EFFECT OF FEEDING BROKEN RICE IN SUBSTITUTION OF CORN ON pH, COLOUR AND LIPID AND PROTEIN OXIDATION OF FRESH AND AGED POULTRY MEAT

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Abstract - The objective of this study was to evaluate the meat quality of poultry meat receiving a diet with increasing levels of broken rice in substitution of corn. For this, 30 Ross birds 35 days aged were fed with a diet containing 0, 30 and 60% of broken rice in substitution of corn. The birds were slaughtered and pH and colour, L*, a*, b*, were measured at 10, 45, 90 and 24 hours *post mortem*. At 24 hours *post mortem,* drip loss was determined in *Pectoralis major* (PM) and *Gastrocnemius* (GM) muscles. After that, both muscles were obtained and divided in two pieces, one was frozen at -20ºC and the other was vacuum packaged and aged at 2-4ºC during 5 days. TBARS and carbonyls were measured in fresh and aged muscles. Increasing broken rice in the diet decreased pH at 45, 90 min *post mortem* in both muscles but no effect on drip loss was observed. Parameters b* and a* and b*, were significantly decreased ($p<0.05$) in GM and PM respectively, by the broken rice. Lipid oxidation was significantly ($p<0.03$) decreased by 60 % broken rice while protein oxidation was not affected. We can conclude that broken rice, a strategic source to substitute corn, modifies pH and colour and improves oxidative stability in poultry meat.

I. INTRODUCTION

In Uruguay, rice production is a valuable and exportable commercial product and its by-products as broken rice is an alternative to corn in poultry diets (1). The broken rice separated out after the polishing stage has the similar chemical composition as polished rice. There is seldom any surplus of broken rice available for feeding. Broken rice is a palatable, energy-rich and easily used feed. It is used for all classes of livestock, but its high energy value and low fiber content make it especially valuable in rations for growing chickens. Broken rice produced in Uruguay has a chemical composition, 9.4 % CP and 17.83 MJ/kg EM that makes it adequate to replace corn in diet for poultry (2; 3). Uriyapongson et al. (4) and Hung et al. (5) showed that the inclusion of broken rice in the diet in substitution of corn increases nutrient digestibility while modifications in pH fall *post mortem* in meat was observed. The aim of this work was to evaluate the modifications in meat quality caused by the level of broken rice in the diet on pH, colour, drip loss and lipid and protein oxidation in *Pectoralis* and *Gastrocnemius* muscles fresh and aged during 5 days in vacuum packaged at 2-4 °C.

II. MATERIALS AND METHODS

The animal care and handling were approved by the Honorary Committee of Experimental Animals of the Universidad de la República, Montevideo, Uruguay (CHEA) before the experimentations started. The trial was conducted at the Facultad de Agronomía of the Universidad de la República (UDELAR, Montevideo, Uruguay), following the human animal care and handling procedures, according to the protocol accepted. One-day old males birds (Ross) obtained from a commercial hatchery were reared until thirty-five days of age on litter floor, in an acclimatized room with a photoperiod of 23 hours of light. They were fed *ab libitum* with a commercial corn-soya diet (21.9 % PC; 13.35 MJ of ME/kg). Fresh water was provided *ad libitum*. At thirty-five days old, twenty- four birds were selected by weight and health appearance and assigned completely randomly into three groups of eight birds each individually located in the pens with floor litter. Each group was fed with one of the experimental diets until sacrifice. All birds received water and food *ad libitum* during the whole period. At fifty-

six days old, all the birds were sacrificed in an experimental abattoir. Pre-harvest handling and transportation (transportation time was 3 minutes) were in accordance with good animal welfare practices. Slaughtering procedures followed the CHEA accepted protocols. A corn-soya based diet was formulated to meet nutrient requirements for finishing male broilers (6; 7) using ground corn as a starch source and considered as a test diet. The additional two diets were formulated by substituting 30% or 60% of corn by broken rice in the iso-nitrogenous and iso-caloric diets. At 56 days all the birds were slaughtered after fasting for 4 hours according to standards established by CHEA, making the sacrifice by cutting the jugular vein until total bleeding (3min) so as to cause the least possible stress to the animal. Immediately after exsanguinations the pH was determined at 10, 45, 90 minutes and 24 hours *post mortem* (kept at 4°C) in the *Pectoralis* and *Gastrocnemius* muscles from both sides, using a penetration pH meter LT Lutron pH-201. Also, meat colour was determined using CIELAB method, L*, a*, b* at 10, 45, 90 minutes and 24 hours *post mortem* (at 4°C), with a Minolta Lab CR-10 colourimeter. Water drip loss was determined by the weight difference in 2.5 g of each muscle samples at 24 hours *post mortem* from both sides (8). For the oxidation of lipids and proteins determinations, samples of both muscles (both sides and at 24 hours *postmortem*) were stored in polyethylene bags at -30°C until analysis (fresh meat) or were vacuum packaged, kept at 4°C for 5 days and then frozen at -30°C until determinations (aged). Lipid oxidation was determined by TBARS method (9) with some modifications (10). The results were given as mg of MDA/kg of fresh meat. Protein oxidation was estimated by the reactions between carbonyls and DNPH (*2,4*-dinitrophenylhydrazine) (10) with the resulting formation of a Schiff base which produces the corresponding hydrazone, quantified spectrophotometrically at 360 to 385 nm. The determination was carried out using the method of (11) with some modifications. The concentration of DNPH was calculated using its molar extinction coefficient of 22.000 M-1 cm-1, and results were expressed as nmol DNPH/mg protein. Protein content was determined at 280 nm in the homogenized using bovine serum albumin (BSA). To evaluate level of broken rice, muscle, time *post mortem* and ageing effects for each variable determined, a repeated measures ANOVA or ANOVA GLM (NCSS, 2007) was followed. Also, a one way ANOVA was used to compare within diet, muscles or fresh and aged muscles.

III. RESULTS AND DISCUSSION

In Table 1, it can be observed that broken rice in substitution of corn modifies the pH causing a higher pH at 10, 45, 90 min and at 24 hours *post mortem* with a marked effect of muscle type. Indeed, this effect is more clear in PM than in GM. It would be doubt to highly digestible starch in broken rice which could be influenced by the glycogen stores (12). Also, the parameters of colour, L* are higher and a* and b* are decreased by the incorporation of broken rice in diet (Table 1). Redness and yellowness of the PM are diminished and it remains at 24 hours *post mortem* while in GM the effect on redness disappears at 24 hours resting only the effect on the b* parameter. Drip loss was not affected by the broken rice (Table 2). When increasing the level of substitution of broken rice to 60% in the diet of poultry, the lipid oxidation expressed as TBARS was decreased in the Pectoralis and *Gastrocnemius* muscles, fresh and aged related to 30 % and 0% (Table 3). No effect on protein oxidation was observed (Table 3).

Table 1. Effect of increasing broken rice in poultry diet on the kinetics of *p*H and color L*, a*, b*, of *Pectoralis* (PM) and *Gastrocnemius* (GM) muscles at 10, 45, 90 min and 24 hours *post mortem (*T*pm).*

	T*pm*	Broken rice (%)					
		0	30	60	0	30	60
		PM			GM		
*p*H	10min	6.27 ±0.06 a	6.13 ±0.06 a	6.46 ±0.07 b	6.24 ±0.04 a	6.24 ±0.09 a	6.60±0.11 b
	45min	5.98±0.04 b	5.52 ±0.05 a	6.08 ±0.06 b	6.07 ±0.04 a	5.78 ±0.01 a	6.20 ±0.06 b
	90min	5.92 ±0.09 b	5.44 ±0.09 b	5.55 ±0.04 a	5.99 0.1 b	5.56 ±0.12 a	6.02 ±0.07 b
	24 h	5.91 ±0.02 a	6.00 ±0.02 b	6.02±0.01 b	5.96±0.06	6.10±0.05	6.09±0.01
L*	10min	45.52 ±0.3	46.74 ±0.4	47.37 ±0.8	55.06 ±0.09	55.16 ±0.79	54.13± 1.0
	45min	46.44 ±0.4	46.57 ±0.5	46.61 ±0.3	54.55 ±0.4	55.63 ±0.6	53.5 ±0.9
	90min	46.84 ±0.3	46.02 ±0.5	46.64 ±0.3	56.65 ±1.08	54.37 ±0.9	55.18 ±0.9
	24 h	51.13 2.9	54.9 ±0.7	56.65 ±0.6	54.2± 0.7	53.3± 1.2	54.0 ±0.9
a*	10min	0.26 ±0.1 b	0.09 ±0.1 b	-0.89 0.1a	4.45 ±0.3 b	3.38 ±0.4 ab	2.73 ±0.4 a
	45min	0.52 ±0.1 c	-0.09 ±0.1 b	-0.68 0.1a	3.7± 0.6	2.97 ±0.4	3.14± 0.4
	90min	0.4 ±0.1 b	0.17±0.11 b	-0.55 0.07a	2.8 ±0.5	2.3 ±0.4	2.27 ±0.5
	24 h	1.43 ±0.2 b	-0.34± 0.1 a	0.19 0.3 a	6.12 ±0.8	5.06± 0.5	5.19 ±0.6
b*	10min	6.8 ±0.2 c	5.6 ±0.2 b	3.5 ±0.2 a	10.9 ±0.8 b	8.63 ±0.5 ab	6.52 ±0.6 a
	45min	9.01± 0.3 b	7.76 ±0.2 b	4.72 ±0.3 a	12.0 ±0.7 b	9.01 ±0.4 a	7.21 ±0.2 a
	90min	8.6 ±0.4 b	7.81 ±0.4 b	6.03 ±0.2 a	10.8 ±0.4 b	9.83 ±0.5 a	8.17 ±0.4 a
	24 h	10.01 ±0.3 c	8.23 ±0.5 b	4.97 ±0.2 a	14.7 ±0.7 b	10.91 ±1.1 a	7.41 ±1.2 a
		Mains effects					
	pH *Diet: p<0.001* *Muscle:p<0.001* *Time: p<0.001*		*L* *Diet: p<0.05* *Muscle:p<0.001* *Time:p<0.01*		*a** *Diet:p<0.001* *Muscle:p<0.001* *Time: p<0.01*		b* Diet: p<0.001 Muscle:p<0.001 Time: p<0.001

Data are mean ± SEM. Main effects for diet, muscle and days of aging were analyzed by repeated measures ANOVA and post hoc Tukey test (P<0.05) (NCSS, 2007).

Table 2. Effect of broken rice in diet on the drip loss (%) of *Pectoralis* and *Gastrocnemius* muscles 24 hours post mortem.

	Muscle	**Broken rice (%)**			
		0	**30**	**60**	***P***
Drip loss (%)	**PM**	**3.43±0.43**	**3.04±0.3**	**3.98±0.41**	**ns**
	GM	**3.46±0.38**	**2.96±0.3**	**3.43±0.26**	**ns**

Data are mean ± SEM of n=8. Main effects for diet and muscle were analyzed by ANOVA GLM and post hoc Tukey test (P<0.05) (NCSS, 2007).

IV. CONCLUSION

From this work we can conclude that the substitution of corn with broken rice is a valuable alternative. The main effects on meat quality are the modification of pH and the loss of redness and yellowness at 24 hours *post mortem*. The positive improvement on the fresh and aged meat stability is an interesting and original effect of rice in diet in the preservation of the oxidative deterioration of poultry meat.

Table 3. Effect of feeding broken rice in substitution of corn on the lipid (TBARS, mg MDA/kg meat) and protein oxidation (carbonyls, nM DNPH/mg protein) of *Pectoralis* and *Gastrocnemius* muscles fresh (F) and aged (A).

			Broken rice (%)		
	Muscle	Aging	0	30	60
TBARS (mg MDA/kg meat)	PM	F	0.29	0.31	0.28
		A	0.30	0.27	0.26
	GM	F	0.30	0.40	0.27
		A	0.38	0.40	0.26
Main effects					
Diet : *p<0.03* ; 60%<30%<0					
Muscle : *p<0.03* ; G>P Aging : ns					
Carbonyls (nM DNPH/mg protein)	PM	F	0.15	0.17	0.15
		A	0.14	0.18	0.15
	GM	F	0.13	0.11	0.15
		A	0.13	0.18	0.14
Main effects					
Diet : ns Muscle : ns Aging : ns					

Data are mean ± SEM of n=8. Main effects for diet, muscle and ageing were analyzed by ANOVA GLM and post hoc Tukey test (P<0.05) (NCSS, 2007).

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