# FAT SOURCES IN DIETS FOR FEEDLOT-FINISHED STEERS - CARCASS AND MEAT CHARACTERISTICS

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## ABSTRACT

The object of this study was to compare the effect of different sources of fat in the diet for feedlot steers on carcass and meat characteristics. Twenty steers were distributed into four treatments: BC – basic concentrate; IRB – basic concentrate + rice bran + rice oil; M3 - basic concentrate + 3% of fatty acids calcium salts; and M6 – basic concentrate + 6% of fatty acids calcium salts. Previously to slaughter, the animals were submitted to a 14-hour fasting and were weighted to obtain slaughter weight. A slaughter was carried out in a commercial slaughterhouse and followed normal slaughter flow. The complete randomized block experimental design was used, with four treatments and five replications, being the animals' genetic group the blocking criteria. The highest fat accumulation was found in carcasses of animals from M6 treatments (5.21mm). Animals that consumed 6% of fatty acid calcium salts showed carcass with higher edible portion (6.31 vs. average of 5.7, respectively, for M6 and others treatments). The inclusion of fatty acids calcium salts in the diet improved carcass finishing and increased carcass total fat content. The inclusion of rice bran and oil or fatty acid calcium salts did not change animal's meat characteristics.

KEYWORDS**:** fatty acids calcium salts; fat thickness; rice oil; whole rice bran subcutaneous.

# FONTES DE GORDURA NA DIETA DE NOVILHOS TERMINADOS EM CONFINAMENTO – CARACTERÍSTICAS DA CARCAÇA E DA CARNE

## RESUMO

O objetivo deste trabalho foi comparar o efeito de diferentes fontes de gordura na dieta de novilhos confinados nas características de carcaça e carne. Vinte novilhos foram distribuídos em quatro tratamentos: BC – concentrado base; IRB – concentrado base + farelo de arroz integral + óleo de arroz; M3 – concentrado base + 3% de sais de cálcio de ácidos graxos; e M6 – concentrado base + 6% de sais de cálcio de ácidos graxos. Previamente ao abate, os animais foram submetidos a jejum de 14 horas e pesados para obtenção do peso de fazenda. Os animais foram abatidos em frigorífico comercial, seguindo o fluxo normal do abatedouro. O delineamento experimental utilizado foi o de blocos ao acaso, com quatro tratamentos e cinco repetições, sendo o critério de bloqueio o grupo genético. As carcaças de animais do tratamento M6 apresentaram a maior espessura de gordura subcutânea (5,21 mm). Animais que consumiram 6% de sais de cálcio de ácidos graxos apresentaram carcaças com maior porção comestível (6,31 contra média de 5,7, respectivamente para M6 e demais tratamentos). A inclusão de ácidos graxos na dieta melhorou o acabamento das carcaças e aumentou o conteúdo total de gordura. A inclusão de farelo de arroz integral e óleo ou sais de cálcio de ácidos graxos não alterou as características da carne dos animais.

PALAVRAS-CHAVE**:** espessura de gordura subcutânea; farelo de arroz integral; óleo de arroz; sais de cálcio de ácidos graxos.

## INTRODUCTION

In the latest years, consumer´s demands for healthy products as well as the quality concept, including animal welfare, traceability and health safety. These demands have affected food industry that tries to attend consumer´s requirements (SCOLLAN et al., 2006). This new concept affects directly the primary production sector, including beef cattle production. In order to attend meatpacking industry requirements for higher carcass and meat quality, as well as animal health, Brazilian producers have look for management and nutritional techniques to increase animal production and improve carcass and meat quality.

Several studies have been conducted searching for information about genetic and nutritional influences on carcasses and meat quality (RESTLE et al., 1999; JAEGER et al., 2004; AFERRI et al., 2005; MENEZES et al., 2005a; MENEZES et al., 2005b; BRONDANI et al., 2006). In order to guarantee bovine nutrition, the producers may use a range of alternative food, such as protein, energy or mineral supplementations. However, literature restricts the use of free fat in the rumen environment to a level of 7%, because of interference on rumen metabolism (VAN SOEST, 1994; KOZLOSKI, 2002). JAEGER et al. (2004) remark that, in spite of that, a growing interest at using fat supplementation as energy source in ruminant´s diet, stimulating the research on many varieties of fat sources.

Therewith, unsaturated fatty acid calcium salts (protected fat) were developed, in order to increase energy density of the diet for bovines without changing rumen environment, keeping it inert to fat interaction with microbial growing and fiber fermentation. According to JAEGER et al. (2004), nowadays, the use of protected fat is indicated as a potential and viable alternative of food for finishing cattle. Nevertheless, few studies were made on the effect of protected, searching for information about protected fat supplementation on carcass and meat characteristics. Therefore, the purpose of this study was to compare the effect of different diet fat sources on carcass and meat characteristics of feedlot finished beef cattle.

## MATERIAL AND METHODS

The experiment was conducted at “Laboratório de Bovinocultura de Corte” of Animal Science Department of “Universidade Federal de Santa Maria” (UFSM), from July to December of 2007. Twenty castrated steers were taken from the experimental herd of UFSM. The animals were born at the same calving season and kept under the same food conditions until finishing period.

At the beginning of the finishing period, the steers presented average age of 20 months and average live weight of 260 kg. The feedlot finishing period lasted 126 days. Steers were distributed into four treatments: BC – basic concentrate; IRB – basic concentrate + whole rice bran and rice oil; M3 – basic concentrate + 3% of fatty acid calcium salts (Megalac-E®), on dry matter (DM) basis of total offered diet; M6 – basic concentrate + 6% of fatty acid calcium salts (Megalac-E®), on DM basis of total offered diet. Each treatment was composed of five animals, belonging to the following genetic groups: one Charolais (Ch), one Nellore (Ne), two 11/16 Ch 5/16 Ne and one 21/32 Ne 11/32 Ch.

The animals were individually allocated in 12 $m^2$ covered stalls, with paved floor. The feeders were of wood and drinkers had float controlled valve to level the water. The animals were adapted to feed management and installations per a period of 21 days. At the beginning of the adaptation period, the animals received a subcutaneous shot of a commercial product of albendazole sulfoxide, according to the manufacturer’s recommendation to control external and internal parasites.

The roughage offered to the animals was consisted of corn silage, and the basic concentrate was constituted by ground corn grain, wheat bran, soybean meal, urea, sodium chloride and limestone. The roughage:concentrate ratio was 66:34. The animals were fed twice a day, being the diet divided into two meals, in morning (08:30 am) and in afternoon (2:00 pm). The diet was calculated according to NRC (2000) to attend the animal’s nutritional requirements, aiming at an average daily weight gain of 1.2 kg/animal, estimating a dry matter (DM) intake of 2.5 kg of DM/100 kg of live weight. All diets had crude protein average of 13%. The IRB and M3 diets presented the same amount of ether extract (average of 4.75%), while M6 diet presented average of 7.30% (Table 1).

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Table 1 – Participation of ingredients and diets chemical composition

| Ingredients | Treatments | | | |
|---|---|---|---|---|
| | BC | IRB | M3 | M6 |
| Corn silage, % | 60 | 60 | 60 | 60 |
| Wheat bran, % | 20.6 | 10.6 | 25.3 | 20.7 |
| Ground corn grain, % | 11.2 | 8 | 3.6 | 3.2 |
| Soybean meal, % | 6 | 6 | 5.6 | 7.6 |
| Whole rice bran, % | - | 12 | - | - |
| Rice oil, % | - | 1.2 | - | - |
| Megalac-E®, % | - | - | 3.2 | 6.3 |
| Limestone, % | 1.2 | 1.2 | 1.2 | 1.2 |
| Urea, % | 0.5 | 0.5 | 0.6 | 0.5 |
| Sodium chloride, % | 0.5 | 0.5 | 0.5 | 0.5 |
| | Chemical Composition | | | |
| Dry matter (%) | 58.11 | 58.65 | 58.17 | 58.52 |
| Crude protein (%) | 13.52 | 13.06 | 13.77 | 13.54 |
| Ether extract (%) | 2.18 | 4.72 | 4.78 | 7.30 |
| Neutral detergent fiber (%) | 46.16 | 45.40 | 46.81 | 45.55 |
| Acid detergent fiber (%) | 23.75 | 23.95 | 24.26 | 23.89 |
| Lignin (%) | 2.91 | 3.16 | 3.11 | 2.96 |
| Total digestible nutrients (%) | 66.91 | 68.74 | 68.41 | 71.37 |
| Digestible energy (Mcal/kg) | 2.94 | 3.02 | 3.01 | 3.14 |

BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

Previously to slaughter, the animals were submitted to a 14-hour fasting period and were weighted to obtain slaughter weight. The slaughter was in a commercial slaughterhouse and followed normal slaughter flow. At the end of slaughter line, carcasses were halved to obtain right and left half carcasses. The carcasses were weighted to obtain hot carcass weight. After 24 hours of cooling (2ºC), carcasses were weighted to obtain cold carcass weight. Chilling loss and hot and cold carcass dressing percentages were calculated. The carcasses were also evaluated for conformation and physiologic maturity, according to MULLER´s (1987) methodology.

The left half carcass was divided into the commercial cuts: saw cut, forequarter and sidecut, which were weighted. After calculation, commercial cut percentages were determined. At right half carcass, measurements were done to obtain: carcass length (anterior edge of pubis to anterior medial edge of the first rib); leg length (distance from anterior edge of pubis and tibial-tarsal articulation); shank thickness (between lateral and medial faces of superior portion of the shank, with a compass), arm perimeter (arm medial portion perimeter) and arm length (from radio-carpal articulation to olecranon extremity).

After these measurements, a cut between the 10th and 12th ribs exposed *Longissimus dorsi* muscle. The fat which covered this muscle was evaluated, as well as color, texture, marbling and muscle area. The subcutaneous fat thickness was obtained by the arithmetic average of three points around the muscle (MULLER, 1987). Color, texture and marbling were obtained subjectively by MULLER´s (1987) methodology, with a scale ranging from 1 to 5 to color and texture and from 1 to 18 for marbling (color=1: dark; 3: slightly dark red and 5: red; texture=1: very thick; 3: slightly thick and 5: very fine; marbling=1: trace minus; 5: light; 8: small; 11: medium; 14: moderate; 17: abundant). Muscle area was obtained by outlining *Longissimus dorsi* contour in a parchment, being later measured with a table scanner.

A section between 10th and 12th ribs was physically separated to obtain weight and percentages of muscle, fat and bones in carcass. After physical separation, the samples of *Longissimus dorsi* muscle were vacuum-packed, identified and frozen to later evaluations of the meat.

Meat evaluations were done at Meat Laboratory of UFSM, by a trained team. Two 2.5-cm-thick steaks were extracted (steaks A and B). The frozen steak A was weighed on a precision balance to obtain frozen weight. After thawing at a temperature between 4 and 10ºC, the steak was weighed to obtain thawing loss. After cooking, the steak was weighed to obtain cooking loss. Three muscle samples were extracted from steak B, which was cooked under the same conditions of steak A and, after that, evaluated by a trained team to obtain, subjectively, meat tenderness, palatability and juiciness by chewing.

A complete randomized block experimental design was used, with four treatments and five replications, being the animals' genetic group the blocking criteria. The data were analyzed by the F variance test and the averages were compared by t test, using SAS (2001), with the following mathematical model:

$Y_{ij} = \mu + \beta_i + \tau_j + \varepsilon_{ij}$ ,

where: $Y_{ij}$ = depedent variables; $\mu$ = observation average; $\beta_i$ = i-th block effect; $\tau_j$ = j-th treatment effect; $\varepsilon_{ij}$ = residual error.

Contrast studies between diets and a correlation between carcass and meat characteristic were also calculated by SAS (2001).

## RESULTS AND DISCUSSION

No statistical difference was observed for carcass weight and dressing percentage (Table 2), showing that fatty acid calcium salts can be used as an energy source in bovine's diet. Similar results were observed by JAEGER et al. (2004) and JORGE et al. (2009), who did not verify any difference between carcass characteristics of steers receiving or not protected fat in the diet. According to MENEZES et al. (2005a), gradually, the commercialization of bovines will be made only in carcass weight basis, mainly hot carcass weight, indicating that animals with higher carcass dressing percentage will increase beef cattle profitability.

The level of carcass finishing is expressed by subcutaneous fat thickness and is extremely important to assure carcass quality as to determinate the costs of bovine finishing. According to LUCHIARI FILHO (2000), the excessive fat cover causes increase of labor force to remove it, decreasing system profitability. Several authors (MULLER, 1987; PEROBELLI et al., 1995; RESTLE et al., 1999; LUCHIARI FILHO, 2000; MENEZES et al., 2005a) reported problems caused by scarce subcutaneous fat thickness to carcass quality (muscle fibers darkened by cold, cold shortening and loss of carcass liquids), which can result in decrease of carcass dressing percentage. Thus, MENEZES et al. (2005a) remarked that subcutaneous fat thickness required by slaughterhouses ranges between 3 and 6 mm.

Table 2- Means, coefficient of variation (CV) and probabilities (Prob.) of slaughter weight, hot and cold carcass weight, hot and cold carcass dressing percentage, chilling loss and subcutaneous fat thickness of feedlot steers, receiving different sources of fat in the diet

| Characteristics | Treatments | | | | CV | Prob. |
|---|---|---|---|---|---|---|
| | BC | IRB | M3 | M6 | | |
| Slaughter weight, kg | 411.3 | 411.9 | 430.7 | 429.5 | 7.08 | .6062 |
| Hot carcass weight, kg | 243.1 | 239.7 | 2560 | 252.9 | 6.71 | .3937 |
| Cold carcass weight, kg | 234.7 | 231.2 | 245.2 | 243.9 | 6.77 | .4694 |
| Hot carcass dressing percentage, % | 59.2 | 58.2 | 59.3 | 58.8 | 2.22 | .5258 |
| Cold carcass dressing percentage, % | 57.1 | 56.1 | 56.8 | 56.7 | 2.23 | .6646 |
| Chilling loss, % | 3.62 | 3.66 | 4.46 | 3.72 | 26.76 | .5384 |
| Subcutaneous fat thickness, mm | 3.11b | 3.61b | 3.81b | 5.21a | 22.81 | .0155 |
| Subcutaneous fat thickness, % | 1.32b | 1.58b | 1.56b | 2.10a | 23.41 | .0400 |

BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

ALVES FILHO (2007), reviewing the influence of including fat in the diet of finishing bovines, concluded that fat, in the rumen environment, can cause suppression of methanogenic and cellulolytic bacterias, decreasing rumen pH. According to KOZLOSKI (2002), these changes can decrease acetic acid production and increase propionic acid production, reducing fat accumulation. Probably, this fact occurred in this present study. Animals that did not receive fat in the diet accumulated the same quantity of subcutaneous fat than the ones that consumed whole rice bran and oil (average of 9.81 kg/day; METZ, 2009), showing that fat deposition of the latest was less efficient. However, when 6% fatty acid calcium salts were added to the diet, an increase (5.21 mm; Table 2) on subcutaneous fat thickness was observed in relation to the other treatments, indicating that a higher level of fatty acid calcium salts inclusion can increase subcutaneous fat thickness due to increase of the energetic contribution at duodenum level. The same behavior was observed when this characteristic was expressed in relation to 100 kg of cold carcass (Table 2).

Normally, rumen pH values tend to remain within neutrality, allowing a dynamic digestive process, ensuring the volatile fatty acid production as microbial protein (VAN SOEST, 1994). Fatty acids calcium salts have the property to dissociate at acid abomasum conditions of the ruminants (NGIDI et al., 1990), where pH reaches values lower than 5 (SUKHIJA & PALMQUIST, 1990), separating little at rumen environment. Thus, lipid content of these salts is not affected by bacterial action, remaining with its lipid composition quite similar to the ingested product with little modification by rumen biohydrogenation. When the salts are in contact with the acid content of abomasums, they become free, assuring higher energetic contribution to the first portions of small intestine.

Lipids from the calcium salts, when dissociated, reach duodenum as fatty acids and could also reach as triglycerides. The pancreatic lipase has the function of hydrolyzing esters, releasing fatty acid and monoacilglycerides, which can be totally absorbed at jejunum, but also at duodenum and ileum (NÖRNBERG, 2003). By reaching the small intestine, they interact with bile salts and pancreatic content forming micelles, thus being absorbed by enterocytes and then re-esterified and transported by VLDL (very low lipid density) and chylomicrons via the lymphatic system (NÖRNBERG, 2003). According to KOZLOSKI (2002), with the fatty acid flow over small intestine, the increase of pH and of detergent action of bile salts and phospholipids determine the passage of these fatty acids from particulate to micelle phase, allowing the absorption of them by passive diffusion. The lipoproteins are captured by target tissues, such as the adipocytes of adipose tissue, and re-esterified to be stored as triglycerides (LEHNINGER, 2005).

The animals presented 11.4 points of conformation, classified as good (Table 3). According to ALVES FILHO (2007), slaughterhouses are interested in carcass with conformation around 13 points (very good conformation). The conformation became an important characteristic to analyze carcass quality because it is connected to higher muscle:bone proportion and primal cuts (LUCHIARI FILHO, 2000). This fact can be observed in a study conducted by MENEZES et al. (2005a), who found a positive correlation between carcass conformation and muscle percentage ($P<.05$; $r=.36$); however this fact was not observed in this study, being the correlation between conformation and muscle percentage not significant ($P>.05$; Table 7).

Table 3 - Average, coefficient of variation (CV) and probability (Prob.) of conformation, physiologic maturity, *Longissimus dorsi* area, carcass, arm and leg length, shank thickness and arm perimeter of feedlot steers, receiving fat from different sources in diet

| Characteristic | Treatments | | | | CV | Prob. |
|---|---|---|---|---|---|---|
| | BC | IRB | M3 | M6 | | |
| Conformation, points* | 11.8 | 10.8 | 11.6 | 10.8 | 12.87 | .6043 |
| Physiologic maturity, points* | 13.6 | 14.0 | 14.0 | 14.0 | 1.89 | .0759 |
| *Longissimus dorsi* area, $cm^2$ | 63.15 | 61.75 | 67.54 | 65.45 | 10.84 | .5954 |
| *Longissimus dorsi* area, % of LW | 27.29 | 26.83 | 27.61 | 26.97 | 10.80 | .9750 |
| Carcass length, cm | 125.9 | 126.3 | 126.5 | 125.1 | 2.50 | .8993 |
| Leg length, cm | 68.9 | 72.3 | 70.3 | 70.3 | 4.58 | .4456 |
| Arm length, cm | 44.1 | 43.7 | 44.3 | 42.7 | 4.76 | .6337 |
| Shank thickness, cm | 31.0 | 30.8 | 30.0 | 29.4 | 12.46 | .9001 |
| Arm perimeter, cm | 39.7 | 39.3 | 40.1 | 38.3 | 6.50 | .7189 |

* Values varying between 1 and 18, being 10: good minus; 11: good; 12: good plus; 13: very good minus.
** Values varying between 1 and 15, being 1-3: more than 8 years; 4-6: between 5.5 e 8 years;7-9: between 4 and 5.5 years; 10-12: between 2.5 and 4 years; 13-14: lower than 2.5 years.
BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

The physiologic maturity, according to MULLER (1987) and LUCHIARI FILHO (2000), can be verified by animal's dentition and the ossification of thoracic and lumbar spinous process and between sacral vertebras. MULLER (1987) highlights that this measure has correlation to chronologic age and, if another factors remain constant, young animals present higher meat quality. In the present study, the animals presented average of 13.9 points for this characteristic (Table 3), confirming the role of chronologic age because the animals were younger than 2.5 years old (MULLER, 1987).

Although the *Longissimus dorsi* area is not the only characteristic that presents correlation to carcass muscle proportion; when associated to another parameters, it can help to evaluate boneless cuts yields (MULLER, 1987). In the present study, the characteristics related to carcass muscle, as conformation, shank thickness and arm perimeter (Table 3), as well as carcass muscle quantity (Table 5), were not influenced by the inclusion of different fat sources in the diet, observing the same fact to *Longissimus dorsi* area (average of 64.57 $cm^2$). In the study made by JORGE et al. (2009), *Longissimus dorsi* area was similar for carcasses of animals that received or not fatty acid calcium salts; these authors did not observe differences in carcass cuts yields either.

The addition of different sources of fat in the diet did not alter carcass metric characteristics of feedlot steers. Contrast analysis between animals that received different fat sources in the diet, in other words, the ones that consumed whole rice bran and oil versus animals that consumed fatty acid calcium salts, did not show any differences regarding the characteristics presented in Table 3. The measurements of length, shank thickness and arm perimeter, besides being objective, are important because they present medium to high positive correlation to other characteristics (ALVES FILHO, 2007), relating carcass length with slaughter weight (r = .76; MENEZES et al., 2005a) and carcass weight (r = .68; r = .69; MENEZES et al., 2005a and PACHECO et al., 2005, respectively). In the present study, it is noticeable that these characteristics are also positively correlated, observing that not only slaughter weight is correlated to carcass length, but also hot and cold carcass weight (r = .84; r= .81 and r = .80, respectively; P<.05; Table 7).

As for the commercial cuts (Table 4), no difference was observed when this characteristic was analyzed in absolute (kg) or relative (%) values. According to MENEZES et al. (2005a), carcasses that present higher absolute weight tend to present higher absolute values for commercial cuts, which was not observed in this study because slaughter weight was similar (P>.05) for all treatments.

Table 4 - Average, coefficient of variation (CV) and probabilities (Prob.) for saw cut, forequarter and sidecut, in kg and percentage, of feedlot steers, receiving fat from different sources in diet

| Characteristics | Treatments | | | | CV | Prob. |
|---|---|---|---|---|---|---|
| | BC | IRB | M3 | M6 | | |
| Saw cut, kg | 122.8 | 119.9 | 127.4 | 127.6 | 6.85 | .4935 |
| Forequarter, kg | 88.6 | 87.1 | 90.9 | 91.2 | 6.80 | .6863 |
| Sidecut, kg | 27.2 | 27.6 | 28.8 | 28.9 | 10.66 | .7392 |
| Saw cut percentage, % | 52.3 | 51.9 | 51.9 | 52.0 | 1.93 | .8863 |
| Forequarter percentage, % | 37.7 | 37.7 | 37.2 | 37.4 | 1.92 | .6167 |
| Sidecut percentage, % | 11.6 | 11.9 | 11.7 | 11.9 | 6.40 | .8894 |

BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

As for sidecut, VAZ & RESTLE (2001) consider that fat deposition in this body portion tend to increase with the weight of this cut, generating a positive correlation between subcutaneous fat thickness and weight/percentage of sidecut. Even presenting higher value (mm and percentage) of subcutaneous fat thickness, the animals that received 6% fatty acid calcium salts did not present superiority for sidecut (28 kg) in relation to the other treatments (27.2; 27.6 and

28.8, respectively for BC, IRB and M3).

Regarding data of carcass quality (quantity and percentage of muscle, fat and bone) (Table 5), the source of fat used in diet of feedlot steers influenced these characteristics. The carcasses with higher subcutaneous fat thickness presented higher total fat content (Table 2). The total fat content of the carcass, in kg or percentage, was higher for the animals that consumed 6% fatty acid calcium salts (68.3 kg and 27.9%), because of the higher energy content of this diet. Thus, animals from this treatment presented lower values for bone and muscle percentages (13.8 and 58.8%, respectively), although the absolute values of these tissues were not altered (P>.05). In several works compiled by ALVES FILHO (2007), the carcasses of steers generally obtain percentage nearly to 60% for muscle, oscillating from 15 to 26% for bone, and 15 to 24% for fat. Based in these studies, it was noticed that animals consuming basic concentrate, whole rice bran and oil or 3% of fatty acid calcium salts presented values for these characteristics similar to the literature; however, animals that consumed 6% of fatty acid calcium salts presented higher values for fat percentage.

Table 5 – Average, coefficient of variation (CV) and probabilities (Prob.) for carcass quantity and percentage of muscle, fat and bone, and the relations between muscle and bone, muscle and fat and edible portion (muscle + fat) and bone of feedlot steers, receiving fat from different sources in the diet

| Characteristic | Treatments | | | | CV | Prob. |
|---|---|---|---|---|---|---|
| | BC | IRB | M3 | M6 | | |
| Muscle, kg | 149.0 | 147.6 | 153.1 | 143.1 | 8.89 | 0.7034 |
| Muscle, % | 63.5a | 63.9a | 62.3a | 58.8b | 3.66 | 0.0145 |
| Fat, kg | 51.5bc | 48.5c | 57.3b | 68.3a | 9.84 | 0.0004 |
| Fat, % | 21.8b | 20.9b | 23.3b | 27.9a | 10.39 | 0.0027 |
| Bone, kg | 34.9 | 35.6 | 35.8 | 33.5 | 8.69 | 0.6465 |
| Bone, % | 14.9a | 15.4a | 14.7a | 13.8b | 5.19 | 0.0316 |
| Muscle:bone relation | 4.26 | 4.15 | 4.26 | 4.28 | 6.53 | 0.8678 |
| Muscle:fat relation | 2.97a | 3.11a | 2.74a | 2.14b | 14.98 | 0.0134 |
| Edible portion:bone relation | 5.73b | 5.51b | 5.85b | 6.31a | 6.36 | 0.0301 |

BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

Analyzing absolute values, the carcasses of the animals that consumed whole rice bran and oil showed lower values for fat quantity (48.5 kg). This data can be explained by higher presence of lipid in the rumen environment which modifies acetate:proprionate relation, mainly by decrease of rumen pH. According to KOZLOSKI (2002), the acetate is responsible for direct fat tissue deposition in ruminants, while propionate, generated in the rumen environment, initially has to be converted into glucose by the liver and then deposited as fat in adipose tissue, decreasing the efficiency of fat deposition. The use of whole rice bran and oil in ruminant rations provides, to rumen environment, bigger free fat quantity, which is capable of involving the fiber, decreasing its degradation and, consequently, installing the situation described above.

As a consequence of carcass composition alteration, the relations between muscle and fat and edible portion (muscle + fat) and bone were also modified. Carcasses from animals that consumed 6% fatty acid calcium salts presented lower muscle:fat relation (2.14) when compared to the other animals' carcasses. On the other hand, this same treatment provided carcasses with higher edible:bone relation (6.31). For slaughterhouses, carcasses with higher edible portion are preferred because they maximize labor force, providing higher cut yields.

Meat quality was not modified by diet fat sources (Table 6). Meat quality objective and subjective evaluations aim to give scores indicating which meat would have greater acceptation by consumers. Characteristics as color did not affect meat organoleptic value, but it is important for commercialization, considering that abnormal meat color could be rejected by consumers (MULLER, 1987). Evaluations as texture, tenderness, marbling and juiciness can interfere in organoleptic characteristics, increasing or decreasing meat flavor.

According to MULLER (1987), adipose tissue deposition between muscle fibers contributes positively to meat palatability (r =.47; P<.05; COSTA et al., 2002) and tenderness (r = .50; P<.05; KUSS et al., 2005). DI MARCO (1998) comments that marbling shows later deposition and with the increase of animal's fat level (subcutaneous fat), marbling increases proportionally. In the present study, the steers that received 6% fatty acid calcium salts presented higher subcutaneous fat thickness (5.21 mm, Table 2); however, this higher value did not increase marbling (9.04 points) in relation to other treatments (8.64; 7.04 and 9.04 points, respectively for BC, IRB and M3), as well as no significant correlation was observed between marbling and fat thickness, tenderness, palatability and juiciness (P>.05; Table 7).

Table 6 – Averages, coefficient of variation (CV) and probabilities (Prob.) of meat color, texture, marbling, palatability, shear force and thawing and cooking losses, of feedlot-finished steers, receiving different sources of fat in the diet

| Characteristics | Treatments | | | | CV | Prob. |
|---|---|---|---|---|---|---|
| | BC | IRB | M3 | M6 | | |
| Color, points* | 3.21 | 3.21 | 3.21 | 3.01 | 15.81 | .8935 |
| Texture, points* | 3.97 | 3.77 | 3.97 | 3.77 | 20.49 | .9560 |
| Marbling, points** | 8.64 | 7.04 | 9.04 | 9.04 | 18.94 | .1984 |
| Marbling, % of LW | 3.74 | 3.07 | 3.73 | 3.77 | 16.28 | .2043 |
| Tenderness, points*** | 6.29 | 6.47 | 6.79 | 6.29 | 14.25 | .8138 |
| Palatability, points*** | 4.80 | 5.37 | 5.50 | 5.62 | 11.76 | .2244 |
| Juiciness, points*** | 4.07 | 4.62 | 4.89 | 5.02 | 17.92 | .3277 |
| Shear force, kgf/cm$^3$ | 3.55 | 3.79 | 3.66 | 3.70 | 21.38 | .9693 |
| Thawing loss, % | 10.67 | 11.55 | 12.04 | 12.52 | 15.37 | .4418 |
| Cooking loss, % | 26.89 | 22.63 | 26.09 | 24.26 | 16.24 | .3770 |

*Variation from 1 to 5, being 1 – dark; very gross; 3-slightly dark red; slightly gross; 5-red; very thin. **Variation from 1 to 18, being 1-trace minus; 5-light; 8-small; 11-medium; 14-moderate; 17-abundant; ***Variation from 1 to 9, being 1-hard, unpalatable and not juicy and 9-very tender, very palatable and very juicy.
BC: basic concentrate; IRB: basic concentrate + whole rice bran + rice oil; M3: basic concentrate +3% of fatty acid calcium salts (Megalac-E®); M6: basic concentrate + 6% of fatty acid calcium salts (Megalac-E®).

LAWRIE (1967) highlights that among the advantages of cooling meat in low temperatures is the fact that meat remains stored for a long time; besides, it prevents chemical and microbiological modifications. However, this author remarks as a disadvantage the exudates produced during thawing, losing components as proteins, peptides, amino acids, lactic acid, purines, B-group vitamins and minerals. Among the most important factors that determine the quantity of exudates formed during thawing process are the nature freezing process and muscle protein capacity to retain water. The increase of pH and the quantity of lipid muscle content favor the capacity of the muscle protein to retain water; therefore, the data observed in the present study for thawing loss can be associated to LAWRIE (1967) observation, because steers showed similar averages for marbling and thawing loss.

The cooking loss was similar between treatments, presenting average values of 24.97 (P>.05). The liquid losses during cooking occur by meat retraction during this process, mainly when meat is submitted to high temperatures, denaturing proteins and decreasing considerably water retention capacity (LAWRIE, 1967). In addition, this author also comments that meat with higher intramuscular fat content tend to lose greater content with cooking process because of the solubilization of fatty acids and lower water content. Thus, similar values for marbling can also contribute to any difference between studied treatments.

Table 7 –Pearson correlation coefficient between carcass and meat characteristic of feedlot steers, receiving different sources of fat in the diet

| Variable | HCW | CCW | CLEN | LLEN | CONF | SFT | MARB | %MUS | %FAT | %BONE | RM:F | TEND | PAL | JUI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLW | 0.98* | 0.98* | 0.84* | 0.40 | 0.39 | 0.43 | 0.23 | 0.02 | 0.14 | -0.47* | -0.09 | 0.27 | 0.25 | 0.11 |
| HCW | | 1.00* | 0.81* | 0.43 | 0.43 | 0.44* | 0.20 | -0.01 | 0.16 | -0.46* | -0.11 | 0.30 | 0.28 | 0.12 |
| CCW | | | 0.80* | 0.46* | 0.43 | 0.46* | 0.17 | -0.02 | 0.18 | -0.47* | -0.13 | 0.29 | 0.25 | 0.09 |
| CCLEN | | | | 0.28 | 0.57* | 0.12 | 0.26 | 0.24 | -0.13 | -0.25 | 0.18 | 0.29 | 0.28 | 0.17 |
| LLEN | | | | | -0.07 | 0.37 | -0.10 | -0.39 | 0.31 | 0.09 | -0.36 | 0.04 | 0.09 | 0.004 |
| CONF | | | | | | 0.12 | -0.03 | 0.21 | -0.10 | -0.26 | 0.16 | 0.39 | 0.19 | -0.01 |
| SFT | | | | | | | -0.18 | -0.62* | 0.78* | -0.69* | -0.71* | -0.03 | 0.15 | -0.08 |
| MARB | | | | | | | | -0.03 | 0.08 | -0.16 | -0.10 | 0.19 | 0.33 | 0.20 |
| %MUS | | | | | | | | | -0.94* | -0.16 | 0.96* | 0.10 | -0.09 | -0.29 |
| %FAT | | | | | | | | | | -0.50* | -0.98* | -0.005 | 0.20 | 0.31 |
| %BONE | | | | | | | | | | | 0.42 | -0.24 | -0.34 | -0.16 |
| RM:F | | | | | | | | | | | | -0.005 | -0.15 | -0.28 |
| TEND | | | | | | | | | | | | | 0.54* | 0.51* |
| PAL | | | | | | | | | | | | | | 0.81* |

*P<0,05.
SLW=slaughter weight; HCW=hot carcass weight; CCW=cold carcass weight; CLEN=carcass length; LLEN=leg length; CONF=conformation; SFT=subcutaneous fat thickness; MARB=marbling; %MUS=muscle percentage; %FAT=fat percentage; %BONE=bone percentage; RM:F=relation of muscle and fat; TEND=tenderness; PAL=palatability; JUI=juiciness.

## CONCLUSIONS

The inclusion of 6% of fatty acid calcium salts in the diets of steers gives to carcasses higher finishing degree and higher total fat content, increasing the edible:bone relation. The inclusion of whole rice bran and oil or fatty acid calcium salts in the diet of steers does not change meat quality.

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