CANONICAL CORRELATION BETWEEN MINERAL CONTENT AND MEAT QUALITY TRAITS OF BUFFALO AND ZEBU-TYPE CATTLE

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Keywords: tenderness, flavour, mineral content, beef, buffalo

Introduction

There is a growing interest in Venezuela and other South American countries to utilise water buffaloes (*Bubalus bubalis*) as an alternative to produce meat in tropical flooding savannas where conditions are detrimental for productivity of most cattle breed types. Recent studies (Huerta-Leidenz *et al.*, 2001a,b) have shown that buffalo raised in tropical conditions can produce carcass with excellent attributes and good-quality meat at young ages. Red meat provides essential nutrients, and it is rich in mineral of high bioavailability like Fe and Zn. Many researchers have used several minerals, such as Ca, Zn, and P in solutions injected or infused in whole cuts or carcasses as a way to improve meat tenderness. However, the relationship between natural mineral content of meat and its quality traits have not been reported. The objective of this study was to determine the relationship between the mineral content and the organoleptic characteristics in meat of buffalo and cattle.

Materials and Methods

A group of conformed by 47 buffalo and 53 cattle was randomly selected in a cow-calf operation located at the western Venezuelan llanos. Buffalo were crossbred, with a predominance of Murrah and Mediterranean breeds. Beef calves came from Brahman dams which were artificially inseminated with bulls of several breeds (Brahman, Black Angus, Red Angus, Romo Sinuano, and Charolais). Half of the animals were castrated at weaning (7mo of age). Three groups of 33 animals each (16 buffaloes and 17 cattle) were randomly selected, and serially slaughtered at 17, 19 and 24 mo of age, respectively, following industrial standard procedures. At 48 h. *postmortem*, two 2.5 cm-thick steaks from the *longissimus dorsi thoracis* muscle were taken from each animal for Warner-Bratzler shear force (WBSF) determination and trained panel evaluation of tenderness, juiciness, amount of connective tissue, general tenderness and flavour intensity. A third steak was taken for mineral content analysis. The Na, K, Ca, Fe, Mg, Cu, Zn and Mn contents (mg/100g fresh tissue)were determined by atomic absorption and /or emission spectrophotometry (Pelkin-Elmer, 1994), while P was determined by UV-VIS spectrophotometry (A.O.A.C. 1990). Canonical correlation analysis using the CANCORR procedure was used to determine the relationship between mineral concentrations and meat quality traits (SAS, 1999-2000) for each species. The analysis is a multivariate statistical method that consists on finding two composite variables (canonical variables) correctly, so that the relationship among the groups of variables is a maximum (Johnson, 2000). The canonical variate that included the mineral content (Ca, Mg, Na, P, K, Cu, Fe, Zn, and Mn) was called "Mineral". The canonical variate that included meat quality-related traits (Warner Bratzler shear force, juiciness, general tenderness, and flavour intensity) was called "Quality".

Results and Discussion

Two canonical correlations coefficients were obtained for mineral content and quality traits for both beef and buffalo groups. The first canonical correlations for beef samples explained approximately 50.53 % of the relationship (r= 0.71) between variables (P=0.01). The first canonical correlation coefficient for buffalo samples explained a tendency of (P=0.09) of 41.36 % of the association (r= 0.64) between variables. These results point out a dependent relationship between mineral content and meat quality traits. For both species, the second canonical correlation was not significant (P>0.10). Canonical correlation coefficients by gender or age within specie were not significant.

Canonical variety coefficients for the canonical variety "Mineral" (M) were as follows:

$M_{Buffalo}$ = (0.82) Ca + (-0.09) Mg + (-0.10) P + (0.14) K + (-0.22) Na + (0.03) Fe + (-0.25) Zn + (-0.07) Cu + (-0.20) Mn.

M_{Beef} = (0.90) Ca + (0.12) Mg + (0.15) P + (-0.06) K + (-0.18) Na + (-0.04) Fe + (-0.22) Zn + (-0.32) Cu + (-0.21) Mn.

Calcium content resulted as the variable within the Mineral canonical variety with the highest weight in the equation for both species.

Canonical variety coefficients for the canonical correlation variety "Quality" (Q) were as follows:

$Q_{Buffalo}$ = (1.12) WBSF + (-0.11) Juiciness + (0.46) General Tenderness + (-0.33) Flavour intensity.

Q_{Beef} = (0.84) WBSF + (0.30) Juiciness + (0.22) General Tenderness + (-0.41) Flavour intensity.

WBSF and flavour intensity and WBSF and tenderness were the variables with the largest weight in the second equation for beef and buffalo samples, respectively.

Correlations coefficients between original variables and canonical variates are shown in Table 1. Among mineral components traits, Ca concentrations showed the highest canonical coefficient for both buffalo and beef samples (0.60 and 0.63, respectively), when it is correlated with canonical variety "Quality". WBSF showed the highest canonical correlation coefficient (0.60 and 0.62) for buffalo and beef samples, respectively, when it is correlated with canonical

variety "Mineral". The correlation coefficients between the original variables Tenderness and Canonical variate "Mineral" were negative for both groups of samples. The dual function of Ca^{+2} in *post-mortem* muscle is well known. The initial *post-mortem* toughening (*rigor mortis*) and the tenderisation processes (rigor resolution) are both regulated by Ca^{+2}. Results from this study showed a strong positive relationship between Ca content and WBSF, indicating that tenderness decreases as muscle's intact Ca content increases. This is in contrast to the findings of other researchers, who have demonstrated that the injection or infusion calcium chloride solutions has improved tenderness in pre-*rigor* and *post-rigor* meat (Wheeler *et al.*, 1992). However, the relationship between intact Ca content in the muscle and tenderness has not been reported. An important association between Mg and Cu in beef samples, and P and Mg in buffalo samples, with the canonical variety "Quality", was obtained, which should be considered for further studies.

Table 1: Canonical Correlation between Original variables and Canonical variates.

Original variables	Beef		Buffalo	
	Canonical Variety "Mineral"	Canonical Variety "Quality"	Canonical Variety "Mineral"	Canonical Variety "Quality"
Ca	**0.8985**	**0.6387**	**0.9388**	**0.6038**
Mg	0.3597	0.2557	0.2671	0.1718
P	-0.2000	-0.1422	-0.5721	-0.3679
K	0.2481	0.1764	0.3117	0.2004
Na	0.0819	0.0582	-0.2417	-0.1555
Fe	-0.2229	-0.1585	-0.0854	-0.0549
Zn	-0.1351	-0.0961	-0.0607	-0.0390
Cu	-0.3345	-0.2378	-0.1107	-0.0712
Mn	-0.2735	-0.1944	-0.3696	-0.2377
WB Shear force	**0.6234**	**0.8769**	**0.6038**	**0.8674**
Juiciness	0.2033	0.2860	0.1718	-0.1075
Tenderness	-0.1988	-0.2797	-0.3679	-0.2040
Flavour intensity	-0.4000	-0.5626	0.2004	-0.3268

Bold font indicates the highest correlation coefficients.

Conclusions

The mineral content and quality traits of meat from buffalo and beef are not independent. However, results are not conclusive to justify prediction analysis based on mineral content. The Ca content is the variable most highly correlated among the minerals studied. Results indicated a strong and positive correlation between Ca content and shear force values. Other nutritional components such as fatty acids profile, total lipids, and amino acids might be included in further studies to improve understanding of the relationship between quimical content of meat and its organoleptic characteristics.

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