EFFECT OF DIETARY ALLOSTATIC MODULATOR (ATPQM®) ON CARCASS AND BEEF MEAT QUALITY

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Abstract – In order to elucidate the influence of dietary allostatic modulator (ATPQM®) on carcass and meat quality, cattle were administered the supplement in a feed lot, *ad libitum*, for 30 days before slaughter during three seasons (winter, summer, fall). Animal welfare parameters during transport to the slaughterhouse and welfare practices during the slaughtering process (unloading, stunning, and bleeding) were monitored. Blood samples were collected upon exsanguination to test for glucose, creatine kinase and lactate dehydrogenase (LDH). Carcass traits such as pH, temperature (at 45 min and 24 h) and color, including morphometric characteristics, were evaluated. Meat (M. *L. thoracis*) parameters were analyzed (pH, color, texture, collagen, water holding capacity, cooking loss weight and myofibril fragmentation index). The results indicated that animal welfare was improperly handled during all stages of meat production (farm to slaughter); seasonality did not affect the analyzed morphometric characteristics of the carcass (P>0.05); and, with the used dosage method, dietary supplementation of allostatic modulator was effective against texture, myofibril fragmentation and a* value (mainly in summer and fall) compared with the controls (P<0.05). Therefore, the results showed that the dietary supplementation of an allostatic modulator in cattle during their last stage at the feed lot improved the carcass and beef meat quality.

Key Words – Allostatic modulator, Animal stress, Beef meat quality.

I. INTRODUCTION

Beef meat is considered to be a nutritive food for human consumption and contains high quality proteins, fats, vitamins and minerals [1]. The composition of beef meat depends on many factors, such as the genotype of the animal, its age and sex, in addition to specific cuts/muscles, conditions of animal welfare, the production system utilized and the type of feed consumed, among others. Typically, the day of transport to the slaughterhouse and subsequent animal slaughter consist of a series of potentially stressful events, which may adversely affect animal welfare and thereby carcass and meat quality [2, 3]. Animal welfare refers to the physiological or biochemical state of an animal as it attempts to respond to *ante-mortem* conditions [4] and also involves the application of sensible and sensitive animal husbandry practices to livestock during its stay on the farm. The protection of animal welfare has a positive effect on meat production.

Concerns for animal welfare and its influence on meat quality are major considerations in many developed countries [5]. Thus, the beef industry continues to adapt to changing consumer demands, and beef producers have developed and used research-based dietary additives to enhance the efficiency of meat gain and quality [2]. To the authors´ knowledge, no previous studies have been performed on the use of an allostatic modulator as a dietary supplement in cattle.

The present study was designed to determine the effect of a dietary allostatic modulator in carcass and beef meat quality.

II. MATERIALS AND METHODS

In this study, beef heifers (*Bos taurus*, 433 kg weight) located on a farm in Hermosillo, Sonora, México (28°56'52.4"N, 111°04'17.4"W) were fed in the last stage of production with an allostatic modulator (ATPQM®). Animal welfare parameters were evaluated over the course of the transportation process from the farm to the slaughterhouse. During the slaughter process, blood samples were collected to test for creatine kinase, lactate dehyhdrogenase and glucose. After slaughtering (45 min *postmortem*), the pH and temperature were measured in the *Semimembranosus* muscle (SM). At 24 h, in the *Longissimus thoracis* muscle (LT) and SM, pH and temperature analyses were performed, respectively. Further analyses to determine carcass conformation [6] and classification [7] were realized. Meat quality (LT) was measured in a total of eight untreated (control) and treated (supplemented) samples, four to each treatment, at 0 and 14 days, determining the pH, color (L*, a*, b*), texture (WBSF), water holding capacity (WHC), cooking loss weight (CLW), myofibril fragmentation index (MFI) and total collagen (TC). A factorial ANOVA was performed for the data in order to study the influence of the dietary allostatic modulator and the effect of seasonal conditions. Duncan´s test was carried out at a 95% confidence level (P<0.05). Statistical analysis of the data was performed by NCSS07 statistical software package.

III. RESULTS AND DISCUSSION

An increase in meat production is not always the main priority and concern of producers, as welfare and livestock health are also of concern to society and have improved in recent years. Animal welfare is a diverse issue, encompassing many different factors (freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury and disease, freedom to express normal behavior, freedom from fear and distress), which are highly correlated with quality of both meat and production practices [3]. The results of the animal welfare evaluation (Table 1) indicated that animal welfare was applied improperly during all stages of meat production (farm to slaughter). In animal transport and animal slaughter, high negative values were reported, more so during winter than in comparison with summer (P<0.05), which can have negative effects on carcass and meat quality.

The handling of beef cattle, including their loading, transport and slaughter, are factors commonly related to levels of glucose, creatine kinase and the activity of lactate dehydrogenase, which were measured in the blood exsanguinations, along with the pH and temperature at 45 min and 24 h after slaughter [8]. The results shown in Table 2 revealed that the dietary allostatic modulator did not have an effect on CK, LDH or pH at either 45 min or 24 h intervals (P>0.05). However, glucose values increased in the treatment group when compared with the control, mainly in summer and fall (P<0.05), and high values of glucose were found in samples collected during winter. However, morphometric characteristics such as length of carcass and height and width of hump were not affected (data not shown).

In addition, the conformation assessment is performed to estimate the amount of meat obtainable from the cow [6]. Results showed that the convex conformation was the most representative measure for all seasons (P<0.05). The USDA evaluation was applied to estimate yield and quality grade [7]. The results showed moderate marbling levels in the samples and acceptable KPH values (~6). Also, it was observed that choice classification was obtained for the beef cattle. Furthermore, the supplementation of a dietary allostatic modulator increased the ribeye area and a* value of beef carcass.

In meat samples, the supplementation of a dietary allostatic modulator did not have effects on WHC, L*, b* and TC parameters during 14 days of storage (P>0.05). The pH values remained within the range of characteristic values for fresh meat 5.5-5.7 [9]. However, in the case of meat and meat products, color is one of the most important organoleptic characteristics, which influences product acceptance and plays a major role in the purchase decision [10]. The a* value (redness) ranged from 18 to 22, and dietary supplementation had a positive effect on this parameter in meat samples, mainly during the summer season (P<0.05). These results indicated that the allostatic modulator preserved the red color of fresh meat.

Tenderness is also one of the most important quality attributes of beef and depends on many physical, chemical and biochemical factors [11]. The texture analysis showed that the allostatic modulator reduced the texture values of all seasons (P<0.05) when compared with the control samples, which indicated that meat tenderness improved. Also, the results of MFI showed that the allostatic modulator increased its values, which are correlated with improved meat texture. One of the main components contributing to meat tenderness are the myofibrils, and it is well established that the proteolysis of myofibrillar proteins leads to increased fragmentation of myofibrils and decreased shear force during *postmortem* storage [12].

The present results indicated that the addition of a dietary allostatic modulator had a positive effect on carcass and beef meat quality.

Table 1 Animal welfare evaluations.

Parameters		Animal transport		
Time (min)		46		
Distance (km)		27		
Animal density/m^2		1.8		
		W	S	F
Electric prods (%)	*	65.4^{c}	51.3^{a}	57.1^{b}
	**	0.0^{a}	0.0^{a}	9.5^{b}
Shouting-whistles (%)	*	310.3^{c}	90.0^{b}	41.7^{a}
	**	48.7^{c}	35.0^{b}	27.4^{a}
Knocking (%)	*	69.2^{c}	0.0^{a}	40.5^{b}
	**	0.0^{a}	0.0^{a}	0.0^{a}
Refused (%)	*	55.1^{b}	0.0^{a}	56.0^{c}
	**	0.0a	0.0a	0.0a
Temperature (°C)		26.5^{a}	37.8^{b}	25.2^{a}
Relative humidity (%)		32.5^{b}	45.0^{c}	23.5^{a}
THI		71.5^{b}	87.2^{c}	69.1^{a}
	Ref	Animal slaughter		
Knocking	10	100^{c}	15^{b}	5^{a}
Electric prods	25	81^{c}	79^{b}	75^{a}
Nod	0	18^{b}	14^{a}	31^{c}
Cattle standing box (seg)	5	4-60	5-39	5-61
Knocked-slaughter interval (seg)	30	72-128	50-92	53-111
Shot accuracy	14	73^{b}	77^{c}	24^{a}
Shot repetition	0	11^{b}	8^{a}	14^{c}
Tonic phase	98	25^{a}	27^{b}	43^{c}
Clonic phase	2	67^{a}	73^{b}	66^{a}
Slaughter Sensitivity	0.2	33^{b}	19^{a}	56^{c}

W: winter; S: summer; F: fall; *, shipment; **, disembarkation; THI: temperature and humidity index; Ref.: acceptable reference value. Different superscripts (a-c) differ significantly (P<0.05).

Table 2 Carcass characteristics.

Analysis	Wc	Wt	Sc	St	Fc	Ft
Glucose (mmol/l)	9.0^{b}	9.0^{b}	6.5^{a}	7.0^{a}	6.6^{a}	6.9^{a}
CK (u/l)	530^{a}	510^{a}	690^{a}	540^{a}	617^{a}	540^{a}
LDH (u/l)	519^{a}	560^{a}	787^{a}	614^{a}	404^{a}	395^{a}
pH 45 min	6.7^{a}	6.6^{a}	6.6^{a}	6.6^{a}	6.8^{a}	6.8^{a}
pH 24 h	5.6^{a}	5.6^{a}	5.7^{a}	5.6^{a}	5.6^{a}	5.7^{a}
T (°C) 45 min	40.1^{a}	40.2^{a}	40.0^{a}	40.2^{a}	40.2^{a}	40.2^{a}
T (°C) 24 h	2.6^{a}	2.6^{a}	4.3^{b}	5.4^{b}	5.5^{c}	5.7^{c}
	NMX Conformation $^{(\%)}$					
-concave	10^{c}	2^{b}	1^{a}	1^{a}	1^{a}	1^{a}
-straight	6^{b}	1^{a}	1^{a}	5^{b}	1^{a}	10^{c}
-convex	80^{a}	95^{d}	97^{d}	93^{c}	97^{d}	88^{b}
-round convex	4^{c}	2^{b}	1^{a}	1^{a}	1^{a}	1^{a}
	USDA evaluation					
Fat thickness (cm)	1.1^{a}	1.4^{b}	1.5^{b}	1.3^{b}	1.0^{a}	1.1^{a}
Adjusted fat (cm)	1.4^{b}	0.5^{a}	1.4^{b}	1.3^{b}	1.2^{b}	1.2^{b}
KPH (kg)	7.7^{c}	8.1^{c}	7.0^{b}	6.8^{b}	6.2^{a}	5.7^{a}
Ribeye (cm^2)	83^{b}	82^{b}	75^{a}	77^{a}	72^{a}	74^{a}
%M$^{(-2)}$	24^{e}	21^{d}	5^{c}	2^{b}	0^{a}	0^{a}
%M$^{(-1)}$	10^{a}	18^{b}	21^{c}	31^{d}	12^{a}	38^{e}
%M	26^{a}	28^{b}	42^{c}	25^{a}	73^{e}	50^{d}
%M$^{(+1)}$	40^{f}	33^{e}	22^{c}	26^{d}	15^{b}	12^{a}
%M$^{(+2)}$	0^{a}	0^{a}	10^{b}	16^{c}	0^{a}	0^{a}
Ma	90^{d}	90^{d}	75^{b}	90^{d}	85^{c}	55^{a}
Mb	10^{a}	10^{a}	25^{c}	10^{a}	15^{b}	45^{d}
	Marbling Classification $^{(\%)}$					
-choice	77^{a}	79^{a}	78^{a}	78^{a}	95^{c}	80^{b}
-select	21^{d}	19^{c}	15^{b}	14^{b}	0^{a}	0^{a}
-standard	2^{a}	2^{a}	7^{c}	8^{d}	5^{b}	20^{e}
	Color					
a*	24.0^{b}	26.0^{b}	21.0^{a}	21.2^{a}	25.2^{a}	23.4^{a}

W: winter; S: summer; F: fall; c: control; t: treatment; CK: creatine kinase; LDH: lactate dehydrogenase; M: marbling; Ma: maturity 9-30 months; Mb: maturity 30-42 moths. Different superscripts (a-f) differ significantly (P<0.05).

Table 3 Beef meat quality.

	d	Wc	Wt	Sc	St	Fc	Ft
pH	0	5.6^{bA}	5.6^{bA}	5.4^{aA}	5.5^{aA}	5.6^{bA}	5.6^{bA}
	14	5.6^{aA}	5.6^{aA}	5.7^{bB}	5.7^{bB}	5.6^{aA}	5.6^{aA}
CLW	0	27.6^{aA}	30.9^{aA}	26.4^{aA}	28.4^{aB}	28.0^{aA}	28.5^{aA}
	14	29.3^{aA}	29.3^{aA}	26.4^{aA}	23.5^{aA}	24.0^{aB}	29.6^{aB}
a*	0	18.5^{bA}	18.1^{bA}	14.7^{aA}	18.3^{bA}	18.7^{bA}	19.4^{bA}
	14	23.3^{aB}	23.6^{aB}	20.1^{aB}	20.5^{aB}	21.8^{aB}	24.7^{aB}
Text.	0	10.4^{bB}	8.6^{bB}	9.5^{bB}	8.0^{bB}	7.1^{aB}	5.0^{aB}
(kgf)	14	4.7^{bA}	4.5^{bA}	6.0^{bA}	5.4^{bA}	3.8^{aA}	3.4^{aA}
MFI	0	30.5^{aA}	43.7^{cA}	38.0^{bA}	46.4^{cA}	46.2^{cA}	51.6^{dA}
	14	53.0^{bB}	52.6^{bB}	48.2^{aB}	49.0^{aB}	55.1^{cB}	54.0^{cB}

d: day; WHC: water holding capacity; CLW: cooking loss weight; Text.: Texture; MFI: myofibril fragmentation index; TC: total collagen. Different superscripts (a-d) between treatments and different sampling day (A-B) differ significantly (P<0.05).

IV. CONCLUSION

In conclusion, dietary supplementation with an allostatic modulator in beef cattle is a means of increasing carcass and beef meat quality.

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