EFFECT OF MALT SPROUTS ON NUTRIENT FERMENTATION IN THE RUMEN OF COWS AND THEIR PRODUCTIVITY

Darius Šidagis, Virginijus Uchockis, Saulius Bliznikas

Institute of Animal Science of Lithuanian University of Health Sciences
R. Žebenkos 12, LT-82317 Baisogala, Radviliškis Distr., Lithuania, tel.8422 65383, e-mail virginijus@lgi.lt

Abstract. The trial was conducted with twenty Lithuanian black-and-white milking cows at the LUHS Institute of Animal Science in February-May 2010. The cows were allotted into two groups of ten cows each, analogous by age, production and calving time. In the pre-experimental period, the cows in both groups were fed with wet mash composed of maize silage, 62.5 percent, perennial grass silage, 37.5 percent, and compound feed (barley, triticale, rapeseed cake, mineral-vitamin supplement). During the trial, the cows in the control group were additionally offered 2 kg of barley meal and those in the experimental group 2 kg of malt sprouts. The purpose of this study was to investigate the effect of malt sprouts on nutrient metabolism in the rumen of cows, their production and milk quality. The study indicated that somewhat bitter flavour of malt sprouts increased the intake of wet mash and improved the energy value of the diet by 2.2 percent. Also it turned out that the usage of malt sprouts in the feed allowance (2 kg daily) created favourable conditions for infusoria growth and development in the rumen. Infusoria count in the rumen of the treated animals was on average by 139.19 thou/ml or 68.94 percent higher than that in the control group ($p<0.05$). Supplementation of the diet with malt sprouts had no significant influence on the other investigated biochemical indices of the rumen. Supplementation of the compound feed with malt sprouts had no significant influence on the nutrient breakdown processes in the rumen of cows. Production studies indicated that malt sprouts in the diet of cows had a positive influence on the milk yield because during the trial the cows yielded on average by 12.45 percent ($p<0.05$) more whole milk and by 0.41 percent more milk fat. However, this feed had no significant influence on milk protein content.

Keywords: malt sprouts, milking cows, rumen, cow productivity, production quality.

Introduction. Milk production is one of the most complicated branches of agricultural production. Farmers and agricultural enterprises with good management get on the average from 7000 to 8000 kg of milk per cow per year. Numerous factors influence the profitableness of dairy farming: the genetic potential of animals, feeds and feeding, housing and care technologies. Feeds make up more than a half of all milk production expenses. To reduce the expenses, it was started to look for cheaper alternative feeding material among the by-products of food industry (wheat bran, gluten syrup, glycerol, malt sprouts, etc.). However, the use of by-products for animal feeding might be unsuccessful without research and production practice because it might result in lower production and its quality, feed conversion changes, health problems, etc. Thus, the main criteria for the supplementation of the diets with alternative feeds are their effect on animal body and production quality.

Beer production in Lithuania is characterized as a developing and promising sector. Besides its main produce – beer, this sector releases quite a number of by-products, such as malt sprouts, brewers' yeast, the expedient use of which might add to the solution of both ecological and alternative feeds for animal production problems.

To produce brewers' malt, grain is soaked, grown, dried and cleaned. In the process of cleaning, sprouts and rootlets, that appeared when growing, are removed. Afterwards, the sprouts are pelleted. The analysis indicates that malt sprouts are composed of on average dry matter, 95%, organic matter, 88.6%, crude protein, 26.9% (including 21.1% digestible protein), pure protein, 17.0% (including 11.2% digestible), crude fibre, 16.2%, crude ash, 6.4% and nitrogen-free extracts, 44.5% (Dammers, Hamm, 1960). The content of crude protein in malt sprouts may vary from 25 to 30% (Heller, Potthast, 1990).

High NDF amount is characteristic of malt sprouts. It is on average 460–560 g per kg sprouts on a DM basis. Malt sprouts contain high amounts of NDF and limited amounts of structural carbohydrates if compared with grain. Malt sprouts have 630 MJ NEL or 11.0-12.0 MJ metabolizable energy per kg DM (Salama et al., 1997). Due to high content of fibre, pelleted malt sprouts may be used as a protein supplement for ruminants and horses. Malt sprouts are mostly used to reduce the amount of non-structural carbohydrates in the diets of lactating cows or as a replacement for roughage feeds. Until now, most of the studies were carried out to determine the nutrient digestibility of malt sprouts and feeding doses. This is important because somewhat bitter flavour of malt sprouts might restrict the intake. Conversely, higher amount of malt sprouts in a feed allowance may influence the usage of animal production due to worse palatability.

Trials with castrated rams allowed determining digestibility coefficients of some nutrients. The trials indicated that the DM digestibility of malt sprouts was 75.2%, organic matter 77.5%, crude protein 78.4%, pure protein 70.7%, crude fibre 73.6%, crude ash 43.7%, common digestibility of crude fat and nitrogen-free extracts accounted for 78.3%. The estimated starch equivalent accounted for 46.0% (Dammers, Hamm, 1960). *In vitro* dry matter digestibility of malt sprouts was 85% (Erickson et al., 1986; Robinson, Kennelly, 1989; Swain, Armenato, 1994). The total amount of digestible nutrients in malt sprouts accounts for approximately 82%

of the corresponding amount in maize. Despite the fact that malt sprouts are somewhat bitter, animals eat them willingly. However, due to bitter taste, it is recommended to mix malt sprouts with other feeds. To prevent bitter taste, the amount of sprouts in the concentrated feed for milking cows should not exceed 10% (Heller, Potthast, 1990; Granz, 1985) or 15% (Matz, 1991). H. Jeroch et al. (1999; 2010) indicate that the highest amount of malt sprouts in the feed allowance for milking cows should be up to 1-2 kg daily per animal or no be more than 20% in the concentrated feed. In the compound feed for fattening cattle, the amount of malt sprouts should not exceed 25%.

According to J. R. Gillespie and F. B. Flanders (2010), the amount of malt sprouts in the concentrated feed should not be higher than 20%. Wet mash production technologies can be used for malt sprout inclusion into feeds (Erickson et al., 1986; Robinson, Kennelly, 1989; Swain, Armenato, 1994).

Two supplements in the feed allowance for lactating cows were compared. One of the two was composed of maize (573%), cottonseed oil-meal (37%) and mineral premix (6%), another – of malt sprouts 995%) and mineral premix (5%). The live weight, body score, conception rate, weight of newborn calves, calving ease and live weight of calves did not differ between the groups of cows fed these supplements (1.36 kg DM per cow). Three supplements were compared in the trials with fattening cattle. The diet of the cattle in Group 1 was supplemented with 0.45 kg maize meal, in Group 2 – 0.50 kg cottonseed oil-meal and in Group 3 – 0.47 kg malt sprouts per animal. Animals in all groups were fed hay *ad libitum*. There were no differences for the initial and finish live weight between the three groups of fattening cattle (Creasy et al., 2001). B. P. Arora and C. Lotha compared two feed allowances for calves. The control allowance consisted of maize (45%), rice straw (17%), peanut oil-meal (35%) and mineral premix (3%). The experimental allowance was composed of malt sprouts (50%), rice straw (20%), barley (10%), peanut oil-meal (17%) and mineral premix (3%). The amount of crude protein in both feed allowances was 19.7%. The calves of both groups consumed similar amounts of feeds on a DM basis and gained daily 0.37 and 0.34 kg, respectively (Arora, Lotha, 1980).

Scientific publications about the use of malt sprouts in animal feeds are not numerous, and there is little information about the effects of malt sprouts on the degradation of nitrogenous matter and carbohydrates in the rumen of lactating cows, as well as cow productivity and milk quality. Therefore, the aim of this study was to investigate the effects of malt sprouts on the nutrient fermentation in the rumen of cows and their productivity.

Materials and methods. The feeding trial was carried out at the LSHU Institute of Animal Science in February-May, 2010. Lactating cows of the Lithuanian Black-and-White breed were allotted into two groups of 10 animals each. The groups were analogous by the age, productivity and calving time of cows. The housing conditions for the groups were the same. Both groups followed the routine farm requirements for feeding, cleaning and motion. The cows were tethered, automatically watered and milked twice daily. The trial was divided into two periods – preparatory and experimental. In the preparatory period (20 days), the cows in both groups were offered the same feed allowance composed of wet mash-maize (62.5%) and perennial grass silage (37.5%) – and compound feed composed of barley and triticale meal, rapeseed cake and mineral-vitamin premix. In the experimental period (82 days), the cows of both groups were fed the same diet, except that the diet of the cows in the control group was supplemented with 2 kg of barley meal and that of the experimental group with 2 kg of malt sprouts. The experimental design is presented in Table 1.

Table 1. **Experimental design**

Group of cows	No of cows	Feeding pattern in the experimental period
Control (C)	10	Wet mash *ad libitum*, 5.6 kg compound feed, 2 kg barley meal
Experimental (E)	10	Wet mash *ad libitum*, 5.6 kg compound feed, 2 kg malt sprouts

During the trial, all the consumed feeds were recorded, by carrying out control feeding every week and analyzing the chemical composition and quality of feeds every two weeks.

Analysis of the chemical composition of feeds. Feed samples were analyzed for dry matter, crude protein, crude fibre, crude fat, nitrogen-free extracts, calcium and phosphorus. The energy value of feeds was expressed as net energy for milk production (NEL). The quality of wet mash was determined by analyzing lactic, acetic and butyric acid contents and pH-values. The analyses were carried out at the Analytical laboratory of the LHSU Institute of Animal Science using ordinary methods (AOAC, 1995).

Studies of milk yield and quality. Every cow had its control milking once a week to determine the daily milk yield and collect individual milk samples for chemical analysis. Analyzer "Milko–Scan 133B" (A/SN. Foss Electric, Hillerod, Denmark) was used to determine the content of fat and total protein.

Studies of the rumen contents. The rumen content was analyzed once in the preparatory period and three times (once a month) in the experimental period. Four analogous cows from each group were used to collect the rumen fluid 1.5–2 hours after the supplementary feeding with barley meal and malt sprouts. The rumen fluid was collected using the pharynx probe with a metal tip. The rumen content was analyzed for the dry matter content by drying to a constant weight at 105°C; Infusoria content in a Goryaev's chamber; pH – by pH-meter „Orion–710" with a glass electrode; total volatile fatty acid (VFA) content by distilling with Markgam apparatus; VFA ratio by gas chromatograph „Shimadzu GC–2010" (Shimadzu corporation, Kyoto, Japan) and Erwin methods (Erwin et al., 1969) for the preparation of acidified rumen content. For this purpose, 0.25 mm in inner diameter and 25 m long capillary column filled with AT^{TM}-1000 (Alltech

Associates, USA) phase was used. Total and ammonia nitrogen was determined by Tecator equipment (Foss–Tecator AB, Höganäs, Sweden).

Statistical analysis. The biochemical data of the rumen contents and cow productivity were statistically analyzed and presented as the arithmetic mean (X) and standard deviation (SD). The analysis was carried out using „Statistica for Windows, version 7.0" (Stat Soft Inc. Tulsa, OK, USA).

Results and Discussion. Chemical composition of malt sprouts. Malt sprouts used in this trial contained on average 95.0% of dry matter. The average content of crude protein was 219.4 g, crude fat 11.48 g, crude fibre 116.33 g, calcium 1.65 g and phosphorus 6.36 g per kg dry matter. The energy value of malt sprouts was close to that of barley meal used in the trial (6.80 MJ NEL/kg DM malt sprouts and 6.85 MJ NEL/kg DM barley meal).

Feed intakes. The average composition of the diets on as fed basis is presented in Table 2. High quality wet mash with prevailing lactic acid was offered to the cows. The animals consumed all the given compound feeds, barley meal and malt spouts despite the bitter taste of the latter feed.

Table 2. **The average diets of milking cows on feed basis**

Feeds	Groups	
	Control	Experimental
Wet mash, kg	42.2	43.9
Compound feed, kg	5.6	5.6
Barley meal, kg	2.0	-
Malt sprouts, kg	-	2.0
Analysis:		
Dry matter, kg	18.27	18.79
NEL MJ	129.79	132.65
Crude protein, g	2139.2	2425.1
Crude fat, g	376.5	383.3
Crude fibre, g	4237.1	4518.2
Calcium, g	102.5	104.0
Phosphorus, g	58.3	65.7

The cows of the experimental group that, according to H. Jeroch, received the maximum daily amount of malt sprouts (2 kg) consumed 4% higher amount of wet mash (Jeroch et al., 2010). Due to this, the average daily intake of dry matter was by 0.52 kg or 2.85% higher and that of crude fibre by 281.1 g or 6.63% higher. The feed allowance of the cows in this group was richer in crude protein. The cows in this group received on the average more crude protein (285.9 g or 13.36%) and crude fibre (6.8 g or 1.81%) in comparison with the control group. Due to higher intake of wet mash, the energy value of the diet for the experimental cows was 2.86 MJ or 2.20% higher. Thus, it can be concluded that feeding malt sprouts increases the intake of bulky wet feeds.

Biochemical parameters of the rumen contents. Malt sprout usage in the diet of cows resulted in favourable conditions for the infusoria growth and development in the rumen. This presumption is based on the results from our study because in the experimental period the infusoria count in the rumen of animals fed malt sprouts was on average 139.19 thous.ml or 68.94% higher than that of the cows in the control group ($P<0.05$). Supplementation of the diets with malt sprouts had no significant influence on the biochemical parameters of the rumen content (Table 3).

Table 3. **Characteristics of the rumen content**

Item	Group	Preparatory period	Experimental period
Infusoria count, thou/ml	C E	232,34±16,75 247,64±38,82	201,91±28,17 341,10±27,03*
Dry matter, %	C E	1,87±0,15 1,95±0,14	2,42±0,06 2,48±0,06
pH	C E	7,08±0,10 7,10±0,08	6,70±0,08 6,76±0,06
Ammonia nitrogen, mg/100 ml	C E	8,40±0,23 7,45±0,45	7,34±0,69 8,78±0,35
Total nitrogen, mg/100 ml	C E	34,07±1,13 34,08±2,68	37,48±1,37 37,75±2,26
VFA, mg/100 ml	C E	10,82±0,55 9,46±1,00	10,04±0,38 8,88±0,33
VFA ratio:			
acetic acid	C E	67,17±0,30 71,66±0,33	66,67±1,40 69,12±1,37
propionic acid	C E	17,81±0,37 15,82±0,39	18,83±0,76 16,90±1,15
butyric acid	C E	10,46±0,56 8,61±0,24	11,45±0,60 10,86±0,20

*$p<0.05$

The same amount of dry matter in the rumen content indicates that during the trial the cows in both groups drank the same amount of water. The rumen contents reaction in both groups of cows was slightly acid during the whole experimental period. The pH-value of the rumen contents of the experimental cows was on average 0.06 units higher.

Supplementation of the diet with malt sprouts had no influence on the amount of total nitrogen in the rumen. Its concentration was the same in the rumen of both control and experimental groups of cows. In the experimental period, the content of ammonia nitrogen in the rumen of the treated cows was 1.44 mg/100 ml higher than that in the rumen of the control cows. Jeroch et al. (2010) as well as other authors indicated that non-protein nitrogenous compounds might make up to 50% of crude protein in malt sprouts. The solubility as well as the breakdown activity in the rumen are dependent on the composition of these compounds. The results of our study indicated insignificantly higher fermentation of nitrogenous compounds in the rumen of the treated cows. However, it cannot be assumed that this result was influenced by the use of malt sprouts as the difference was not statistically significant. Moreover, the results of our study would disagree with the findings of P. S. Erickson et al. (1986) who indicated that the crude protein of malt sprouts do not have a high biological value. Crude protein has slower fermentation in the rumen; therefore, it is for the most part digested in the other parts of the digestible tract (Erickson et al., 1986).

The concentration of volatile fatty acids in the rumen contents of both groups of cows was significantly different already in the preparatory period – VFA content in the experimental group of cows was 12.57% lower. It is believed that the difference was due to the individual qualities of the cows. The same tendency was observed in the experimental period – VFA concentration in the rumen contents of the treated cows was 1.16 mmol/100 ml or 11.56% lower.

The percentage of the acetic acid in the rumen contents of the treated cows was by 4.49% higher and remained as such (on average by 2.45% higher) in the experimental period. The part of the propionic acid in the rumen contents of the treated cows was on average by 1.99% lower in the preparatory period and in the experimental period it increased by 1.02 and 1.08% in, respectively, the control and treated groups. Due to this reason, the part of the propionic acid in the rumen contents of the control cows also remained higher by 1.97%. The part of the butyric acid in the experimental period was similar between the groups by its numerical value and the difference of 1.85% registered in the preparatory period decreased as low as 0.59% in the experimental period.

Cow productivity and milk composition. In the experimental period, whole milk yield of the cows in the control and tretaed groups decreased by, respectively, 4.07 kg/d and 1.34 kg/day (Table 4) in comparison with the preparatory period. The yield of whole milk was lower in both groups of cows because they were chosen for the trial on average 5 months after calving.

Table 4. **Cow productivity**

Groups (n=10)	Period		± compared with preparatory period
	Preparatory $x \pm SD$	Experimental $x \pm SD$	
Whole milk, kg/d			
Control	22.46±0.93	18.39±0.52	-4.07
Experimental	22.02±0.92	20.68±1.03*	-1.34
Milk fat, %			
Control	4.20±0.16	4.32±0.13	+0.12
Experimental	4.16±0.10	4.57±0.07	+0.41
4% fat corrected milk, kg			
Control	23.21±1.34	19.28±0.51	-3.93
Experimental	22.55±0.86	22.45±0.97	-0.10
Milk protein content, %			
Control	3.21±0.06	3.16±0.06	-0.05
Experimental	3.15±0.05	3.05±0.06	-0.10

*p< 0.05

In the preparatory period, the difference in whole milk production between the groups was 0.44 kg/d (P>0.05), whereas in the experimental period this difference was already on average 2.29 kg/d. In the experimental period cows fed malt sprouts yielded daily 20.68 kg or 12.45% more milk than the cows in the control group (18.39 kg/d).

The difference between the groups was statistically significant (P>0.05). In general, the lactation of the treated cows was more stable due to higher intake of wet mash and higher energy value of the feed allowance. The treated cows yielded 0.29% more milk fat, but 0.05% less milk protein.

It can be concluded that supplementation of the cow diets with malt sprouts increased the whole milk yield and milk fat content, and had no significant influence on milk protein content.

Conclusions. Supplementation of the cow diets with 2 kg of malt sprouts daily resulted in 4.0% higher intake of wet mash on the average. Infusoria count in the rumen of the treated cows was 68.94% higher (P<0.05). Malt sprout supplementation of the diet had no influence on the pH-value, ammonia and total nitrogen content, total VFA content and ratio in the rumen fluid of cows. The whole milk daily yield was on average by 2.29 kg higher in the treated group of cows due to higher intake of wet mash. The fat content of milk in this group of cows was on average by 0.29% higher. Malt sprout supplementation of the diet had no significant influence on the milk protein content.

References

1. AOAC. Official methods of analysis. Vol.1. Association of official analytical chemists. 481 North Frederick Avenue, Suite 500. Gaithersburg, Maryland 20887–2417, USA, 1995.

2. Arora S. P., Lotha C. Nutritive value of malt sprout and its effect of feeding on growth rate. Indian Veterinary Journal. 1980. 57(11). P. 934–936.

3. Creasy M. E., Gunter S. A., Beck P. A., Weyers J. S. Malt sprouts as a supplement for forage fed beef cattle. Journal of Applied Animal. Research. 2001. 20. P. 129–140.

4. Dammers J., Hamm G. De verteerbaarheid en voederwaarde van moutkiemen. Landbouwkundig Tijdschrift. 1960. 72. P. 127–128.

5. Erickson P. S., Murphy M. R., Davis C. L. Malt sprouts as a source of supplemental protein for ruminants. Journal of Dairy Science. 1986. 68. P. 2959–2962.

6. Erwin E., Marco G., Emery E. Volatile fatty acid analysis of blood and rumen fluid by gas chromatography. Journal of Dairy Science. 1969. 44. P. 1768–1778.

7. Gillespie J. R., Flanders F. B. Modern Livestock and Poultry Production. 8th edition. Delmar. 5Maxwell Drive, Clifton Park, NY. 2010. P. 770.

8. Granz E. Tierproduktion. 10 Auflage. Verlag Paul Parey. Berlin und Hamburg. 1985. P. 269–270.

9. Heller D., Potthast V. Erfolgreiche Milchviehfutterung. 2. überarbeitete Auflage. DLG-Verlag Frankfurt (Main). 1990. S. 56.

10. Jeroch H., Sederevičius A., Pilipavičius V., Mikulionienė S., Steinhöfel O., Stankevičius R. (Sudarytojas Jeroch H.) Pašarai tradiciniai ir ekologiški. Vitae litera. Kaunas. 2010. P. 423.

11. Jeroch H., Drochner W., Simon O. Ernahrung landwirtschaftlicher Nutztiere. Verlag Eugen Ulmer, Stuttgart. 1999. S. 225–229.

12. Matz S. A. The chemistry and technology of cereals as food and feed. 2nd edition. Springer. 1991. P. 310–311.

13. Robinson P. H., Kennelly J. J. Evaluation of the feeding value of malt sprouts. Spec. Issue 68, 1968. P. 34–35. Faculty of agric., Forestry, Home Econ., University Alberta, Edmonton, Alberta, Canada.

14. Salama A. R. A., El-Sham M. A., Mesallam A. S., El-Tabey-Shehata. The chemical composition, the nutritive value and the functional properties of malt sprout and its components (acrospires, rootlets and husks). Journal of the Science of Food and Agriculture. 1997. 75. P. 50–56.

15. Swain S. M., Armentano L. E. Quantitative evaluation of fiber from non forage sources used to replace alfalfa silage. Journal of Dairy Science. 1994. 77. P. 2318–2331.

16. The encyclopedia of farm animal nutrition. Edited by Fuller M.F. CABI publishing, Cambridge, MA 02139, USA. 2004. P. 64.

Received 11 September 2012
Accepted 9 January 2014