PE1.43 Effect of betaine intake on muscle and backfat characteristics of pigs 278.00

Jose Neves (1) jneves@uevora.pt, Jose Martins(1), Amadeu Freitas(1) ,
(1)Evora University

***Abstract*— This study was undertaken to investigate the effects of long term betaine intake on the chemical and physical characteristics of *m. Longissimus dorsi* (LD), and backfat (BKF) of Alentejano (AL) pigs. Purebred AL pigs were allocated to open-air individual pens and fed a commercial (C) diet offered at 85% estimated *ad libitum* consumption. The pigs were divided into two experimental groups: Group C (n=6), consuming the C diet, and Group CB (n=8), consuming the C diet supplemented with betaine (1g/kg). After 20 weeks of trial, pigs were slaughtered at ~100 kg live weight (LW). LD and BKF individual samples were obtained from the chilled left half carcasses. Chemical (moisture, protein, lipids, myoglobin, and collagen) and physical (pH, water-holding capacity, CIE L*, a* and b*, chroma, and hue angle), as well as the LD area and BKF thickness, were determined. Significant differences were found mainly on the gross chemical composition and colour of LD and BKF samples. Betaine-fed pigs showed a higher (P=0.05) amount of LD neutral lipids and a lower (P<0.05) LD moisture content. Meanwhile, BKF average thickness and its lipid concentration were not affected. The fatty acid (FA) composition of lipids from LD and BKF was also not affected by treatments. On the other hand, the colour component Cie b* (yellowness) tended to be higher on LD (P=0.06) and was higher (P<0.05) on the BKF of pigs fed betaine, suggesting a global trend to a more yellowish tone in pork colour. The results obtained suggest that betaine supplementation in AL pigs has no effects on improving the lean:fat ratio of the carcass and on the LD and BKF FA profiles. However, intramuscular fat from LD was increased by betaine, as well as the yellowness on both tissues, suggesting an effect of betaine on overall pork quality.**

Neves, J., Universidade de Évora, Departamento de Zootecnia/ICAAM, Apt. 94, 7002-554 Évora, Portugal (phone: +351266760884; fax: +351266760841; e-mail: jneves@uevora.pt).

Martins, J.M., Universidade de Évora, Departamento de Zootecnia/ICAAM, Apt. 94, 7002-554 Évora, Portugal (e-mail: jmartins@uevora.pt).

Freitas, A., Universidade de Évora, Departamento de Zootecnia/ICAAM, Apt. 94, 7002-554 Évora, Portugal (e-mail: jmartins@uevora.pt).

***Index Terms*—Alentejano pig, betaine, *Longissimus dorsi*, backfat, chemical and physical characteristics**

I. INTRODUCTION

Betaine, i.e., trimethylglycine, is used in dietary supplements in human and animal nutrition. In pigs, betaine has been increasingly used as a dietary supplement to reduce fat deposition [1] but its efficacy is inconsistent. Some studies report a reduction of the body fat [1-2], while others report an increase [3] or no effect [4-5]. The Alentejano (AL) pig, an autochthonous breed reared in the southern region of Portugal, is characterised by slow growth rates and high lipogenic activity at early stages of development [6]. Nowadays, a production system based on the production of fresh meat for human consumption during all the year is been increasingly used. This system, based on free-range management where pigs are fed on natural feeds with no growth promoters and antibiotics [7], is therefore an important field of interest. However, the precocious lipogenic activity of the AL breed results in low lean:fat carcass ratio and low commercial lean cuts yield, compromising the economic viability of this alternative production system. Therefore, betaine could be used to reduce fat deposition, with a beneficial impact on the commercial value of the AL carcass. However, very little research has been conducted evaluating the effects of betaine on pork quality. Producers using betaine as a carcass modifier have limited or no information regarding possible alterations of the chemical and physical characteristics of muscles and fat obtained from pigs (namely form AL pigs) long-term supplemented with this compound.

The purpose of this study was to evaluate the effects of long-term betaine supplementation on the chemical and physical characteristics of *m. Longissimus dorsi* (LD) (representative of the loin meat cut), and of the backfat (BKF) from AL pigs slaughtered at ~100 kg LW.

II. MATERIALS AND METHODS

Fourteen AL pigs were allocated in open-air individual pens ($3m^2$), fed a commercial diet (C) offered at 85% estimated *ad libitum* consumption, and divided into two experimental groups: i) Group C (n=6), consuming the C diet; and ii) Group CB (n=8), consuming the C diet supplemented with betaine (1g/kg) (Betafin® S1, Danisco Animal Nutrition). At an average LW of 100 kg, pigs were killed by electrical stunning and exsanguination. Hot carcasses were submitted to a 24h chill, followed by commercial cuts and sample collection (from the carcass left side) of LD muscle and BKF, which were vacuum packaged and stored (-30º C) until analysis. Loin muscle area was determined by tracing the loin muscle surface area at the 10^{th}-rib, and area was determined with a compensating polar planimeter. The individual BKF thickness was obtained by an average of three measurements, done at the 3^{rd}-4^{th} lumbar vertebrae, the 10^{th}-11^{th} ribs, and the last rib of the chilled left half carcass. Moisture (Portuguese Norm 1614), total protein (Portuguese Norm 1612), and total, neutral and polar lipids [8] were analyzed. The fatty acid (FA) composition of lipid extracts from LD [8] and BKF [9] was identified after FA methylation [10] on a 6890 Hewlett Packard gas chromatograph with a 30 m × 0.32 mm × 0.25 µm cross-linked polyethylene glycol capillary column (Omegawax^{TM} 320, Supelco 24152). Identification of FA methyl esters was based on the retention times of reference compounds (Supelco cat. n. 47801 and 47885-U). The muscle pH values were measured following the Portuguese Norm 3441 and its water-holding capacity (WHC) was measured as water losses after pressure during 1 min, according to Goutefongea [11]. The muscle myoglobin content was calculated by multiplying heme pigment concentration (analyzed according to Hornsey [12]) by the factor 0.026 [7]. Total hydroxyprolin was analyzed [13] and multiplied by 7.14 [14] to obtain the total collagen content of muscle samples. Colour CIE L* (lightness), a* (redness), and b* (yellowness) were determined with a Chromameter CR-200 (Minolta Camera Co. Ltd, Japan). Hue angle and chroma values were obtained from the values a* and b*.

Results are presented as means ± SEM. Statistical analysis was performed by one-way ANOVA with the statistical software Statview 5.0 (SAS Institute Inc, Cary, NC, USA). Differences were considered significant when $P<0.05$.

III. RESULTS AND DISCUSSION

Daily weight gain, final, and hot carcass weights were not affected by betaine supplementation (data not shown). The same was observed for LD area, average BKF thickness (Table 1), and BKF weight (data not shown). These data suggest that LD muscle area and body fat deposition of betaine-fed pigs was not affected, contrary to what it was observed by some authors [1-2], but in agreement with others [4-5]. Even though a moderate dose (1 g/kg) was used in this work, Fernández-Fígares et al. [15] supplemented Iberian pigs with 5 g/kg of betaine, and also found no reduction on body fat. These data may indicate the possibility that this breed possess a refractoriness to the effects of betaine, namely on carcass fat. However, betaine-fed pigs presented a ~65% higher ($P<0.05$) amount of neutral lipids on LD muscle, but no difference on BKF lipids content. This selective effect on intramuscular lipids suggests that the metabolism of lipids in muscle and adipose subcutaneous tissues have different regulation factors. Data obtained by Neves [16] in AL pigs fed high and low energy diets, showed that diet had no effect on intramuscular fat from several muscles (LD, *Biceps femoris*, and *Semimembranosus*), but significantly increased the overall carcass fat content. These data suggest that the deposition of intramuscular neutral lipids is endogenously regulated. Since pigs fed betaine presented a higher content of LD neutral lipids, this compound may interfere with the intramuscular lipid metabolism. Finally, and as expected, a high correlation (-0.882, $P<0.001$) between neutral lipid and moisture content of LD muscle was observed.

The FA composition of neutral (C12, C14, C16, C16:1, C17, C17:1, C18, C18:1, C18:2, C18:3, C20, C20:1, and C20:2), and polar lipids (C14, C16, C16:1, C17:1, C18, C18:1, C18:2, and C20:4) of LD muscle and of BKF tissue (C12, C14, C16, C16:1, C17, C17:1, C18, C18:1, C18:2, C18:3, C20, C20:1, and C20:2) was not affected by betaine supplementation (data not shown). SFA, MUFA, and PUFA were also not affected on both tissues (Table 1). These data indicate that betaine has no effect on FA global profile.

Betaine intake did not affect the pH values of LD muscle, its WHC, and the total myoglobin and collagen content. The LD colour parameters were also not affected by betaine consumption, with the exception of Cie b* (yellowness), which tended to be higher ($P=0.06$) on the animals supplemented with betaine. Matthews et al. [17] found that crossbred barrows and gilts fed 0% betaine had no detectable tissue betaine concentration, but pigs supplemented with betaine had detectable betaine concentrations in the loin muscle. Considering the results obtained for colour traits on the BKF tissue, betaine-fed pigs also presented a higher ($P<0.05$) value of Cie b* and lower ($P<0.01$) value of Cie L* (lightness). These results seem to indicate that betaine could be deposited on muscle and also on fat tissues. Betaine colour varies from white to yellow, and has a stabilizing effect on vitamins such as A and B complexes [18], therefore having the potential to affect colour properties of these tissues. Matthews et al. [4] also found differences in the subjective colour of pork from pigs consuming betaine. However, and according to our data, no other physical characteristic of LD and BKF tissues was affected by betaine supplementation.

IV. CONCLUSION

The results obtained suggest that betaine supplementation in AL pigs have no effects in improving the lean:fat ratio of the carcass and on the fatty acid profiles. Pigs supplemented with betaine presented a higher amount of neutral lipids in *m. Longissimus dorsi*. This trend was accompanied by a lower amount of moisture observed on muscle samples from betaine-fed pigs. However, thickness and lipid content on backfat tissue was not affected by treatments. Since the lipid metabolism in muscles seem to be mainly endogenously regulated, these results suggest that betaine may affect the lipid metabolism on muscular tissue. On the other hand, the consumption of betaine seems to have an effect on muscle and backfat colour, with an increase of the yellowish tone. These data suggest that betaine may affect the overall pork quality.

REFERENCES

[1] Huang, Q.-C., Xu, Z.-R., Han, X.-Y., & Li, W.-F. (2006). Changes in hormones, growth factor and lipid metabolism in finishing pigs fed betaine. Livestock Science, 105(1-3), 78-85.

[2] Cadogan, D.J., Campbell, R.G., Harrison, D., & Edwards, A.C. (1993). The effects of betaine on the growth performance and carcass characteristics of female pigs. In E. S. Batterham (Ed.), Manipulating Pig Production (pp. 219-225). Attwood, Victoria, Australia: Australasian Pig Science Association.

[3] Haydon, K.D., Campbell, R.G., & Prince, T.J. (1995). Effect of dietary betaine additions and amino:calorie ratio on performance and carcass traits of finishing pigs. Journal of Animal Science, 73(Suppl. 1), 83.

[4] Matthews, J.O., Southern, L.L., Pontif, J.E., Higbie, A.D., & Bidner, T.D. (1998). Interactive effects of betaine, crude protein, and net energy in finishing pigs. Journal of Animal Science, 76(9), 2444-2455.

[5] Øverland, M., Rorvik, K.A., & Skrede, A. (1999). Effect of trimethylamine oxide and betaine in swine diets on growth performance, carcass characteristics, nutrient digestibility, and sensory quality of pork. Journal of Animal Science, 77(8), 2143-2153.

[6] Neves, J.A., Sabio, E., Freitas, A., & Almeida, J.A.A. (1996). Déposition des lipides intramusculaires dans le porc Alentejano. L'effet du niveau nutritif pendant la croissance et du régime alimentaire pendant l'engraissement. Produzione Animale, 9, 93-97.

[7] Cava, R., Estévez, M., Ruiz, J., & Morcuende, D. (2003). Physico-chemical characteristics of three muscles from free-range reared Iberian pigs slaughtered at 90 kg live weight. Meat Science, 63(4), 533-541.

[8] Marmer, W., & Maxwell, R. (1981). Dry column method for the quantitative extraction and simultaneous class separation of lipids from muscle tissue. Lipids, 16(5), 365-371.

[9] De Pedro, E., Casillas, M., & Miranda, C.M. (1997). Microwave oven application in the extraction of fat from the subcutaneous tissue of Iberian pig ham. Meat Science, 45(1), 45-51.

[10] Bannon, C., Craske, J., & Hilliker, A. (1985). Analysis of fatty acid methyl esters with high accuracy and reliability. IV. Fats with fatty acids containing four or more carbon atoms. Journal of the American Oil Chemists' Society, 62(10), 1501-1507.

[11] Goutefongea, R. (1966). Étude comparative de différentes méthodes de mesure du pouvoir de rétention d'eau de la viande de porc. Annales de Zootechnie, 15(3), 291-295.

[12] Hornsey, H.C. (1956). The colour of cooked cured pork. I. - Estimation of the Nitric oxide-Haem Pigments. Journal of the Science of Food and Agriculture, 7(8), 534-540.

[13] Woessner Jr., J.F. (1961). The determination of hydroxyprolin in tissue and protein samples containing small proportions of amino acid. Archives of Biochemistry and Biophysics, 93(2), 440-447.

[14] Etherington, D.J., & Sims, T.J. (1981). Detection and estimation of collagen. Journal of the Science of Food and Agriculture, 32(6), 539-546.

[15] Fernández-Fígares, I., Conde-Aguilera, J.A., Nieto, R., Lachica, M., & Aguilera, J.F. (2008). Synergistic effects of betaine and conjugated linoleic acid on the growth and carcass composition of growing Iberian pigs. Journal of Animal Science, 86(1), 102-111.

[16] Neves, J. (1999). Influência da engorda em montanheira sobre as características bioquímicas e tecnológicas da carne fresca e do presunto de porco Alentejano. Doctoral Thesis, Universidade de Évora.

Table 1. Chemical and physical characteristics of *m. Longissimus dorsi* and dorsal subcutaneous fat from Alentejano pigs fed a commercial diet without or with betaine supplementation (1g/kg) and slaughtered at 100 kg LW †

	C	**CB**	**Sig**
***m. Longissimus dorsi*:**			
Moisture (g/100g)	73.3 ± 0.4	72.3 ± 0.3	*
Protein (g/100g)	23.6 ± 0.1	23.3 ± 0.2	NS
Total lipids (g/100g)	2.43 ± 0.22	3.69 ± 0.44	*
Neutral lipids (g/100g)	1.69 ± 0.19	2.81 ± 0.42	0.05
Σ SFA ‡	41.9 ± 1.7	41.8 ± 1.1	NS
Σ MUFA ‡	54.9 ± 1.3	55.2 ± 1.0	NS
Σ PUFA ‡	3.2 ± 0.5	3.0 ± 0.3	NS
Polar lipids (g/100g)	0.74 ± 0.08	0.88 ± 0.03	NS
Σ SFA ‡	36.8 ± 1.0	38.1 ± 0.6	NS
Σ MUFA ‡	37.1 ± 1.5	35.0 ± 0.6	NS
Σ PUFA ‡	26.1 ± 1.1	26.9 ± 0.4	NS
pH	5.53 ± 0.04	5.49 ± 0.02	NS
Water-holding capacity §	16.3 ± 1.4	17.5 ± 0.6	NS
Myoglobin (mg/g)	1.54 ± 0.06	1.66 ± 0.11	NS
Total collagen (mg/g dry matter)	13.8 ± 1.0	12.4 ± 0.8	NS
Lightness (Cie *L**)	43.7 ± 1.0	43.1 ± 0.8	NS
Redness (Cie *a**)	13.2 ± 0.6	14.2 ± 0.3	NS
Yellowness (Cie *b**)	6.0 ± 0.4	6.8 ± 0.2	0.06
Chroma (C)	14.5 ± 0.7	15.7 ± 0.3	NS
Hue angle (Hº)	24.4 ± 1.0	25.7 ± 0.3	NS
Dorsal subcutaneous fat:			
Moisture (g/100g)	5.2 ± 0.3	5.1 ± 0.2	NS
Protein (g/100g)	1.14 ± 0.05	1.19 ± 0.09	NS
Total lipids (g/100g)	93.7 ± 0.3	93.7 ± 0.2	NS
Σ SFA ‡	40.6 ± 0.6	40.4 ± 0.5	NS
Σ MUFA ‡	51.3 ± 0.5	51.4 ± 0.4	NS
Σ PUFA ‡	8.1 ± 0.1	8.2 ± 0.1	NS
Lightness (Cie *L**)	81.1 ± 0.3	78.6 ± 0.6	**
Redness (Cie *a**)	2.2 ± 0.3	2.3 ± 0.4	NS
Yellowness (Cie *b**)	3.7 ± 0.1	4.4 ± 0.2	*
Chroma (C)	4.4 ± 0.2	5.1 ± 0.3	NS
Hue angle (Hº)	59.6 ± 2.4	62.8 ± 3.1	NS

† C - Group fed a commercial diet without betaine (n=6), CB - Group supplemented with betaine (n=8); Significance: ** P<0.01, * P<0.05, NS - P≥0.05;
‡ Expressed as g/100g of the total FAME identified;
§ Measured as water loss after pressure during 1 min.