

NUTRITIVE VALUE OF BREWERS' GRAIN AND MAIZE SILAGE FOR FATTENING RABBITS

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Abstract: Specific knowledge of the nutritive value of raw materials is fundamental to formulate balanced diets for rabbits and allows greater use of by-products and non-conventional feedstuffs. This paper examines the feeding value of sun-dried brewers' grain and maize silage (whole plant) for fattening rabbits. Twenty-four individually caged 8-wk-old rabbits were used to determine the digestibility. Both wet products were sun-dried and ground before being incorporated into a basal diet. The inclusion level at the expense of all basal ingredients amounted to 30%. Basal diet and both experimental diets were fed *ad libitum* to 8 rabbits during the 4-d balance trial. The determined digestibility of protein, fat, crude fibre and neutral detergent fibre digestibility amounted to 76.2 and 77.2%; 86.5 and 99.1%; 8.1 and 8.3% and 28.0 and 13.5%, respectively, for brewers' grain and maize silage. The digestible energy content amounted to 11.66 MJ/kg dry matter (DM) (brewers' grain) and 11.10 MJ/kg DM (maize silage). Both by-products have potential as alternative feedstuff in rabbit diets. However, further experiments are necessary to determine the effect of ensiling the whole maize plant, as a significantly lower ($P<0.001$) feed intake was observed.

Key Words: fattening rabbit, brewers' grain, maize silage, digestibility, nutritive value.

INTRODUCTION

Feeding outlay represents at least 60% of rabbit meat production costs. Moreover, in recent years a pronounced trend towards increased prices of raw materials and in consequence animal feed has been observed. Feed therefore appears as the dominant input in animal production, ranging from 60 to 70% of the total cost of production (Nworgu *et al.*, 1999).

Alternative sources or locally available by-products can become interesting in such a situation, as the main objective is to reduce feeding costs (Carabaño and Fraga, 1992; Lui *et al.*, 2004; Kadi *et al.*, 2011). Raw materials that contain a certain amount of fibre fractions are especially suitable for rabbits, as they need different sources of fibre in their diet (Gidenne 2003). Brewers' grain, which is a wet by-product of the beer industry, is one such product, widely available in many countries and primarily used in ruminant feeding. Every hectolitre of beer produced generates 20 kg of brewers' grain as by-product (Reinold, 1997).

Brewers' grain is a highly variable by-product whose composition and nutritional value depend on the grain used, the industrial process (temperature, fermentation...) and the method of preservation. Brewers' grains are sold wet or dried and can be ensiled (Blezinger, 2003). According to the Feedipedia database (Sauvant *et al.*, 2015), on a dry matter (DM) basis the dried product contains 25.8% (19.5-31.9%) crude protein (CP), 6.7% (1.7-9.9%) ether extract (EE), 15.8% (11.8-19.9%) crude fibre (CF), 21.9% (15.5-28.6%) acid detergent fibre (ADF) and 5.4% (3.0-10.6%) lignin. The combination of a protein and fibre-rich product fits with the requirements for rabbits. However, data on the feeding value of dried brewer's yeast for rabbits are rarely reported (Fernández-Carmona *et al.*, 1996; Maertens and Salifou, 1997).

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doi:10.4995/wrs.2016.4353

Another feedstuff widely available is maize silage (*Zea mays* L.). The whole maize plant is harvested and chopped and the humid conservation method used is ensiling. Maize silage is a major forage and energy source around the world. Because of its high biomass yield and high concentration of soluble carbohydrates, whole maize plant has been used extensively as a silage crop in both temperate and tropical climates (Phipps, 1996; Njoka *et al.*, 2005). It is traditionally used for ruminants, mostly as silage. The Feedipedia database classed maize silage in the cereal and grass forage category, but only limited information is available on its nutritive value for the rabbit (Martínez *et al.*, 2006). However, maize silage as a livestock feed has a low CP concentration, 8-9% (Carruthers *et al.*, 2000; Darby and Lauer 2002) and 8.1% according to Feedipedia for the silage, with less than 25% DM. Protein content decreases with the maturing process (Tolera and Sunstol, 2001; Michalet-Doreau *et al.*, 2004).

The DM content of maize plant increases from 23 to 37% during the ripening process of the grain (Abreu *et al.*, 2000). The stage of maturity at harvest and mechanical processing are major factors in determining the nutritive value of silage.

Both products, brewers' grains and maize silage, are wet products and have to be dried if incorporated in a pelleted diet for rabbits.

In order to formulate balanced diets, knowledge of the feeding value is essential information (Maertens *et al.*, 2002). Therefore the objective was to determine the nutrient digestibility and energy content of sun-dried maize whole plant silage and brewers' grain in fattening rabbits.

MATERIALS AND METHODS

Experimental design and diets

In total 24 rabbits (8/diet) of 8-9 wk were used to determine the feeding value of brewers' grain and maize silage. The animals were housed in digestibility cages measuring 30×45×35 cm (width×depth×height). They were kept individually and the cages allowed accurate collection of the faeces separately from the urine. The balance trial was executed (duration: 4 d) after 1 wk of adaptation to the experimental diets and to the cages.

Table 1: Basal diet composition.

Ingredient	%
Alfalfa meal 16	30.10
Wheat	9.50
Wheat middlings	17.50
Beet pulp	11.00
Sunflower meal 28	15.00
Full fat soybeans	2.00
Flax chaff	7.00
Soybean oil	1.00
Vitamin and mineral premix*	2.50
Molasses	4.00
NaCl	0.13
L-Lysine HCl	0.125
DL-methionine	0.120
Clinacox	0.02

*Vitamin A: 320 IU/g; Vitamin D3: 70 IU/g; Vitamin E: 0.80 mg/g; Vitamin K3: 0.020 mg/g; Vitamin B1: 0.20 mg/g; Vitamin B2: 0.11 mg/g; Calcium-D-pantothenate: 0.27 mg/g; Vitamin B6: 0.020 mg/g; Vitamin B12: 0.00060 mg/g; Nicotinic acid: 0.71 mg/g; Choline chloride: 4.46 mg/g; Butyl hydroxyl toluene: 0.60%; Potassium chloride: 0.0040%; Cobalt hydroxyl carbonate: 0.0030%; Sodium selenite: 0.0012%; Copper sulphate: 0.040%; Manganese oxide: 0.13%; Zinc oxide: 0.24%; Iron sulphate 0.40%; Aromatic substances: 6%; Calcium: 11.9%; Phosphorus: 4.4%; Sodium: 6.2%.

No dynamic ventilation or heating were used in the experimental farm building. The rabbit house was windowless and a lighting schedule of 10 h light and 14 h dark was used throughout the trial period. The test took place in the April-May period and the temperature reached 22°C during the day and 14°C at night.

For the whole period, rabbits were fed *ad libitum* and the apparent digestibility was measured according to the European methodology (Perez *et al.*, 1995).

A basal diet (Table 1) was formulated to fulfil the requirements of fattening rabbits (De Blas and Mateos, 2010). The experimental diets were obtained by replacing 30% of the basal diet by the test raw material (Brewers' grain or maize silage).

Fresh brewer's grain, a co-product of the beer industry, was obtained from a local brewery (Huyghe, Melle, Belgium). The maize silage, with a DM content of 32%, was the quality used for ruminant feeding in the institute's experimental farm.

Because both tested items were wet products, they were sun-dried by spreading over a thin layer on a plastic sheet. They were turned twice a day to improve the drying

process. During the night, the plastic sheet was closed and after 2 d both products reached a DM content higher than 85% and were collected in bags. Afterwards they were milled in a hammer mill with a 9 mm screen before being added to the basal mash.

The basal mash diet (70%) and test ingredients (30%) were mixed in a small mixer and then transported in a plastic tub to the pelletiser. In order to avoid contamination in the feed plant tubes, the mash was manually introduced on the top of the pellet press. Diets were in the form of pellets of 1 cm length and 3 mm diameter.

Animals and measurements

Rabbits used were taken from a large group of fatteners which were weaned at 35 days of age. At about 8 weeks of age, 24 healthy rabbits were randomly selected for the digestibility trial. They were allotted (8 per diet), according to their weight (mean weight: 2035 ± 139 g) to one of the 3 diets. They were housed individually and fed *ad libitum* one of the 3 diets, with a weekly control of live weight, feed intake and a daily control check on mortality and morbidity (Fernández-Carmona *et al.*, 2005). No medicinal treatment was used during the test and fresh water was always available.

After a 7 d adaptation period, faecal samples were collected for 4 d following the European reference method for digestibility trials in rabbits as described by Perez *et al.* (1995). To collate preliminary data on intake and fattening performance, the trial was prolonged for one week after the digestibility test, until 74 d of age.

Chemical analyses and digestibility

The following chemical analyses were performed: dry matter (SCD 71/393/EEC), ash (5 h at 550°C), nitrogen (ISO 5983-2), gross energy (GE) (adiabatic calorimeter), crude fibre (AOCS, 2005), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (AOAC 2000, procedure 973.187) and Van Soest *et al.* (1991) and lipids (ISO 6492).

Chemical analyses of feeds, faeces and dehydrated brewers' grain and maize silage were performed at the ILVO laboratory, following EGRAN harmonised procedures (EGRAN, 2001).

The digestibility calculation was done according to the recommendations of Villamide *et al.* (2001). It is supposed that there is additivity between the basal diet and the test ingredient. A correction for the difference in DM between the basal mash and the test ingredient was performed to determine the exact inclusion level.

Statistical analysis

Digestibility data of diets and performance data were submitted to a one way ANOVA (StatSoft, 2012). Differences between means were tested by the least significant difference test. Data are presented as means and standard deviation.

RESULTS AND DISCUSSION

The weight of the rabbits was on average 2035 ± 139 g at the beginning of the balance trial and 2508 ± 181 g at the end of the balance trial. This means that the average daily weight, during the adaptation and balance trial period, amounted to 43.0 g, or in the normal range for rabbits at that age. No cases of mortality or morbidity were reported during the test.

Table 2 shows the chemical composition of the 2 test ingredients and 3 experimental diets. The tested brewers' grain contained 20.7% CP and was fat rich (10.3%). However the CP content was lower than those reported by Fernández-Carmona *et al.* (1996) or the Feedipedia database which mentioned a higher CP for this co-product, (27.7; 25.8%, respectively). The ADF content was 19.2%, which equals the value found earlier by Maertens and Salifou (1997) 19.7 vs. 21.9% on Feedipedia. NDF (49%) was lower than that reported by Maertens and Salifou (1997) 62.4% vs. 56.3% on Feedipedia.

Table 2: Nutritional composition of the test ingredients and diets (% as fed).

				Diet 30%	
	Brewers' grain	Maize silage	Basal diet	Brewers' grain	Maize silage
Dry matter (%)	92.3	88.4	91.7	92.4	91.8
Crude fat (%)	10.3	2.9	4.3	5.9	4.5
Crude protein (%)	20.6	5.7	17.0	17.9	14.0
Neutral detergent fibre (%)	49.1	26.0	30.0	35.5	30.2
Acid detergent fibre (%)	19.2	14.4	17.4	17.1	17.1
Acid detergent lignin (%)	4.3	1.5	4.0	3.7	3.5
Gross energy (MJ/kg)	19.9	16.3	17.0	18.0	17.1

Maize silage on the other hand had a low fat (2.9%) and CP (5.7%) content in line with the value mentioned by Martínez *et al.* (2006) at the intermediate maturity stage (mi-dent) and with those in Feedipedia. However, the batch maize silage used had a very low crude fibre (13.2%) and lignin content (1.5%) compared to the values presented in Feedipedia (a mean crude fibre of 20.3 and 2.7% of lignin is supposed). This indicates very clearly that the maize silage tested was harvested at young stage.

Digestibility of the diets is presented in Table 3. The results of one rabbit on the maize silage diet were excluded from the dataset because of overly divergent results (difference >2 standard deviations of mean for DM digestibility).

The digestibility coefficients (DCF) of the diets, with the exception of crude fat, were not significantly different. The great variability of the DCFs with the maize silage diet may be partly responsible for the lack of significance.

The DM digestibility of the maize silage diet is comparable (59%) to that reported by Martínez *et al.* (2006) who substituted 20 or 40% of maize plant at early dough stage. The energy digestibility (63.9%) was higher than the values obtained by the same group at early stage, but in line with their values found at mid-dent stage and full maturity stage (between 60 and 64%). The CP digestibility (75.3%) on the other hand was somewhat higher than for all qualities tested by Martínez *et al.* (2006). Moreover, they mentioned an increase in the digestibility coefficients of DM, GE and CP of the maize plant with the maturing process.

The DCFs of the brewers' grain diet were very comparable with the data obtained by Maertens and Salifou (1997) with the exception of the energy and fat digestibility, which were 5 and 4 points higher in the current experiment.

The DCF of brewers' grain and maize silage are presented in Table 4.

A good protein digestibility for rabbits (76.2%) was observed for brewers' grain, exceeding the values determined for barley (Maertens *et al.*, 1990; Fernández-Carmona *et al.*, 1996) or mentioned in the EGRAN tables (Maertens *et al.*, 2002). A high crude fat digestibility of 86.5% was determined for the quantitative (10.3%) important fat fraction which explained the high digestible energy content. The actual batch tested had a lower fibre digestibility (e.g. NDF: 28.0 vs. 39.6%) but a higher energy content (11.66 MJ instead of 10.06 MJ/kg DM) than reported by Maertens and

Table 3: Digestibility (%) of diets.

	Diets			P-value
	Basal	30% Brewers' grain	30% Maize silage	
Dry matter	59.0±1.3*	55.4±0.8	59.5±3.6	0.152
Crude protein	74.5±1.8	75.0±1.5	75.3±2.8	0.881
Crude Fat	77.7±1.6 ^a	80.4±1.4 ^b	84.0±0.9 ^c	0.001
Crude fibre	24.4±2.9	19.5±1.4	19.7±9.1	0.612
Neutral detergent fibre	34.8±2.2	32.7±2.8	28.5±7.2	0.372
Acid detergent fibre	22.6±4.9	18.6±2.2	19.5±5.2	0.702
Gross energy	64.4±1.3	61.3±0.7	63.9± 3.6	0.356

^an=8/diet except maize silage diet (n=7).

Means in the same row, sharing different superscripts differ significantly ($P < 0.05$).

Table 4: Digestibility of brewers' grain and maize silage.

	Brewers' grain	Maize silage
Dry matter (%)	47.3	60.6
Crude protein (%)	76.2	77.2
Crude fat (%)	86.5	99.1
Crude fibre (%)	8.1	8.3
Neutral detergent fibre (%)	28.0	13.5
Acid detergent fibre (%)	9.3	12.2
Gross energy (%)	54.1	62.8
Dig. energy (MJ/kg DM)	11.66	11.10
Dig. protein (% DM)	15.7	4.4

Salifou (1997). Compared with other cereal by-products, brewers' grain has an energy content between wheat bran and wheat shorts (Maertens *et al.*, 2002).

These results mean that brewers' grain is a suitably fibrous and energetic feedstuff which also makes an important contribution in proteins. The energy content, fibre and crude protein make brewers' grain a valuable by-product in diets for rabbits.

The batch maize silage tested showed a good protein and fat digestibility (77.2 and 99.1%, respectively). However, the low fat content of maize silage hinders an accurate determination (Villamide *et al.*, 2001). The digestible protein of maize silage is low (4.4%, DM) and in line with the values estimated by Martínez *et al.* (2006) for the maize silage mi-dent stage (between 4.5 and 4.7 depending of inclusion level and methodology).

An energy value of 11.1 MJ/kg DM was obtained which is higher than the highest values reported by Martínez *et al.* (2006) at full maturity stage; 10.4 MJ/kg DM both with the substitution as regression method. At 20% substitution, they determined a value of 12.2 MJ/kg DM, but attributed this to the high errors obtained at lower inclusion levels.

The energy value determined for maize silage (11.10 MJ/kg DM or 9.82 MJ/kg for the sun-dried product) is comparable with beet or citrus pulp but much higher than for other fibrous products and alfalfa meal (Maertens *et al.*, 2002). With the direct method, Gaafar *et al.* (2010) determined a much higher value of 12.40 MJ/kg. Lui *et al.* (2004) on the other hand, mentioned a comparable energy content as alfalfa hay. The diets they used consisted of ground forage enriched with 9% oil.

Table 5 shows data on feed intake and fattening performance. Because of the low number of rabbits and the short period, they can only be considered as indicative. Feed intake and weight gain were similar in groups fed basal diet or diet containing 30% brewers' grains. The feed conversion ratio was somewhat (not significantly) lower, in line with the quite high digestible energy content of this by-product.

However, for corn silage a significant ($P < 0.001$) lower intake and weight gain was observed. This negative effect on feed intake was not found by Martínez *et al.* (2006) or Gaafar *et al.* (2010), who obtained a comparable intake as with the control or basal diet. One explanation could be due to the fact that our product was ensilaged, whereas in the aforementioned studies the whole maize plant was fed immediately after harvesting.

Martínez *et al.* (2006) concluded that dehydrated whole maize plant can be utilised in rabbit diets at least at the 20% inclusion rate without affecting feed intake, growth rate, dressing yield and carcass characteristics, although it could impair feed efficiency. However, they signalled that feed intake was affected by maturity stage.

Table 5: Feed intake and weight gain of rabbits fed the experimental diets*.

	Basal diet	Diet 30% Brewers' grain	Diet 30% Maize silage	P-value
Feed intake (g/d)	176±16.6 ^a	177±13.1 ^a	144±10.5 ^b	0.000
Daily weight gain (g/d)	47.9±5.4 ^a	51.3±3.5 ^a	40.2±4.1 ^b	0.001
Feed conversion ratio	3.70±0.31	3.48±0.33	3.60±0.15	0.341

*n=8; from 56 to 74 d of age.

Nevertheless, based on the current experiment, further trials are necessary to determine the possible negative effect of ensilaging of the whole maize plant for rabbits and the maximum inclusion level in balanced diets.

CONCLUSIONS

Both tested products showed good digestibility for rabbits and a reasonably high energy value. If the dried products are available, they can be considered as an alternative raw material in rabbit diets.

However, because of the lower feed intake on the maize silage diet (on average 18% lower), further experiments are necessary to judge the effect of ensilaging and maximum inclusion level in rabbit diets.

Acknowledgments: The authors are grateful to Andre Vermeulen for his skilful technical assistance and to the laboratory personnel for the analyses of diets and faeces.

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