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EFFECT OF SORGHUM GRAIN INCLUSION IN MONTBELIARDE DAIRY COWS DIET ON HEALTH STATUS

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ABSTRACT

The present study investigated the effect of sorghum grain inclusion in dairy cows diet, as an alternative to barley grain, on plasma biochemical markers (glucose, triglycerides, cholesterol, total protein, albumin, urea, creatinine, total bilirubin, calcium, phosphorus, magnesium, iron, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, gamma-glutamyl transferase, lactate dehydrogenase, creatine kinase). Twelve Montbeliarde dairy cows, mid to late lactation, averaging 698 ± 27 kg body weight and 18 ± 1.3 l milk.day^{-1}, were divided into two groups in a 43-day feeding trial: C diet, based on classical energetic sources (corn and barley) and E diet, where sorghum grain replace barley. The cows received the same forage diet. An analyzer BS-130 was used to determine the plasma parameters. Results showed that the use of 25 % sorghum grain in E diet increased (+30 %, P = 0.009) the plasma glucose and decreased the triglycerides (-20 %, P = 0.032) comparing to C diet. Total protein and albumin increased (+10 %, P = 0.002; respectively +17 %, P = 0.013) as effect of dietary sorghum addition. The calcium concentration increased (+21 %, P = 0.022), while the magnesium concentration decreased (-28 %, P = 0.010) in E diet compared to C diet. The enzymes profile slightly increased as effect of fed sorghum grain, but the differences between treatments were not significant (P > 0.05). Replacement of barley grain with sorghum had no adverse effects on health status of dairy cattle, the assessed markers being within the health reference limits.

Key words: dairy cows; barley; sorghum grain; health status; plasma profile

INTRODUCTION

In ruminant nutrition, cereal grains comprise up to 95 % of total diet (McCuistion, 2014). In the future, the use of cereals in grain distilleries and ethanol production, associate with climate change consequences, will increased interest in the utilization of alternative energy sources for the ruminant's nutrition (Gibreel *et al.*, 2009). Thereby, alternative valuable nutritional sources must be evaluated in order to partially or totally replace the classical cereal grains used in dairy cows feeding (Rattray, 2012). Sorghum grain (*Sorghum Vulgare* L.) is considered an important crop for both human and animal nutrition (Dicko *et al.*, 2006) and it was recommended as a suitable energetically resource for ruminants (Brouk and Bean, 2012; Mavromicalis, 2014; Khajehdizaj *et al.*, 2014; Yahaghi *et al.*, 2012). Nowadays, new improved sorghum varieties characterized by a high drought-tolerant capacity, a high yield production, nutritive value close to that of corn and a low tannin content, are available on the market. Blood metabolites are important indicators for animal health, the function of certain tissues and organs and, also provide important information about the effects of different nutritional regimen used in animals feeding. There is still a lack of published information on the effects

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of feeding sorghum grain as substitute of barley on dairy cows performance and health status (Ishler, 2017; Nikkhah *et al.*, 2004; Yahaghi *et al.*, 2012), except few research study reported in fattening steers (Voicu *et al.*, 2014; Voicu *et al.*, 2016). Therefore, the aim of this study was to evaluate the effect of sorghum grain as replacement of barley in dairy cows diets on some plasma metabolites related with health status.

MATERIAL AND METHODS

Dairy cows were treated in accordance with Romanian law no. 305/2006 regarding handling and protection of animals used for experimental purposes. All experimental procedures were approved by the Ethical Committee of the National Research-Development Institute for Animal Biology and Nutrition, Balotesti, Romania.

Animals, feeding and housing

Twelve multiparous Montbeliarde dairy cows, mid to late lactation, averaging 698 ± 27 kg body weight, 175 ± 10 days in milk (DIM), parity number 2.86 ± 0.60 and an initial milk yield of 18 ± 1.3 kg.day^{-1}, were used in a trial of 43 days. The trial design consisted of a 14 day adaptation followed by 29 day experimental period for sample collection. The animals were assigned to two homogenous groups and fed with a control diet (C) based on corn, barley, wheat bran and sunflower meal and an experimental diet (E), where the 25 % sorghum grains replace barley in the compound feed. The bulk feed (fed *ad libitum*) consisted of spring hay (60 % oat hay + 40 % vetch hay) and alfalfa haylage. The bulk to concentrate ratio was 60:40. Feed was given in two allowance per day at 06h and 16h. Diets were adequate to the category of weight and level of production and provided the following nutritional intakes: 18.0 kg dry matter (DM)/cow/day, 17.0 milk feed units (mFU)/cow/day and 1600 g intestinally digestible protein (IDP)/cow/day. During the 43 days trial period, the cows were housed in a conventional shelter equipped with collective feeding boxes and free access to feed and water.

Measurements, analyses and statistics

Standardized methods, as per Commission Regulation (EC) no. 152 (2009), were used to determine the gross chemical composition of the feed ingredients, compound feeds and of the bulk feed. The chemical composition and the nutritive values of the compound feed (CFs) are shown in Table 1.

Table 1. Chemical composition and nutritive value of the compound feed for dairy cows (g.kg DM^{-1})

Item	C	E
Analyzed and calculated values		
Dry matter	882	876
Organic matter	941	944
Gross energy (MJ)	18.95	18.71
Crude protein	143	131
Ether extract	23	23
Crude fiber	84	73
Nitrogen-free extractives	692	717
Ash	59	56
Nutritive values		
mFU	1.16	1.17
IDPN	98	91
IDPE	101	101
Ca	9.5	9.75
P	6.2	6.0

C, control diet (barley grain); E, experimental diet (sorghum grain); DM, dry matter; mFU, milk feed units; IDPN, intestinal digestible protein derived from nitrogen; IDPE, intestinal digestible protein derived from energy; Ca, calcium; P, phosphorus.

The diets were formulated according to the system adopted in Romania by Burlacu *et al.* (1991, 2002), based on the French model of evaluation (INRA, 1988).

The health state of the animals was monitored and accurately reflected in the blood constituents. At the end of experimental period (43 days), after the first milking in the morning before feeding blood samples were aseptically collected by jugular venepuncture into heparinized Vacutainer tubes (Vacutest®, Arzergrande, Italy), from all dairy cows (N = 12). Blood samples were immediately placed on ice, and 9000 µL of each sample was centrifuged for 25 minutes at 3500 x g. Concentration of glucose, cholesterol, triglycerides, total protein, albumin, urea, creatinine, total bilirubine, calcium (Ca), phosphorus (P), magnesium (Mg), iron (Fe) and the activity of alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), alkaline phosphatase (AP), gamma-glutamyl transferase (GGT), lactate dehydrogenase (LDH) and creatine kinase (CK) were determined from blood plasma (4500 − 5000 µL) on an automatic BS-130 Chemistry analyzer (Bio-Medical Electronics Co., LTD, China), using standardized kits ACCENT 200, supplied by PZ Cormay S.A. Poland (Ţăranu *et al.*, 2014). Results are expressed as mean with standard error of the mean (SEM). Statistical differences between groups for different parameter concentrations were determined using SPSS − general linear model (Statistics version 20, 2011). The significance of differences between groups were estabilished using analysis of variance and Tukey's test. Differences between mean values were considered significant at P < 0.05.

RESULTS AND DISCUSSION

In the current study, replacement of barley with sorghum grain in the CFs of dairy cows did not affected (P > 0.05) the total dry matter intake (18.30 DMI kg.day^{-1}, C diet *vs*. 18.61 DMI kg.day^{-1}, E diet) or the consumption of the bulk feed, that was relatively similar between groups (20.82 DMI kg/head/day, C diet *vs*. 21.03 DMI kg/head/day, E diet), this revealed that the inclusion of sorghum grains did not affect the palatability of the ration. Furthermore the digestive processes were not affected by dietary treatments (e.g. absence of diarrhoea or other disorders). However, the sorghum diet had significant influence (P < 0.05) on the milk production (18.06 L.d^{-1}, C diet *vs*. 19.73 L.d^{-1}, E diet; data not shown).

The results of plasma biochemical parameters are summarized in Table 2.

Plasma energy profile

Plasma energy parameters ranged between physiological limits for the species and category (Merk Veterinary Manual, 2010). It is well known that glucose is essential for all organisms (Aschenbach *et al.*, 2010) and cereal grains are important sources that can provide non-fibrous carbohydrate (Van Knegsel *et al.*, 2007). Ruminal and intestinal fermentation of non-fibrous carbohydrate (particularly starch) release propionate, a glucose precursor for tissue and milk synthesis and theoretically increases substrate available for gluconeogenesis (Taylor and Allen, 2005). Van Knegsel *et al.* (2007) have demonstrated that plasma glucose concentrations increased when ruminants were fed with high amounts of energy sources.

In our study, the use of 25 % sorghum grain in E diet, as a substitute of barley grain, increased significant (+30 %, P = 0.009) the plasma glucose. The results agree with previous study (Aguerre *et al.*, 2009, Yahaghi *et al.*, 2012) which reported that the plasma glucose concentration was greater when cattle and sheep were fed with a fresh temperate pasture supplemented with sorghum grain (15 g.kg^{-1} of their body weight) compared to non-supplemented animals. Also, Nikkhah *et al.* (2004) noticed an increased glucose level of Holstein cows in mid-lactation stage in response to 21 days feeding of 20 % ground sorghum. Recently, Ishler (2017) reported that increased concentrations of plasma glucose level in sorghum diet *vs.* barley diet is surprisingly since the rumen digestion of barley is higher than that of sorghum. This effect could be attributed to a lower rumen degradability of sorghum grain non-fibrous carbohydrate which encourages a relatively high amount of starch entering into the small intestine and to the fact that enzymatic hydrolysis activities provides energy into the blood stream, in the form of glucose. The plasma triglycerides concentration significantly decreased (20 %, P = 0.032) as effect of feeding cow E diet compared with C diet. The plasma cholesterol concentration of cow fed E diet was insignificantly increase (+29 %, P = 0.283),

Table 2. Effect of feeding sorghum grain in dairy cows on plasma metabolic parameters

Plasma profile	Parameter	Limits*	C diet	E diet	SEM	*p-value*
Energy	Glucose, mg.dL^{-1}	40 – 100	42.03^b	54.58^a	3.21	0.009
	Triglycerides, mg.dL^{-1}	–	27.01^a	22.50^b	1.14	0.032
	Cholesterol, mg.dL^{-1}	62 – 193	88.61	113.88	15.51	0.283
Protein	Total protein, g.dL^{-1}	6.7 – 7.5	6.76^b	7.46^a	0.28	0.002
	Albumin, g.dL^{-1}	2.5 – 3.8	3.00^b	3.50^a	0.17	0.013
	Urea, mg.dL^{-1}	10 – 25	18.40	14.96	2.06	0.267
	Creatinine, mg.dL^{-1}	0.5 – 2.2	1.32	1.43	0.16	0.790
	Total bilirubin, mg.dL^{-1}	0 – 1.6	0.17	0.17	0.02	0.996
Mineral	Calcium, mg.dL^{-1}	8 – 11.4	8.37^b	10.14^a	0.53	0.022
	Phosphorus, mg.dL^{-1}	5.6 – 8.0	3.24	4.27	0.46	0.113
	Magnesium, mg.dL^{-1}	1.5 – 2.9	2.20^a	1.72^b	0.07	0.010
	Iron, µg.dL^{-1}	–	100.79	128.36	15.01	0.212
Enzyme	Alanine aminotransferase, U/L	6.9 – 35	33.35	35.96	6.01	0.235
	Aspartate aminotransferase, U/L	60 – 125	61.97	67.46	7.94	0.215
	Alkaline phosphatase, U/L	18 – 153	35.33	42.30	8.72	0.713
	Gamma-glutamyl transferase, U/L	6 – 17.4	15.93	17.24	2.70	0.218
	Lactate dehydrogenase, U/L	309 – 938	900.25	990.46	57.60	0.414
	Creatine kinase, U/L	0 – 350	168.80	173.04	12.16	0.143

C, control diet (barley grain); E, experimental diet (sorghum grain); Alanine aminotransferase, ALAT; Aspartate aminotransferase, ASAT; Alkaline phosphatase, AP; Gamma-glutamyl transferase, GGT; Lactate dehydrogenase, LDH; Creatine kinase, CK; *References of normal values (Merck Veterinary Manual 2010); **^{a,b} Different letters = significant differences between groups (P < 0.05).

but the value range in normal limits. Contrary to our results, Voicu *et al.* (2016) feeding fattening steers with two level of sorghum grains (15 % and, respectively 25 %) as substitute of barley, noticed no difference in the plasma triglycerides concentration while the level of plasma cholesterol significantly increased. Voicu *et al.* (2016) stated that this differences could be attributed to the structural particularity of the sorghum fat grains associated with the higher fat amount in the diet.

Plasma protein profile

The plasma protein profile provide valuable information on nutritional status and accurately reflect the protein consumption during a long period of time (Bhagavan and Chung-Eun Ha, 2015). From our knowledge little information's are available about the effects of dietary sorghum grain on plasma protein profile concentration of dairy cows (Baran *et al.* 2008; Bhagavan and Chung-Eun Ha, 2015; Nikkhah *et al.* 2004).

In our study, plasma protein profile of dairy cows fed with sorghum grain significantly increased (+10 %, P = 0.002) comparing to control diet, probably due to the increasing concentration of albumin fraction (+17 %, P = 0.013). However, the value for this two concentrations range in normal limits (Merck Veterinary Manual, 2010).

The other protein fractions (urea, creatinine and total bilirubin) were not affected (P > 0.05) by dietary treatment. In contrast to our results, Baran *et al.* (2008), by feeding 27 % grain sorghum in Holstein cattle did not found any significant differences in terms of serum total protein or albumin level. Nikkhah *et al.* (2004) observed an increased plasma urea concentration when fed cows with diets based on ground sorghum compared to cows fed other treatments.

Plasma mineral profile

Dietary replacement of barley grain with sorghum grain in dairy cows diet did not affect (P > 0.05) the plasma P and Fe concentrations. The calcium concentration increased (+21 %, P = 0.022), while the magnesium concentration decreased (-28 %, P = 0.010) in E diet compared to

C diet. Previous study of Emmanuel *et al.* (2007) have demonstrated that feeding cattle with diets rich in highly degradable carbohydrates results in a decreased plasma amount of Ca^{2+}, Fe^{2+}. Baran *et al.* (2008) stated that plasma mineral profile of beef cattle was not affected by feeding diets with 27 % sorghum grain inclusion.

Plasma enzymatic profile

In a normal physiological state, enzymes are involved in the process by which the body regulates its internal environment for chemical and biological processes. Thus, considerable variation in the enzyme parameters has been reported for bovine (Doornenbal *et al.*, 1988; Jenkins *et al.*, 1982; Peterson and Waldern, 1981) as effect of time, temperature or instability of the blood biochemical indicators.

The results of present study shown that the concentration of ALAT, ASAT, AP, GGT, LDH, and CK enzymes slightly increased as effect of fed sorghum grain, but the differences between treatments were not significant ($P > 0.05$). According to Bobe *et al.* (2004) the activities of enzymes are indicators of organ injury and can impact dairy cow's productivity. Similarly with our results, Voicu *et al.* (2016), reported that serum metabolites AP, GGT and CK were not affected by dietary inclusion of 15 % or 30 % sorghum grain in the fattening steer's diets. Nonetheless, plasma enzyme profile was within the normal physiological range for dairy cows (Merck Veterinary Manual, 2010).

CONCLUSION

Replacement of barley grain with sorghum grain in mid to late lactation dairy cow's diets had no adverse effect on animal's health state. Thus, 25 % of sorghum grain in the dairy cow's diet as alternative to energetically sources could be a good solution for farmers to feed the animals, especially in regions with limited irrigation water supplies.

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