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Influence of sorghum inclusion in fattening steers diets on health and fatty acids profile of *Longissimus dorsi* muscle

DORICA VOICU[1], I VOICU[2], ANDREEA VASILACHI[3], R A UTA[4], T MIHALCEA[5] and RODICA STEFANIA PELMUS[6]

National Research Development Institute for Animal Biology and Nutrition Balotesti, Ifov 077 015 IRomania

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ABSTRACT

The study was conducted using 21 Romanian Black Spotted fattening steers to determine the effects of sorghum grains on health and fatty acid profile of *Longissimus dorsi* muscle. The animals were assigned uniformly to 3 groups of 7 steers each, which received different treatments: control (C) received a compound feed without sorghum grains, experimental group (E1) received 15% sorghum grains in the compound feed, while next experimental group (E2) received 25% sorghum grains in the compound feed. To determine the biochemical parameters, blood samples were collected from animals at the end of experimental period. The laboratory analyses conducted on samples of *Longissimus dorsi* muscle collected from the 3 experimental groups, showed changes in the fatty acid composition. The proportion of saturated fatty acids (SFA) decreased in favour of the unsaturated fatty acids (UFA) with 1.04% in group E2, while the proportion of unsaturated fatty acids increased from 53.00% in the control group to 54.19% in group E2.

Key words: Biochemical parameters, Fatty acids, *Longissimus dorsi*, Sorghum grain, Steers

Factors, viz. feeding regimen, maintenance conditions, microclimate and prolonged stress may affect animals' health state and performance, causing economic losses. The analysis of variation in blood serum parameters can give clues on their influence (Voicu *et al.* 2014). Recent studies showed that many of the saturated and trans monounsaturated fatty acids should be consumed in limited amounts by human consumers. It was also observed that concentration of these fatty acids in the meat and meat products can be reduced by increasing dietary proportion of polyunsaturated fatty acids (PUFA) given to animals, with favourable influence on human health (Bauchart *et al.* 2010, Hãbeanu *et al.* 2011). The purpose of our investigation was to quantify effect of different levels of dietary sorghum grains in compound feeds for fattening steers on health state and fatty acid content of the *Longissimus dorsi* muscle.

MATERIALS AND METHODS

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

Present address: [1,2,6]Senior Researcher (dorica.voicu @yahoo.com, voicu.ilie@yahoo.com, pelmus_rodica_stefania @yahoo.com), [3]Junior Researcher (andryca82@yahoo.com), [4]Research Assistant (razvan_alex_18@yahoo.com), [5]Technical Director (teodor.mihalcea@ibna.ro).

Animals, housing and diets: The trial was conducted for 12 weeks, on 21 Romanian Black Spotted fattening steers with an initial average body weight of 256 kg, kept in collective stalls with slatted concrete flooring and central lane for feed administration. The animals were assigned to 3 homogeneous groups of 7 steers each, divided as follows: control (C) which received only corn, barley and wheat as energy sources and sunflower meal as protein source in the compound feed, with no dietary sorghum grains; experimental group (E1), received 15% sorghum grains in the compound feed with basal diet; experimental group (E2) received 25% sorghum grains in the compound feed with basal diet. Alfalfa haylage was the basic dietary ingredient for all groups. The diets were formulated according to Burlacu *et al.* (2002) and had the same nutritional characteristics (7.94 meat feed units, mFU/day and 676 g intestinally digestible protein, IDP/day). Feed intake and feed leftovers were recorded daily. All animals had *ad lib.* access to the feed and water (constant level drinkers).

Sample collection, analysis and statistics: Blood samples were collected at the end of the experimental period from the jugular vein of all animals and used for the biochemical determination of plasma parameters. The biochemical determinations were performed on a chemistry analyser. *Longissimus dorsi* muscle samples were collected from the slaughtered steers at the end of the experiment and analysed for gross chemical composition (ASRO 2014), fatty acid profile and cholesterol. The analytical methods rely on the determination of fatty acid and cholesterol by gas chromatography method (AOAC Official Method 99410: cholesterol in foods). All the results were processed statistically with the StatView software (version 5.0). One-way analysis of variance (ANOVA) was used to check the differences between the results obtained from the 3 groups of animals at the 0.05 level of significance. The results were expressed as means with standard deviation of the mean (SD). The values for fatty acid are expressed as % of total fatty acids ester methyl (FAME).

RESULTS AND DISCUSSION

Analysing the health state of animals (Table 1) indicated that all the values were within the normal physiological range for the particular species and category of farm animals (Merck Veterinary Manual 2010).

Plasma energy profile: Significant differences (P<0.05) in blood glucose level were noticed between groups C and E1. The concentration of plasma triglycerides did not differ between groups (P>0.05). The total cholesterol and the HDL (high density lipoproteins) showed significant differences both between groups C and E1, and between groups E1 and E2 respectively. These differences can be due to the structural particularities of the fat from the sorghum grains, associating the fact that a higher amount of dietary fat will produce a higher level of the serum cholesterol (Abrams 1980). The serum LDL (low density lipoproteins) showed significant differences (P<0.05), with higher values in groups C and E1 compared to group E2, probably due to the higher dietary proportion (25%) of ground sorghum grains included in the compound feed.

Plasma protein profile: The values of the total protein, albumin, total bilirubin, creatinine and urea were comparable with those reported by Kaneko *et al.* (2008). The differences for the concentrations of total protein and creatinine were not significant (P>0.05), while the differences for albumin concentration were statistically significant between groups C and E1, and between C and E2. The values of the urea concentration were significantly (P<0.05) different between groups C and E1, with higher values for group E1, and with even higher values in group E2 than in group C, knowing that the concentration of serum urea can be influenced, among other, by the diet formulation (Voicu *et al.* 2014). Urea values may indicate changes in protein digestion depending on groups (Castillo *et al.* 2011a).

Plasma mineral profile: The data for plasma phosphorus concentration were also within the normal physiological limits for this species, but it was slightly higher in the 2 experimental groups, probably due to the dietary ground sorghum grains, which are a rich source of minerals especially calcium and phosphorus. The statistical analysis of the data showed that the results obtained for calcium and iron were not significant (P>0.05) between the three groups of animals, while significant differences were noticed for the serum phosphorus concentration, with lower values in the control group compared to the experimental groups (E1 and E2). Statistically significant differences were also noticed for the serum magnesium between group C and E2 and were much lower than those obtained by Baran *et al.* (2008).

Plasma enzyme profile: The common traits of the enzyme parameters display a rather high variability because of the instability of the blood biochemical indicators, as shown

Table 1. Sorghum grain effects on animal health state. Biochemical determination of plasma parameters of the fattening steers[1]

Parameter	Control	Experimental 1	Experimental 2	P-value
Plasma energy profile				
Glycaemia (mg/dL)	69.94±12.71[b]	81.81±7.73[a]	78.23±8.99[ab]	0.0401
Triglycerides (mg/dL)	13.64±5.30[a]	15.93±2.99[a]	18.46±5.11[a]	0.1738
Cholesterol (mg/dL)	86.73±23.84[b]	115.96±22.91[a]	90.11±13.50[b]	0.0316
HDL (mg/dL)	46.57±16.55[b]	67.57±9.00[a]	52.29±6.60[b]	0.0089
LDL (mg/dL)	38.29±2.16[a]	38.53±1.90[a]	28.81±12.30[b]	0.0356
Plasma protein profile				
Total protein (g/dL)	6.76±1.57[a]	7.6±1.05[a]	7.26±0.53[a]	0.3940
Albumin (g/dL)	3.80±0.50[b]	4.26±0.20[a]	4.27±0.22[a]	0.0270
Total bilirubin (mg/dL)	0.35±0.12[ab]	0.49±0.19[a]	0.31±0.15[b]	0.0470
Creatinine (mg/dL)	1.01±0.35[a]	1.16±0.25[a]	1.16±0.15[a]	0.4498
Urea (mg/dL)	13.71±4.27[b]	19.43±2.94[a]	22.57±2.23[a]	0.0003
Plasma mineral profile				
Calcium (mg/dL)	9.72±3.45[a]	9.20±0.62[a]	9.93±1.58[a]	0.8219
Magnesium (mg/dL)	1.94±0.26[b]	2.18±0.38[ab]	3.39±1.86[a]	0.0245
Phosphorus (mg/dL)	6.47±1.54[b]	8.58±1.65[a]	8.27±0.75[a]	0.0210
Iron (μg/dL)	1489.53±170.89[a]	1317.67±677.51[a]	1586.16±109.99[a]	0.4750
Plasma enzyme profile				
Alkaline phosphatase (U/L)	67.94±28.90	97.74±34.58	97.49±36.93	0.1913
Gamma GT (U/L)	14.84±6.07	14.69±3.43	14.99±2.99	0.9918
Creatine kinase (U/L)	397.14±177.66	354.57±68.35	355.86±95.03	0.7649

[1]Mean values and standard deviation; different superscripts within the same row are different.

by Sogorescu *et al.* (2008). Nevertheless, the serum transaminases concentrations (alkaline phosphatase and Gamma GT), which are the most used enzymes for the diagnosis of cattle disorders as they are indicators of the hepatic function, displayed normal values (Table 1) for the category of animals used in the trial, the differences being statistically insignificant (P>0.05).

Our results were similar to findings of other researchers (Al-Suwaiegh *et al.* 2002, Baran *et al.* 2008, Castillo *et al.* 2011b). Khajehdizaj *et al.* (2014) reported that serum metabolites were not affected when using microwave irradiated sorghum grain in sheep.

Table 2. Chemical composition (g/kg muscle) and the cholesterol content of the *Longissimus dorsi* muscle

Group	DM	CP	EE	Ash	Cholesterol*
C	301	217	47	10	0.02662
E1	319	229	79	10	0.01911
E2	302	218	75	10	0.01679

DM – dry matter; CP – crude protein; EE - ether extract; * g/100 g fresh sample

Table 3. Concentration of the main fatty acids in *Longissimus dorsi* muscle (% of total FAME)

Fatty acid	Control	Experimental 1	Experimental 2
C14:0 (myristic acid)	2.72	3.73	3.26
C14:1 (myristoleic acid)	0.55	1.08	1.45
C15:0 (pentadecanoic acid)	0.39	0.54	0.48
C15:1 (pentadecenoic acid)	0.85	0.45	0.61
C16:0 (palmitic acid)	27.25	29.71	27.61
C16:1 (palmitoleic acid)	3.55	3.78	4.50
C17:0 (heptadecanoic acid)	0.79	0.89	0.54
C17:1 (heptadecenoic acid)	0.58	0.53	0.78
C18:0 (stearic acid)	14.96	17.07	12.54
C18:1 (oleic acid)	36.53	35.10	37.67
C18:2n6 (linoleic acid)	7.35	3.90	6.00
C18:3n6 (linolenic acid)	0.00	0.00	0.00
C18:3n3 (linolenic α acid)	1.09	0.74	0.92
CLA	0.25	0.28	0.33
C20:2n6 (eicosadienoic acid)	0.00	0.09	0.48
C20:3n6 (eicosatrienoic acid)	0.00	0.00	0.00
C20:3n3 (eicosatrienoic acid)	0.37	0.11	0.25
C20:4n6 (arachidonic acid)	1.88	0.57	1.20
Other acids	0.89	1.43	1.38
n–3	1.46	0.85	1.17
n–6	9.23	4.57	7.68
n–6/n–3	6.34	5.36	6.55
SFA	46.10	51.95	44.43
UFA	53.00	46.64	54.19
MUFA	42.06	40.93	45.01
PUFA	10.94	5.71	9.18
SFA/UFA	0.870	1.114	0.820
PUFA/MUFA	0.260	0.139	0.204

FAME, fatty acids ester methyl; n–3, omega 3; n–6, omega 6; SFA, saturated fatty acids; UFA, unsaturated fatty

Chemical composition and the cholesterol content of the Longissimus dorsi *muscle*: The diets had a higher influence (Table 2) on the crude fat between experimental groups compared to control, similar reports were shown by Rodriguez *et al.* (2004) *fide* Voicu *et al.* 2008). The cholesterol content in the *Longissimus dorsi* muscle of the steers from groups E1 and E2 was significantly (P<0.05) lower compared to group C, expressing a higher quality of the meat, as also observed by Roseli *et al.* (2007), Cynthia *et al.* (2010) when feeding cattle on pasture.

Fatty acids composition in Longissimus dorsi *muscle:* The overall analysis of the samples from the 3 groups of animals showed that saturated fatty acids (SFA) decreased in favour of unsaturated fatty acids (UFA) namely in the group treated with a higher amount of sorghum grains. The n–6:n–3 ratio was higher in group E2 than in group C, although proportion of unsaturated fatty acids was higher. Generally, high concentrations of stearic acids (Table 3, group E1), are not a major concern, because they do not support increase of plasma cholesterol concentration in humans (Baghurst 2004). The oleic acid forms bulk of unsaturated fatty acids, particularly in group E2, treated with 25% sorghum grains in compound feed. It is the most widespread fatty acid which is found in natural fats and it does not lack completely from any natural fat studied so far. The total amount and the proportion of the different fatty acids present in the meat of ruminants can be changed through feeding, the rumen bacteria playing a major role in these changes, in the transformation of the dietary lipids and synthesis of fatty acids (Sauvant 2001). The concentration of conjugated linoleic acid (CLA) was higher in the experimental groups compared to control. Our results are alike with those reported by others (Enser *et al.* 1999, Lorenz *et al.* 2002, Beaulien *et al.* 2002, Rule *et al.* 2002).

While external adipose tissue of ruminants is actually rich in saturated fatty acids, the intramuscular adipose tissue contains a significant proportion of PUFA (CIV 1996). The total concentration of polyunsaturated fatty acids (PUFA) was higher in E2 than in E1, as also observed by Yang *et al.* (2002) in steers fed cereals (mainly sorghum), but lower than that in group C. Taking into consideration the concentrations of individual monounsaturated fatty acids (MUFA), it was noticed that the highest value was recorded in E2, with an intermediary value in the control group and a lower value in E1. The literature showed that many of the dietary UFA are hydrogenated inside the rumen, yielding a lower proportion of intramuscular UFA than in the monogastric animals (Hocquette and Bauchart 1999, Geay Yves *et al.* 2001 (*fide* Voicu *et al.* 2008). Therefore, the fatty acids from the *Longissimus dorsi* muscle in the steers used in the experiment consisted of about 50% SFA and 50% UFA.

The use of different levels (15% and 25%) of dietary sorghum grains included into the compound feeds for fattening steers did not change the biochemical parameters given by the energy, protein, mineral and enzyme profiles of the plasma.

The laboratory analysis of levels of fatty acid from the samples of *Longissimus dorsi* muscle collected from the 3 groups of fattening steers, showed some changes in their structure. Thus, the proportion of saturated fatty acids (SFA) decreased in favour of the unsaturated fatty acids (UFA) only in group E2 (treated with 25% sorghum grains), confirming the hypothesis that the total amount and proportion of different fatty acids from the meat of ruminants can be manipulated through feeding.

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