PE7.11 Effect of Addition of Yucca (Manihot esculenta) in Pig Feeding on Meat Quality 136.00

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***Abstract*—. We have determined the influence of two different percentages of *Manihot esculenta* added to pigs diet on pork meat quality. Two experiments were performed, the first one with fifteen lactating females and the second with thirty entire males. In both experiments there were three subgroups according to the diet they ate, one control group with no yucca addition and two groups with 30 and 60 % yucca respectively. No important differences in meat quality parameters such as pH, colour, drip loss, fatty acid profile and WBSF, attributed to yucca addition were found.**

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***Index Terms*—*Manihot esculenta*, yucca, feed, meat quality, pig, fatty acid profile.**

I. INTRODUCTION

INDING new raw materials to feed animals with the Fminimum possible cost but keeping meat quality is one of the main purposes in the livestock industry.

Manihot esculenta is a plant primarily cultivated in the subtropical region of South America, Africa and Asia, and it is a very important food source in that area due to its tubers high caloric value [1].

Several studies have been carried out using yucca in different fields. For example, entire pig males fed with a diet based on yucca flour produced firmer and better quality carcasses than pigs fed with a diet based on corn [2]. The replacement of corn by yucca flour did not affect to productive parameters and involved a lower food cost [3].

In other study peel of yucca was used as an ingredient in pigs diet. Until 30 % addition did not affect to productive parameters but obtained a profit increase [4].

The aim of this study was to evaluate the effect of addition of two different percentages of yucca on meat quality in two pig groups, lactating females and entire males.

II. MATERIALS AND METHODS

A. Experimental design

In the first experiment, fifteen crossbred pigs (lactating females) and in the second one thirty entire males, were selected, both from Hypor (Large White x Landrace) crossbred sow and Crany (Large White) sire.

Three kind of diets with different proportion of yucca were used for these experiments. Control feed (no yucca addition), 30 % yucca addition feed and 60 % yucca addition feed.

All these animals were stunned using carbon dioxide and slaughtered at an abattoir at approximately 111.7 ± 0.8 kg (entire males) and 170 ± 1.6 kg (lactating females), 24 hours later *longissimus dorsi* muscle samples were collected for the analysis.

B. Analytical procedures

pH measurements were made in triplicate using a portable puncture pH meter HANNA HI 8424 with fresh samples.

Samples were stored under freezing conditions (-20 ºC). After defrosting, several tests were executed with them.

A reflectance spectrophotometer (Minolta CM-2002; Osaka, Japan) was used to measure colour at the surface of *longissimus dorsi* muscle (LD) exposed to air for 30 min. The reflectance spectrophotometer contained a Xenon light source, calibrated against a white plate supplied by the manufacturater. The illuminant used was D65 and the standard observer position was 10º. The parameters registered were CIE L* (lightness), a* (redness), and b* (yellowness). Each value was the mean of 20 determinations per sample, always trying to avoid areas with excess fat and connective tissue.

A 2 cm-thick steak was cut from LD muscle and immediately weighed. The samples were placed within a

plastic box (*tupperware*) on a supporting mesh ensuring that the sample did not make contact with the box and sealed. After a storage period of 24 h at chill temperatures (1-5 ºC), the samples were taken out from the box, dabbed lightly on filter paper and weighed again. Drip loss was expressed as a percentage of the initial weight, based on [5].

Samples were extracted according to the Bligh and Dyer method [6] to determinate composition in fatty acids from intramuscular fat and the methyl esters from fatty acids (FAMES) were analysed in a gas chromatograph HP-6890 II, with a capillary column SP-2380 (100 m x 0.25 mm x 0.20 µm), using nitrogen as the carrier gas.

Warner Bratzler shear force (WBSF) was measured using a TA-XT2 Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a 250 N load cell. The texture expert version 1.20 (Spanish), computer program was used for data collection and calculations. Samples were fast-thawed in tap water (4 h), then the vacuum was broken and samples were wrapped in aluminium foil and cooked at 200 ºC in a double plate grill (Sammic GRS-5) until the internal temperature reached 72 ºC. Samples were obtained by cutting at least twelve rectangles of 1 x 1 cm^2 of cross section and 5 cm long, parallel to the muscle fibre direction.

C. *Statistical analysis*

Data were statistically analysed by the general linear model (GLM) procedure of SPSS, version 14.0 [7]. Duncan test was applied to compare the mean values of pH, colour, drip loss, fatty acid profile and texture.

III. RESULTS AND DISCUSSION

A. *pH*

The speed and magnitude of the pH fall post slaughter is possibly the most important individual cause in pork meat quality variation. High or low pH values can trigger alterations such as PSE (pale, soft and exudative) or DFD (dark, firm and dry) respectively, which are very important in meat industry [8].

There were no differences among the three diets studied for the lactating females (Table 1), this could be due to the high standard deviation found.

All the data obtained were higher than 6, and the difference among averages was around 0.05.

Differences between control treatment and yucca treatments were significant in entire males experiment ($P < 0.01$).

Control group presented the lowest value and the two others presented similar results.

B. *Colour*

Fresh meat discoloration has been related to the myoglobin state, determined by the oxidative process activity and its effects in oxygen concentration on meat surface and the effectiveness of metmyoglobin enzymatic reduction systems [9]. Colour stability during storage is influenced by several factors, such as muscle, diet, storage temperature or oxygen availability [10].

No significant differences, in luminosity (L*), red (a*) and yellow (b*) values, were found in the lactating females experiment (Table 1).

In entire males, no significant differences were found either. In this case, L- values were higher and a-values lower than the previous experiment. High pH values are related to low L* and high a* values [11].

C. *Drip loss*

Drip loss, as a meat quality parameter, combines two important aspects. In the first place, meat with high losses tends to be paler (luminous) in colour, has less characteristic pork flavour and more undesirable flavour [12]. Secondly, it entails economical losses because of weight losses and productive performance reduction [13].

In lactating females, significant differences were found ($P < 0,05$) between control and 30 % yucca addition treatments. The highest weight loss percentage belonged to control group, no differences were found between 60 % yucca addition treatment and 30 % yucca addition. Therefore, yucca addition can be related to a lower drip loss (Table 1).

Respecting the entire males, no differences were found.

D. *Fatty acid profile*

Interest in meat fatty acid composition comes from the need of finding ways to produce healthier meat, with a higher polyunsaturated fatty acids ratio, and a more favourable n-6/n-3 proportion. Only when α-linolenic acid gets close to 3 % of neutral lipids, some adverse effects in meat quality could appear. Fat tissue hardness, self life and flavour are influenced by meat fatty acid composition [14].

Fat sources with high unsaturated fatty acids proportion is frequently used to obtain a more unsaturated meat fatty acid profile and this is beneficial for human health. However, it entails side effects, for example a fat tissue

tenderizing, more sensitivity to lipid oxidation and a lower technology quality in cured meat products [15].

Lactating females did not present significant differences in fatty acid profile among the treatments, what means that fatty acid proportion in intramuscular fat has not been affected by yucca addition.

Palmitic acid (C:16) is the main saturated fatty acid (SFA) that influences on the saturated fatty acid percentage. Only a light tendency ($P < 0.1$), was observed in entire males, the higher value belonged to 60 % yucca addition, followed by control and 30 % yucca addition (Table 2).

With regard to PUFA, significant differences were found in three of them, α –linolenic acid (C18:3 n-3) ($P < 0.001$), eicosapentaenoic acid (C20:5 n-3) and docosahexaenoic acid (C22:6 n-3) (both $P < 0.05$). In all these cases, 30 % yucca addition showed the lowest values, being the other two treatments similar.

In relation to the n-6/n-3 ratio, there were significant differences among the groups ($P < 0.001$). 60 % yucca addition presented the best value (9.55), after the control (10.13) and 30 % yucca (11.51).

The differences found can not be full attributed to the effect of yucca addition, due to the progression did not match to the yucca proportion.

Therefore these results may be related to other causes, since pig fatty acid composition is determined by other factors, for example breed, sex, genotype or environment, of which diet is probably the most important [16].

Fat affects decisively to pork fatty acid profile, because diets with different fat composition modifies to a great extent the fat tissue proportion in monogastric animals, which increases proportionally while fat contain does [17].

E. Texture

Variation in tenderness can be explained basically by four meat properties: (1) connective tissue structure, (2) intramuscular fat amount, (3) muscle contraction before or during rigor mortis and (4) post slaughter maturation [18].

Several studies have proved the correlation between intramuscular fat and meat hardness [19]. Therefore WBSF was measured in entire males to check if significant differences in fatty acid profile found in this experiment had any influence in texture.

In this study, no significant differences have been detected.

IV. Conclusion

Both the first experiment with lactating females and the second one with entire males did not show differences applicable to yucca addition between the control group and the other two. In this study, *Manihot esculenta* does not alter the final product quality.

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Table 1. Meat quality parameters of lactating female and entire male pigs.

	Lactating females							Entire males						
	Control		30 % Yucca addition		60 % Yucca addition		Sign.	Control		30 % Yucca addition		60 % Yucca addition		Sign.
N	**5**		**5**		**5**			**10**		**10**		**10**		
	x	se	x	se	x	se		x	se	x	se	x	se	
pH 24 h	6.12	0.31	6.02	0.18	6.07	0.50	ns	5.70a	0.05	5.76b	0.06	5.77b	0.05	**
L*	35.50	4.64	36.13	4.83	35.29	4.92	ns	48.46	1.60	47.49	2.73	47.56	1.81	ns
a*	4.35	1.35	4.01	1.51	5.15	0.54	ns	0.96	0.91	1.12	0.69	0.60	0.67	ns
b*	7.19	1.40	7.01	1.16	7.54	1.16	ns	7.48	0.80	6.98	0.61	6.96	0.65	ns
Drip loss (%)	0.93b	0.11	0.79a	0.09	0.82ab	0.05	*	1.33	0.18	1.33	0.34	1.33	0.26	ns
WBSF	nd	nd	nd	nd	nd	nd	nd	4.96	0.71	5.64	1.50	5.09	0.78	ns
IMF (%)	6.02	0.16	6.25	0.23	6.24	0.25	ns	2.30	0.62	2.34	0.55	2.01	0.66	ns

Different letters in the same row indicate significant differences among mean values; ns = p>0.1; ** = p≤0.01; nd = not determined.

Table 2. Fatty acid composition of intramuscular fat of lactating female and entire male pigs. (% of total fatty acids).

	Lactating females							Entire males						
	Control		30% Yucca tion		60% Yucca tion		Sign.	Control		30% Yucca tion		60% Yucca tion		Sign.
N	**5**		**5**		**5**			**9**		**9**		**9**		
	x	**se**	**x**	**se**	**x**	**se**		**x**	**se**	**x**	**se**	**x**	**se**	
C16:0	21.23	1.25	22.07	1.78	21.86	0.93	ns	23.29ab	1.10	22.97a	0.52	23.95b	0.97	t
C16:1	3.23	0.39	3.75	0.64	3.61	0.52	ns	3.60	0.40	3.34	0.31	3.32	0.35	ns
C18:0	10.22	1.55	9.42	1.36	9.41	1.06	ns	10.57	0.91	11.04	0.63	10.98	0.93	ns
C18:1 n-9	42.04	2.70	39.72	1.78	40.05	3.13	ns	39.98	1.60	41.05	1.59	39.45	1.64	ns
C18:2 n-6	10.41	2.56	11.43	2.24	11.39	1.94	ns	9.86	1.67	9.40	1.53	9.58	1.83	ns
C18:3 n-3	0.48	0.10	0.55	0.07	0.54	0.07	ns	0.52b	0.05	0.42a	0.03	0.50b	0.05	***
C20:4 n-6	1.60	0.68	1.95	0.84	1.62	0.36	ns	1.67	0.56	1.56	0.39	1.67	0.48	ns
C20:5 n-3	0.04	0.01	0.05	0.02	0.04	0.01	ns	0.10ab	0.03	0.08a	0.02	0.11b	0.03	*
C22:6 n-3	0.037	0.02	0.05	0.02	0.04	0.01	ns	0.11b	0.03	0.07a	0.01	0.10b	0.02	*
SFA	33.19	2.89	33.31	2.96	33.13	2.10	ns	35.89	2.04	35.91	0.99	36.86	1.85	ns
MUFA	51.61	2.99	50.02	1.03	50.48	3.95	ns	49.26	1.92	50.06	1.81	48.38	2.08	ns
PUFA	13.57	3.57	15.14	3.35	14.67	2.40	ns	13.40	2.58	12.59	2.11	13.18	2.69	ns
n-3	0.90	0.24	1.06	0.24	0.96	0.14	ns	1.21ab	0.24	1.00a	0.15	1.25	0.25	t
n-6	12.65	3.34	14.07	3.11	13.70	2.27	ns	12.18	2.34	11.57	1.97	11.91b	2.44	ns
P/S	0.42	0.13	0.46	0.14	0.44	0.06	ns	0.38	0.09	0.35	0.06	0.36	0.09	ns
n-6/n-3	14.13	1.19	13.36	0.51	14.28	1.03	ns	10.13b	0.24	11.51c	0.54	9.55a	0.31	***

Different letters in the same row indicate significant differences among mean values; ns = p>0.1; t = p≤0.1; * = p≤0.05; *** = p≤0.001.