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Biological evaluation of mechanically deboned chicken meat protein quality

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Abstract

Mechanically deboned chicken meat (MDCM) is a meat product obtained by crushing tissues after meat removal and is largely used in meat products. Protein quality of flour prepared from defatted MDCM and from fresh chicken breast meat (FCBM) was chemically and biologically evaluated by rat growth and nitrogen balance studies. Proximate chemical composition, on a dry basis, of MDCM and FCBM showed protein contents of 90.5% and 82.2%, lipid contents of 3.0% and 13.2% and ash contents of 6.1% and 4.2%, respectively. There was a relatively good balance of essential amino acids in both samples although lysine was in low concentration in MDCM being a limiting amino acid. Feeding of flour diets resulted in high protein efficiency ratio, a high net protein utilization and high nitrogen balance, thus showing a high biological value and also high true digestibility and, consistently, NPU for both samples is similar to casein.

Keywords: Mechanically Deboned Chicken Meat; Biological evaluation; Breast meat

1. Introduction

Brazil is the third ranking chicken meat-producing country in the world with a total production of 6.5 millions tons in 2001 (APA, 2002). It is reckoned that at least 20% of chicken fresh-cut carcasses are transformed into mechanically deboned chicken meat (MDCM). Thus, it is possible to work out, roughly, that 1.3 millions tons of MDCM were produced in Brazil, in 2001.

Brazilian legislation allows a maximum of 20% of total fresh meat to be substituted by MDCM in processed meats, such as meat emulsion, paste meat and chicken nuggets (Brasil, 1981).

Bone, cartilage, and skin are tissues normally present and MDCM chemical composition varies, depending on the origin of raw material, i.e., skin tissues increase the lipid fraction and conversely the protein fraction decreases (Satterle, Froning, & Janky, 1971). Much work has been reported on different aspects of MDCM, such as mineral content (Essary, 1979), production of surimi (Yang & Froning, 1992), quality of meat emulsion (Lee, Williams, Sloan, & Littell, 1997), microbiological contamination (Hoffman, Mansor, Coelho, & Vinturim, 2002) sensory analysis related to lipid oxidation in sausage (Mielnik, Aaby, Rolfsen, Ellekjær, & Nilsson, 2002) and a relatively high collagen and its types

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(Tanaka & Shimokomaki, 1996). Although being largely consumed, world-wide, as an ingredient in meat products, few studies have been reported on its nutritional evaluation (Brinkman & Macneil, 1976). Therefore, this paper reports the MDCM biological evaluation, having FCBM for comparison, using casein as control.

2. Materials and methods

2.1. Sample preparation

A chicken meat abattoir, COMAVES, located in Londrina, PR, Brazil, kindly donated MDCM and deboned FCBM. MDCM originated from dorsal part of the carcass, bone neck meat residues and skin obtained through a Beehive RSTC separator (Beehive Machinery, Inc., Sandy, UT 84091-5002, USA). Flours were prepared from both samples and were previously dried in an air circulator oven at ca. 45 °C and subsequently powdered in a food homogeniser and passed through a 60-mesh sieve. Furthermore, only MDCM was previously defatted according to AOAC (1996), since its high content of lipid fraction did not allow an adequate nutrients balance for the ration. These flours were stored at cold temperature for subsequent chemical analysis and for preparation of the respective rations.

2.2. Animals test

Young, 21–23 days old, white male Wistar rats, weighing 35.0–45.0 g, were obtained from the Central Animal House of the Biological Sciences Centre, Londrina State University. Animals were randomly divided into three groups, each consisting of 10 rats. They were housed individually in metallic cages kept in an air-conditioned room maintained at 23.0 °C with 12 h light and dark cycles.

2.3. Amino acid analysis

Amino acid composition was determined in replicate after acid hydrolysis with 6N HCl for 24 h at 110 °C, following the methodology described by Spackman, Stein, and Moore (1958), using a Beckman HPLC-amino acid analyser.

2.4. Basic chemical composition

Percentages of moisture, fat, protein, and ash were determined by the AOAC method (1996).

2.5. Composition of diets

Diets containing flours of MDCM and FCBM were offered to two groups of 10 rats each. The third group was fed on a casein (INLAB) diet as control. All three diets, having the calculated 10.0% protein level, are listed in Table 1. For the preparation of the diets, ingredients were homogenised and passed through a 60-mesh sieve to ensure uniform distribution of minerals and vitamins, as described previously (Garcia, Mizubuti, Kanashiro, & Shimokomaki, 2001).

Table 1
Composition of the experimental diets for calculated protein as 10.0% and metabolisable energy as 36.0 MJ kg^{-1}

Ingredients	Experimental diets			
	MDCM flour	Diet protein-free	FCBM flour	Casein
Casein	–	–	–	12.23
Sucrose	10.00	10.00	10.00	10.00
FCBM flour	–	–	12.16	–
MDCM flour	11.04	–	–	–
Corn oil	4.00	3.00	4.00	2.00
Mineral mix[a]	3.50	3.50	3.50	3.50
Vitamin mix[b]	1.00	1.00	1.00	1.00
Cellulose	7.81	5.95	9.71	6.2
Corn starch	62.65	76.55	59.63	65.07

MDCM, mechanically deboned chicken meat; FCBM, fresh chicken breast meat.

[a] Containing per kg mix (g/kg): Ca_2PO_4: 490.83, NaCl: 32.63, K_2SO_4: 75.51, $MgSO_4$: 151.03, $MnSO_4 \cdot H_2O$: 60, ZnO: 60, $FeSO_4 \cdot 7H_2O$: 50, $CuSO_4 \cdot 5H_2O$: 10, KIO_3: 2.0, Na_2SeO_3: 0.005, Cobalt Oxide: 1.5.

[b] Containing per kg mix: Retinol: 12.0 IU, Cholecalciferol: 1.8 IU, α-Tocopheryl acetate: 30.0 IU, Vitamin K_3: 3.0 g, Riboflavin: 6.0 g, D-Panthotenic acid: 20.0 g, Niacin: 60.0 g, Cyanocobalamine: 0.02 g, Biotin: 0.05 g, Folic acid: 1.0 g, Thiamine: 6.0 g, Pyridoxine: 7.0 g, Choline chloride: 600.0 g.

2.6. Growth experiment

Protein efficiency ratio (PER) was determined according to AOAC (1996). Animals were initially weighed and food and water were given ad libitum. Rats fed on different experimental diets and control diet were weighed for four weeks and the gain in weight during this period was recorded. The consumed protein was calculated from the consumed nitrogen, based on diet nitrogen content.

PER was calculated by the formula below:

$$\text{PER} = \text{gain in body weight (g)}/\text{protein consumed (g)}$$

2.7. Nitrogen balance studies

Nitrogen balance studies were carried out during the experiment. During the second and third consecutive weeks, faeces and urine of each rat were collected separately. The concentration of nitrogen in urine and faeces was estimated by the microKjeldahl method according to AOAC (1996). The data obtained from this experiment were used to calculate true digestibility (TD) (Urbano et al. (1995)), and biological value (BV)

(Hackler, 1977), net protein retention (NPR) (Walker, 1983) and net protein utilisation (NPU) (Sgarbieri, 1996) by employing the following formulas:

$$\mathrm{TD} = (\mathrm{Ni} - \mathrm{NF}_1 - \mathrm{NF}_2/\mathrm{Ni}) \times 100$$

$$\mathrm{BV} = [\mathrm{Ni} - (\mathrm{NF}_1 - \mathrm{NF}_2) - (\mathrm{NU}_1 - \mathrm{NU}_2)/\mathrm{Ni} - (\mathrm{NF}_1 - \mathrm{NF}_2)] \times 100$$

Here, Ni = Nitrogen intake of animals fed test diet; NF_1 = Nitrogen excreted in faeces of animals fed test diet; NF_2 = Nitrogen excreted in faeces of animals fed protein free diet; NU_1 = Nitrogen excreted in urine of animals fed test diet; NU_2 = Nitrogen excreted in urine of animals fed protein free diet; NPR = Weight gain of test group + weight loss of protein-free group/weight of test protein consumed.

$$\mathrm{NPU} = \mathrm{BV} \times \mathrm{TD}/100$$

2.8. Statistical analysis

The data were subjected to analysis of variance (ANOVA) in a completely randomised design to determine the significant differences among various groups (Statistical Analysis Systems, 1989).

3. Results and discussion

3.1. Proximate chemical composition

Defatted and dried MDCM flour and dried FCBM flour chemical composition is presented in Table 2 and also the raw material for both flours. FCBM showed typical chemical composition for meat muscle, whereas the MDCM presented a relatively higher content of lipid fraction and a lower protein content. This amount of fat is even higher in relation to our previous work (Tanaka & Shimokomaki, 1996) probably because more skin ingredient was used which is corroborated by the lower quantity of ash, an indication of less bone and cartilagenous tissues used. Thus, it was decided to have defatted fresh MDCM to make it possible to be metabolised as flour by the animals. In the prepared flours, however, due to the fat removal process, there were ca. 4 times less lipid fraction in MDCM than in FCBM and conversely ca. 10% more protein.

Table 3
Essential amino acid composition (mg/g protein) of defatted mechanically deboned chicken meat (MDCM) and fresh chicken breast meat (FCBM) in comparison to FAO standard

Essential amino acids	MDCM flour	FAO reference[a]	FCBM flour
Histidine	17.4	19.0	30.9
Isoleucine	29.6	40.0	45.5
Leucine	58.7	70.0	86.4
Lysine	8.2	55.0	88.9
Methionine + Cystine	24.4	35.0	36.7
Phenylalanine + Tyrosine	48.8	60.0	72.6
Treonine	31.2	40.0	49.5
Tryptophan	ND	10.0	ND
Valine	33.3	50.0	48.3

ND: not determined.
[a] Garcia et al. (2001).

3.2. Essential amino acid profile

Table 3 presents the determined essential amino acid composition for flour from MDCM and FCBM. Overall, there were more essential amino acids in FCBM than in MDCM, although both had more than the daily demand for human needs (FAO/WHO/UNU, 1985).

3.3. PER and NPR

Rats fed on casein (control) had the lowest daily body weight gain (4.64 g), significantly different ($p < 0.05$) from the MDCM and FCBM diets (5.31 and 5.63 g, respectively) and both were not significantly different from each other ($p > 0.05$). Daily food and protein intakes were not significantly different ($p > 0.05$) among rat groups (Table 4). The relatively higher essential amino acid balance in FCBM, and somehow in MDCM, seems to favour their flours to give better weight gain than casein. FCBM diet had a PER of 3.74 and this value was high in comparison to MDCM (3.42) and casein (3.11), and significantly different ($p < 0.05$). The corrected PER values followed similar patterns of 3.00, 2.74 and 2.50, respectively, for flour from FCFM, MDCM and casein diets were significantly different ($p < 0.05$). NPR was shown to be higher for FCBM flour (3.68) than MDCM flour and casein (3.19 and 2.94, respectively), and significantly different ($p < 0.05$).

Table 2
Proximate chemical composition of mechanically deboned chicken meat (MDCM) and fresh chicken breast meat (FCBM) and their flour*

Samples	Moisture	Protein	Ash	Lipid
MDCM	61.66 ± 0.59	11.0 ± 0.90	0.70 ± 0.07	24.37 ± 0.47
MDCM flour	6.89 ± 0.02	84.3 ± 0.38	5.7 ± 0.07	2.87 ± 0.28
FCBM	72.34 ± 0.37	24.0 ± 0.27	1.12 ± 0.02	2.04 ± 0.29
FCBM flour	6.07 ± 0.01	77.3 ± 1.19	4.0 ± 0.02	12.42 ± 0.82

* Values are means ± SD of triplicate analyses.

Table 4
Food intake, protein intake, body weight gain of rats, PER* and NPR of mechanically deboned chicken meat flour (MDCM) and fresh chicken breast meat flour (FCBM)

Dietary groups	Daily body weight gain (g)	Daily food intake (g)	Daily protein intake (g)	PER	Corrected PER**	NPR
Casein	$4.64^b \pm 0.17$	$14.88^a \pm 0.38$	$1.48^a \pm 0.37$	$3.11^c \pm 0.04$	2.50^c	$2.94^c \pm 0.05$
MDCM flour	$5.31^a \pm 0.17$	$15.51^a \pm 0.38$	$1.55^a \pm 0.37$	$3.42^b \pm 0.04$	2.74^b	$3.19^b \pm 0.05$
FCBM flour	$5.63^a \pm 0.17$	$14.98^a \pm 0.38$	$1.50^a \pm 0.37$	$3.74^a \pm 0.04$	3.00^a	$3.68^a \pm 0.05$

[a,b,c]Within the same column, means having different superscripts are significantly different ($p \leqslant 0.05$) by Turkey test.
* Values are means ± SD of 10 rats in each group throughout 28 days of experimental period.
** Based on values of 2.5 as standard for casein MDCM.

Table 5
Nitrogen consumed, nitrogen absorbed, nitrogen retained, TD, BV and NPU values[a] of mechanically deboned chicken meat flour (MDCM) and fresh chicken breast meat flour (FCBM) fed to rats measured after second and third weeks of experiment

Dietary group	Nitrogen consumed (g)	Nitrogen absorbed (g)	Nitrogen retained (g)	BV	NPU	TD
Casein	$1.76^a \pm 0.05$	$1.68^a \pm 0.05$	$1.53^a \pm 0.06$	$88.8^a \pm 1.46$	$1.07^a \pm 0.01$	$96.3^a \pm 0.20$
MDCM flour	$1.88^a \pm 0.05$	$1.74^a \pm 0.05$	$1.62^a \pm 0.05$	$91.7^a \pm 1.38$	$1.00^b \pm 0.01$	$92.9^c \pm 0.20$
FCBM flour	$1.88^a \pm 0.05$	$1.71^a \pm 0.05$	$1.52^a \pm 0.05$	$89.0^a \pm 1.24$	$1.05^a \pm 0.01$	$95.2^b \pm 0.20$

BV, biological value; NPU, net protein utilization; TD, true digestibility.
[a] Values are means ± SD of 10 rats in each group.

3.4. Nitrogen consumption, absorption, digestibility, BV and NPU

Nitrogen consumed, nitrogen absorbed and nitrogen retained were not significantly different ($p > 0.05$) between animals fed with casein and those fed with MDCM and FCBM flours.

True digestibility was the lowest ($p < 0.05$) for MDCM flour (92.9) and highest for casein (96.3), FCBM flour having an intermediate value (95.2). It is fair to conclude that these differences are because the essential amino acid profile would have an influence on digestibility (Table 5).

Biological value was observed to be not significantly different ($p > 0.05$), although it was higher in MDCM (91.7) than in FCBM flours and casein (89.0 and 88.8, respectively).

4. Conclusions

Biological parameters indicated that defatted mechanically deboned chicken meat flour presented reasonable nutritional properties, close to chicken breast meat flour, despite its low content of lysine.

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