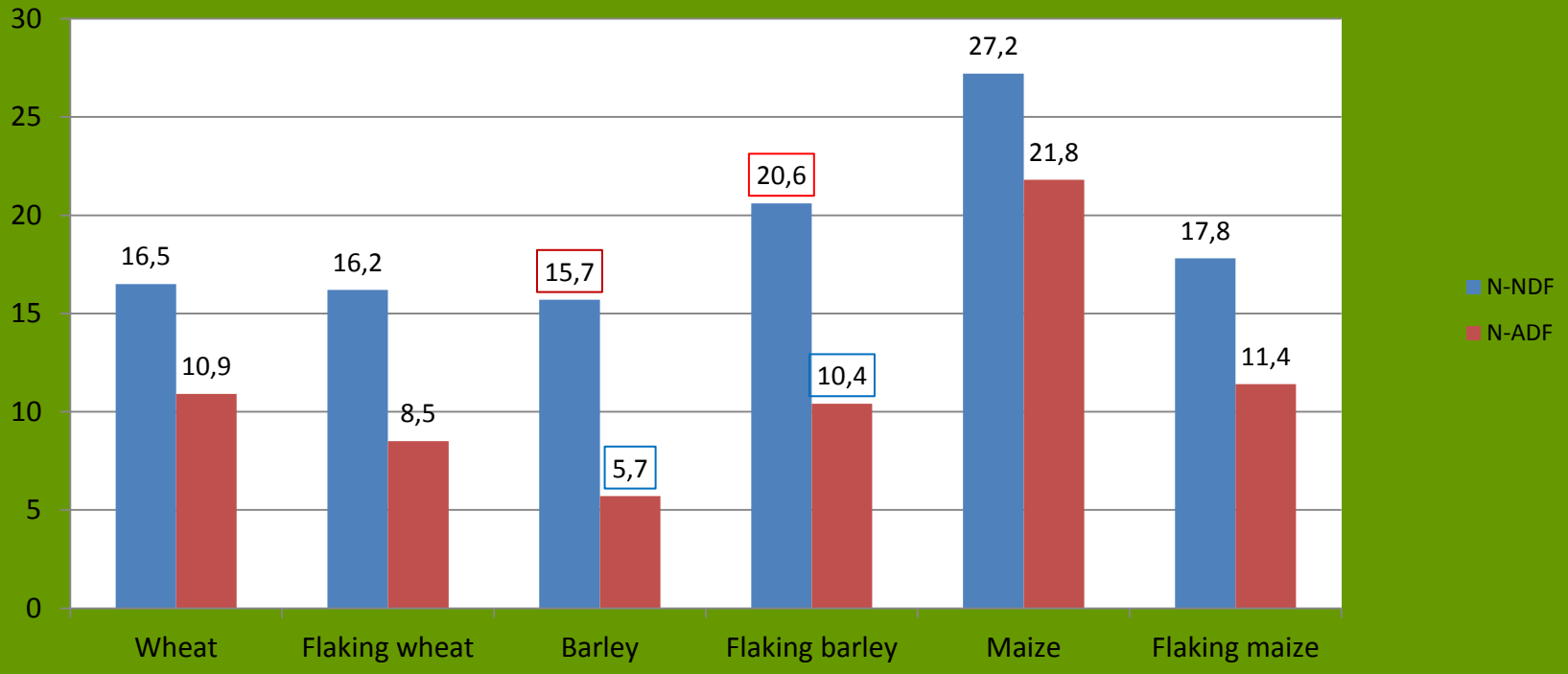
CNCPS protein fractions (% of total CP) in untreated and flaking cereals

Feeds	n	Protein fractions (% of total CP)				
		A	B_1	B_2	B_3	C
Wheat	3	7.4 ± 2.05^{a}	17.5 ± 3.82^{a}	56.4 ± 2.61^{a}	5.6 ± 2.37	10.9 ± 5.79
Flaking Wheat (90 °C 30 min.)	2	1.9 ± 0.10^{a}	3.9 ± 1.05^{a}	77.9 ± 0.39^{a}	7.7 ± 1.43	8.4 ± 0.07
Maize	5	5.1 ± 2.58^{B}	3.6 ± 1.00	56.2 ± 7.34^{b}	4.9 ± 0.64^{B}	21.8 ± 6.85^{B}
Flaking maize (90 °C 30 min.)	2	0.38 ± 0.045^{B}	3.6 ± 0.09	78.2 ± 0.44^{b}	6.42 ± 0.42^{B}	11.4 ± 0.76^{B}
Barley	2	8.4 ± 0.25^{c}	13.0 ± 0.40^{c}	57.2 ± 1.80^{c}	9.9 ± 0.35	5.7 ± 0.66^{c}
Flaking barley (90 °C 30 min.)	2	2.9 ± 0.17^{c}	1.0 ± 0.01^{c}	75.5 ± 0.78^{c}	10.2 ± 0.49	10.4 ± 0.21^{c}

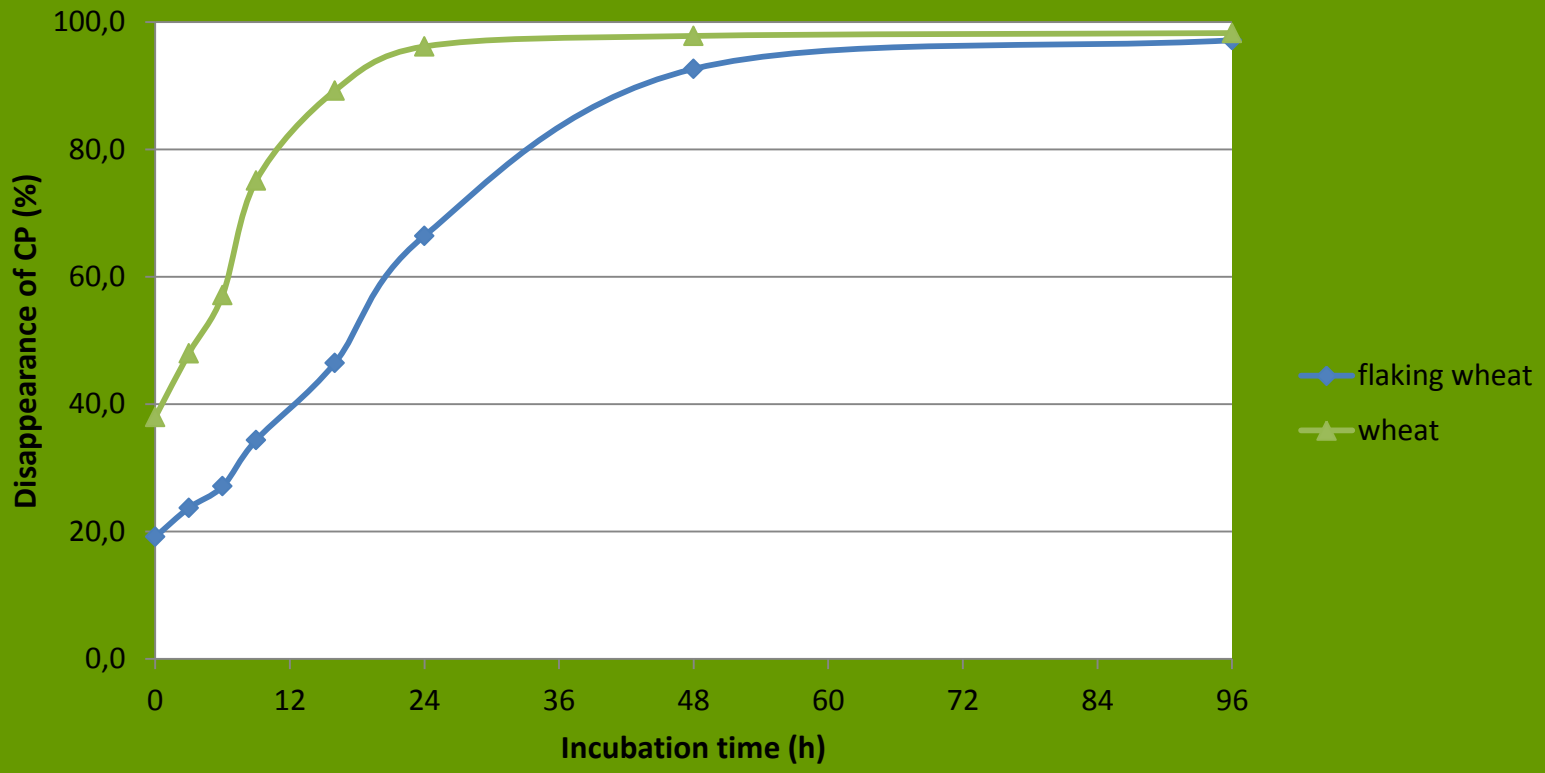
Means with the same letters in the same column are significantly different; ^{B} at $P<0.05$; ^{a,b,c} at $P<0.01$

Protein insoluble in ND & AD solutions (% of total protein)

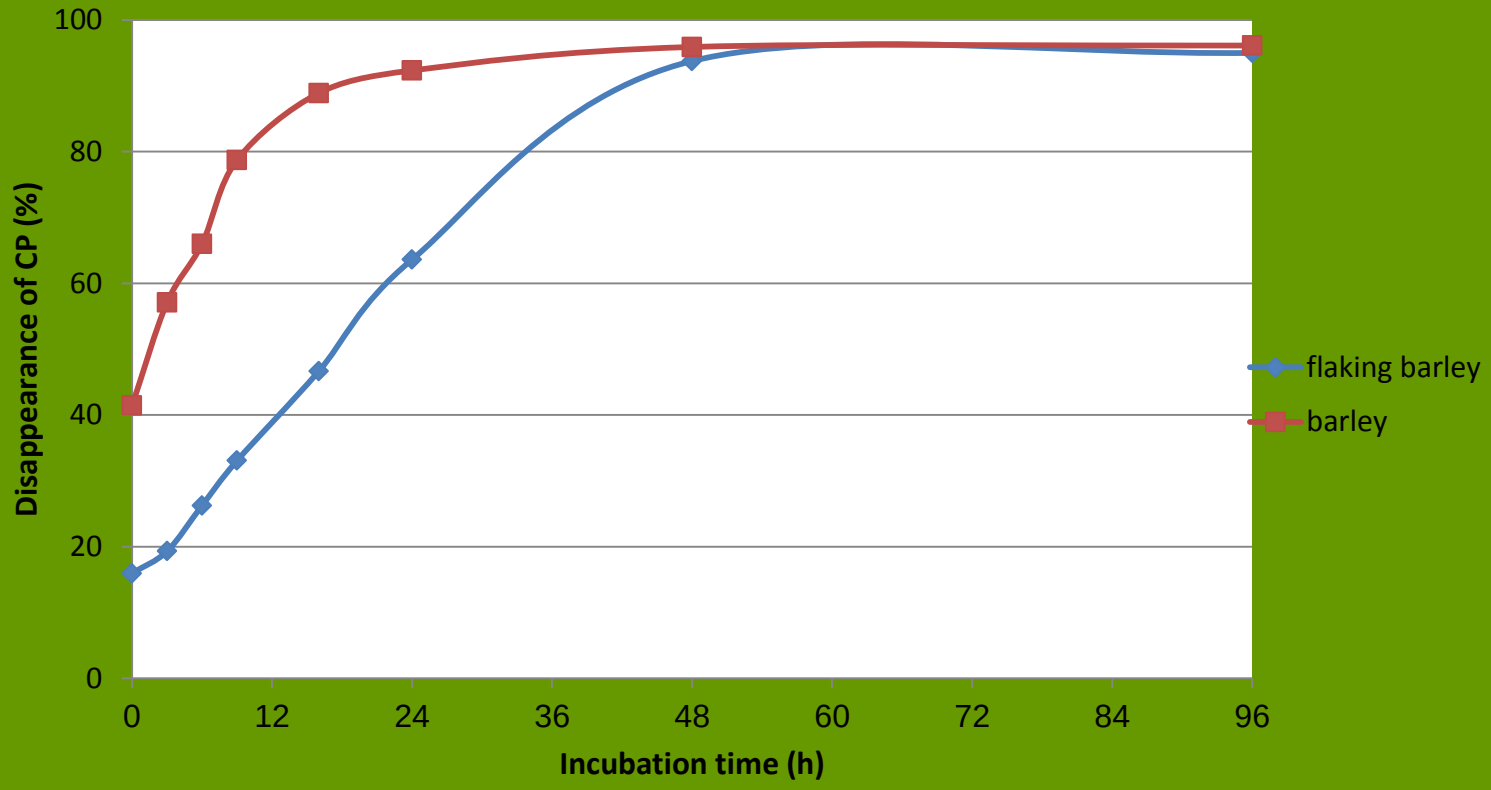
the means between untreated and treated cereals are signifficantly different at P<0.01



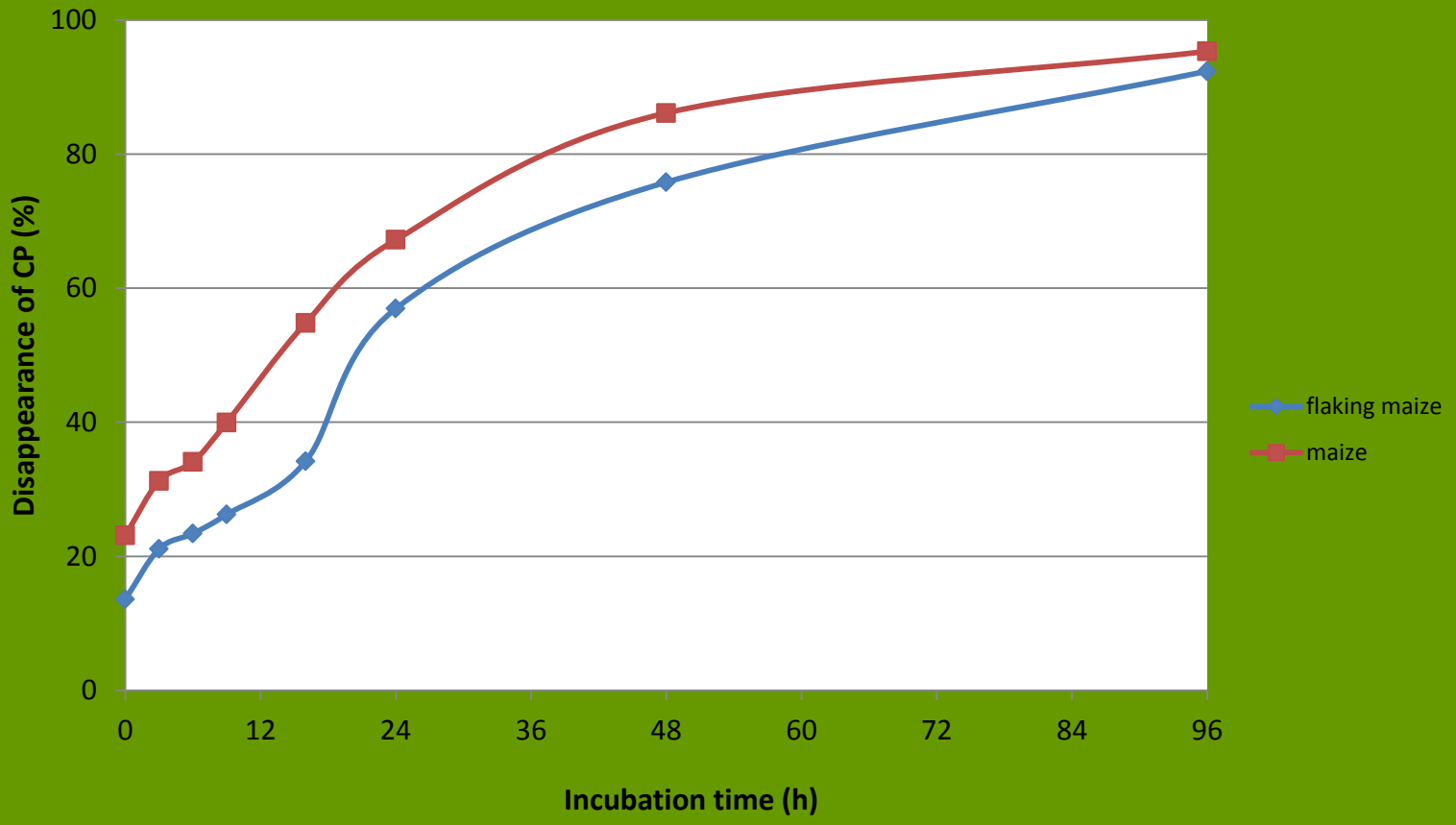
Degradation profiles for CP of untreated and treated wheat



Degradation profiles for CP of untreated and treated barley



Degradation profiles for CP of untreated and treated maize

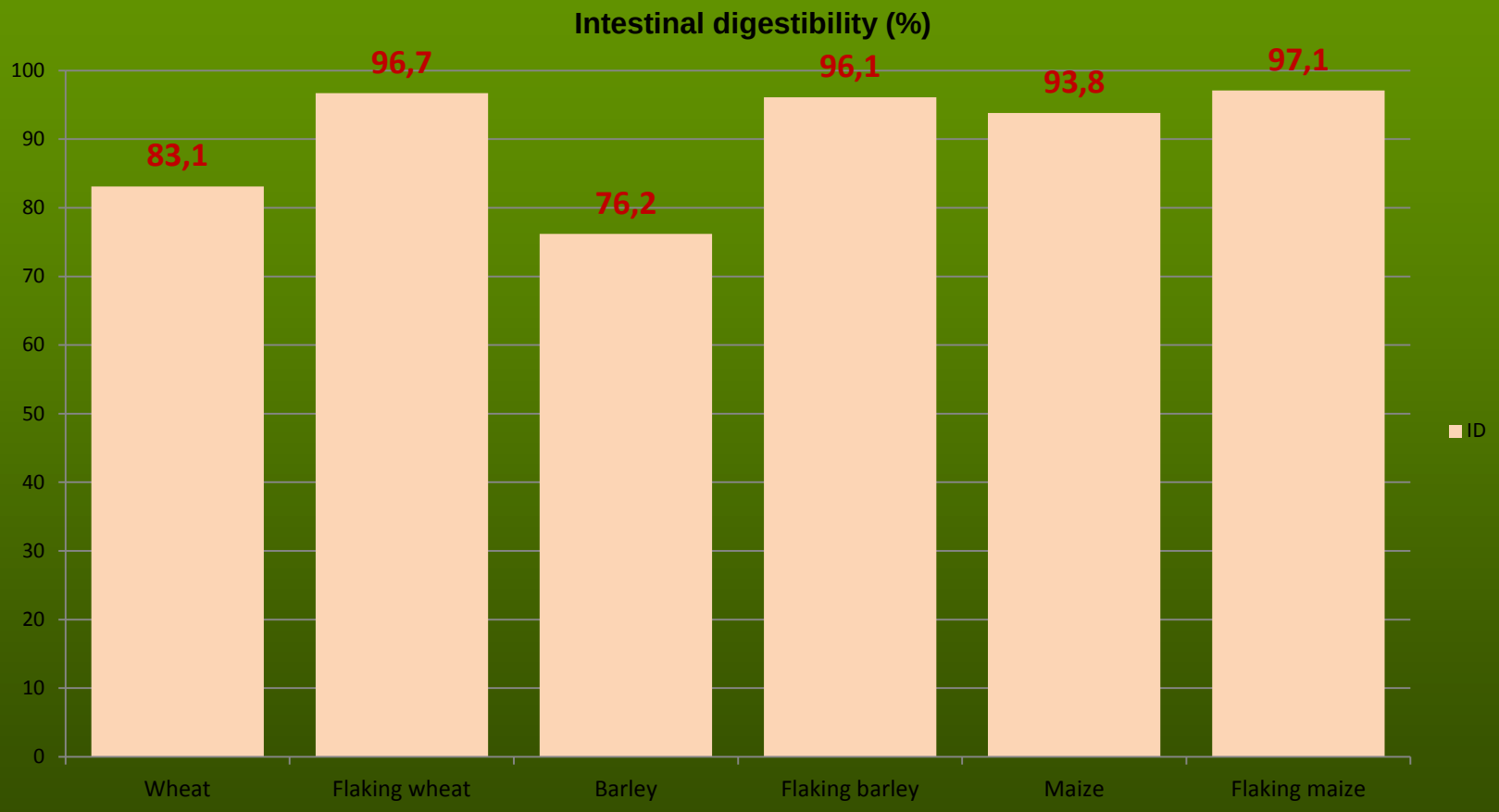


Comparison of the characteristics of crude protein degradability of untreated and flaking cereals

Feeds	n	Characteristics of CP degradability			
		a (%)	b (%)	c (%.h^{-1})	EDCP (%)
Wheat	3	23.1±3.80	75.0±3.85^{A}	0.138±0.010^{a}	75.9±1.62^{a}
Flaking Wheat (90 °C 30 min.)	2	19.2±2.65	80.8±2.65^{A}	0.032±0.0004^{a}	46.2±1.69^{a}
Maize	5	23.1±1.97^{B}	76.6±2.03^{B}	0.036±0.0062^{b}	49.6±1.59^{b}
Flaking maize (90 °C 30 min.)	2	13.6±0.40^{B}	86.4±1.2^{B}	0.0180±0.003^{b}	37.1±1.20^{b}
Barley	2	38.8±0.40^{c}	56.9±0.78^{c}	0.123±0.0003^{c}	77.0±0.18^{c}
Flaking barley(90 °C 30 min.)	2	7.4±0.10^{c}	99.0±1.00^{c}	0.035±0.0005^{c}	44.5±0.30^{c}

Means with the same letters in the same column are significantly different; $^{A, B}$ at P<0.05; $^{a, b, c}$ at P<0.01

Effect of flaking on intestinal digestibility of rumen undegraded protein of cereals



By pass of RUP from wheat

from 1 kg of animal feed wheat

Untreated wheat

at EDgN 89.9%
ID 83.1 %

14 g RUP
11.6 g DCP

Flaking wheat

at EDgN 49.5 %
ID 96.7 %

68 g RUP
65.8 g DCP

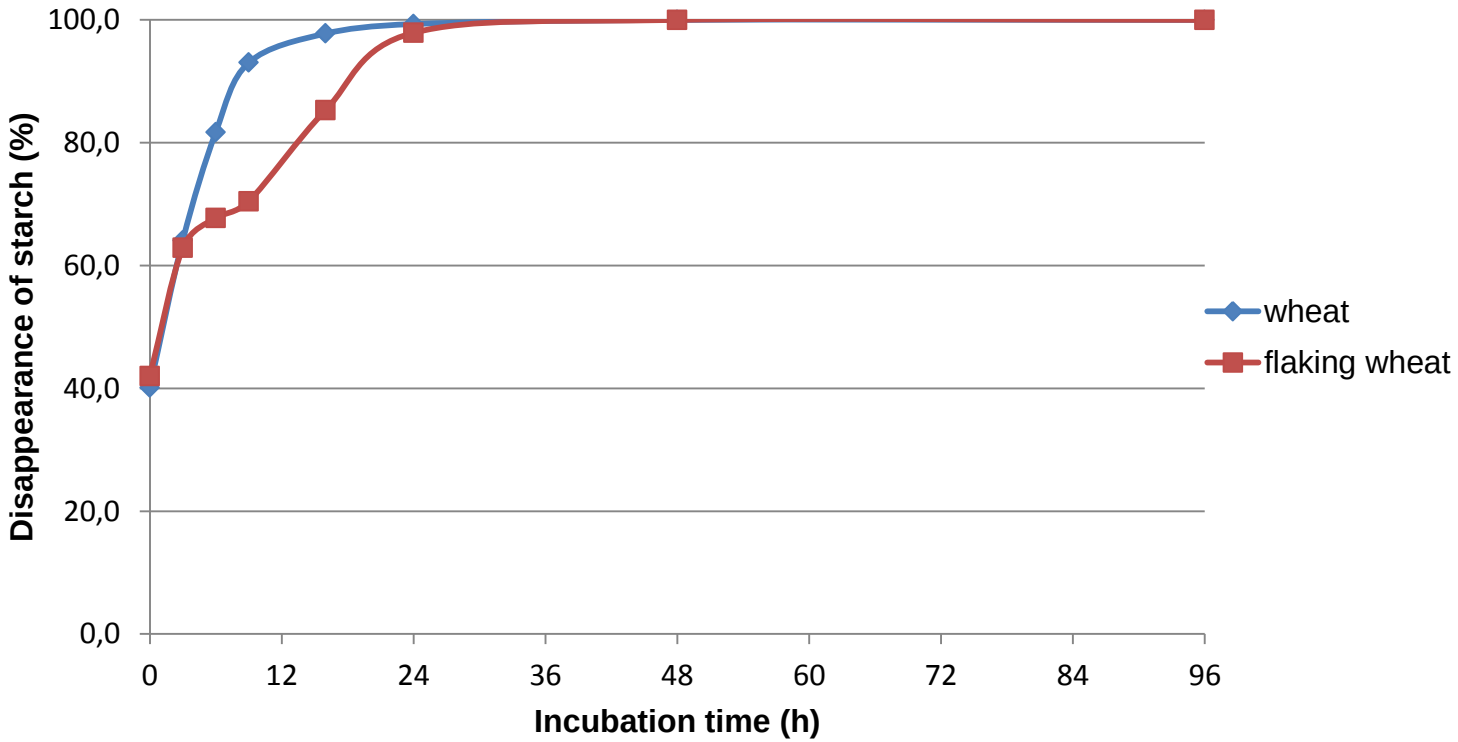
In the intestinum is available

By-pass of digestible protein from barley and maize

From 1 kg of flow into the small intestinum:

- from barley 23 g RUP, and 18 g digestible protein
- from flaking barley 64 g RUP, and 62 g digestible protein
- from maize 46 g RUP, and 43 g digestible protein
- from flaking maize 58 g RUP and 56 g digestible protein

Degradation profiles for starch of untreated and treated wheat



The characteristics of starch degradability of untreated and flaking wheat

Characteristics	Feeds	
	Wheat	Flaking wheat (90 °C 30 min.)
a (%)	40.1	42.0
b (%)	59.8	58.0
a + b (%)	99.9	100
c (%.h^{-1})	0.248	0.073
EDg (%)	86.24	70.41

Content of energy, PDIN and PDIE

Items	Feeds		
	Flaking wheat	Flaking barley	Flaking maize
ME (MJ.kg $^{-1}$ DM)	13.7	13.0	14.1
NEL (MJ.kg $^{-1}$ DM)	8.7	8.4	9.2
NEV (MJ.kg $^{-1}$ DM)	9.2	9.1	10.2
PDIN (g.kg $^{-1}$ DM)	105	97	75
PDIE (g.kg $^{-1}$ DM)	147	138	136

Conclusion

- The conditions of flaking process positively affected monitored parameters feeds quality
- There is significantly increased the fraction of degradable protein
- Significantly is reduced the rate of CP degradation in all three flaking cereals
- Treatment significantly reduces the effective CP degradability in comparison to untreated cereals.
- Amount of in the rumen undegraded and in small intestine digestible protein are significantly increased.
- There is improved energy value in comparison to untreated cereals.
- Flaking improved the values of PDIN, PDIE.

Acknowledgement

The work has been carried out with financial support from the Commission of the EU, FP7, KBB-2007-1.

Thank you for your attention!