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Preliminary communication

PHYSICAL AND CHEMICAL CHARACTERISATION OF SPENT HENS MECHANICALLY SEPARATED MEAT (MSHM) FROM THE BRAZILIAN PRODUCTION

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The objective of this study was to characterise and compare the quality of the MSMs obtained from carcasses from breeding and laying hens to provide useful information for the processing industry. The composition of the mechanically separated meat (MSM) varied between the two groups. Laying hens contained the most crude protein ($P<0.05$) and high ash content ($P<0.05$). Calcium concentrations and bone contents were higher ($P<0.05$) for laying (448 mg/100 g and 1.25%, respectively) than for breeding hens (299 mg/100 g and 0.78%, respectively). Levels of unsaturated fatty acids for laying and breeding hens (75.89 and 72.82%, respectively) and cholesterol concentrations (73 and 61 mg/100 g, respectively) were higher ($P<0.05$) for laying hens than for breeding ones.

Keywords: chemical composition, mechanically separated meat, physical characteristics, spent hens

Consumption of poultry meat products is growing all over the world. Poultry production in Brazil has made tremendous progress in the last decade. In Brazil, the confined chicken herds in 2006 was 64 million commercial layers hens and 34 millions heavy broilers (UBA, 2007). All of the confined laying hens are slaughtered at the end of the commercial laying cycle (between 12 and 18 months) and these hens are referred to and marketed as "spent hens". In the European Community (EC) and other countries, meat recovered from bones and by mechanical procedures from carcass parts is generally considered to be of poor quality. The spent hens are a good source of protein, but they have only a minimal economic value in Brazil and have been used primarily for soups and feedstuffs. Therefore, additional uses need to be developed to increase the value of the spent hen market. The meat from the spent hens is very tough due to its higher

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collagen content in comparison to broilers. According to several authors (LEE et al., 1997), one alternative would be to mechanically separate the meat of these hens, which could be used in sausage production, a very popular product in Brazil. Mechanical separation is an efficient way of getting most of the meat from the bones of chickens, turkeys or other animals. Bones with edible meat attached are forced under high pressure through a device that separates the bone from the meat. The resulting mechanically separated meat (MSM) has the appearance of finely homogenated meat. MSMs are frequently used in the formulation of emulsified meat products due to their fine consistency and relatively low cost in Brazil.

Mechanically separated poultry meat has good nutritional and functional properties and is suitable for the formulation of many meat products (FRONING, 1981; FIELD, 1988). The composition and storage stability of the final product is affected by the raw materials and conditions used for mechanical separation (FRONING, 1981; CROSLAND et al., 1995).

Therefore, the purpose of this research was to characterise and to compare the physical and chemical properties, in addition to some nutritional aspects, of MSM of two different hen types in order to obtain useful information that is in the interest of both the industry and the consumer. This assessment of the quality of MSHM (mechanically separated meat of spent hens) could help to popularise the consumption of products developed from MSM in Brazil.

1. Materials and methods

1.1. Raw materials and mechanical meat/bone separation

Carcasses from approximately 15-month-old broiler breeders (Cobb 500) and 18-month-old White Leghorn layers were obtained from a local slaughterhouse and transported frozen to the processing plant at the Meat Technological Center/ITAL, Campinas, SP. Three replications for each treatment (type of MSM) were used to generate the experimental data. The experiments were conducted over a four-month interval (from December to March). In each replication, 150 kg of meat was mechanically deboned, which is equivalent to approximately 45 breeding hens and 110 laying hens. After the removal of the breasts, the remaining parts of the carcasses were processed by MS using a POSS extractor model PDE 1000. The MSHM was homogenised, packed in polyethylene bags, and stored at –18 °C for further laboratory analysis.

1.2. Chemical and physical characterisation of the MSM

Each analysis was performed in triplicate. For fatty acid profile, only one analysis was done.

1.2.1. Proximal analysis and pH. The MSHM samples were homogenised for 40 s in a food processor prior to chemical analysis. Official A.O.A.C. (1998) methods were used for protein, fat, moisture and ash analyses. The pH values were determined with a pH-meter equipped with an electrode inserted directly into the sample material.

1.2.2. Calcium and iron. For determination of mineral contents, the samples (1.5 g) were ashed at 550 °C for 24 h. After cooling, the ash was dissolved with a few drops of deionised water followed by the addition of HNO_3. Calcium and iron levels were determined by inductively coupled plasma optical emission spectrometry – ICPOES (Baird Analytical Instruments Division).

1.2.3. Bone content and bone particle size. The samples were digested in an alcoholic (15% methanol/85% ethanol) solution containing 8% potassium hydroxide followed by several consecutive rinses with distilled water. The bones were dried in a laboratory-drying oven and weighed. The size of the bones was determined using standard sieves of different mesh sizes (BERAQUET et al., 1989).

1.2.4. Collagen content. The collagen content was determined by measuring the hydroxyproline level by colorimetric analysis (AMTLICHE UNTERSUCHUNGSVEFAHREN, 1980). For this purpose, the samples were oxidised with chloramine T and quantification was carried out by UV-visible spectrophotometer (VARIAN, Model Cary). The colour reaction was developed after the addition of dimethyl-aminobenzaldehyde dissolved in perchloric acid and isopropanol. The standard curve was determined through hydroxyproline. The collagen content was derived by multiplying the content of hydroxyproline by a factor of 8.

1.2.5. Fatty acid profile. The fatty acid profile was established by analysing the fatty acid methyl esters by gas chromatography (HP-Hewlett Packard) equipped with a flame ionisation detector. The exact amounts of the individual fatty acids were calculated from peak areas (dividing the corresponding peak areas by the total area).

1.2.6. Cholesterol level. Cholesterol levels were measured by HPLC (Amershan Biosciences, GE Healthcare) according to the method described by BRAGAGNOLO and RODRIGUEZ-AMAYA (1997).

1.3. Statistical analysis

Differences found between the MSM's values were statistically evaluated by t-test for independent samples (P=0.05).

2. Results and discussion

The yield of the meat-bone separation process was close to 70% for both hen types in the three independent replications.

2.1. Composition of MSHM

The composition of MSM is subject to an extremely large variability and depends on species, breed and age of the animals as well as carcass parts used, degree of trimming, machine type and settings (CROSLAND et al., 1995). The protein, fat and moisture levels of the MSHM analysed in the present study fell within the ranges found by several other authors. The findings indicated a greater concentration of protein and a lower content of fat from the MSM of layers when compared with those values obtained for the broiler breeders (Table 1). AL-NAJDAWI and ABDULLAH (2002) reported greater protein contents (20.45%) and lower fat contents (9.15%) in MSM from whole hens when compared to the data obtained in this study. These differences could be explained by the fact that in our study the MSHM was not obtained from the whole carcass, but from carcasses where the breasts had been removed prior to mechanical extraction, thus reducing the meat content of the carcasses.

Table 1. Chemical composition (wet basis) of the mechanically separated meats (MSM) of white layer hens and broiler breeder hens

	MSM of broiler breeders		MSM of white layers	
	Means	SE	Means	SE
Protein (%)	13.6[b]	0.2	15.2[a]	0.5
Fat (%)	22.5[a]	1.6	16.9[b]	2.5
Moisture (%)	59.9[b]	0.9	63.9[a]	2.0
Ash (%)	1.4[b]	0.1	2.1[a]	0.2
Collagen (%)	1.6[b]	0.08	3.2[a]	0.24
Calcium (mg/100 g)	299[b]	5	448[a]	1
Iron (mg/100 g)	2.4[a]	0.01	2.3[a]	0.03
Cholesterol (mg/100 g)	61[b]	1	73[a]	1
pH	6.4[a]	0.1	6.6[a]	0.1

n=3
Means in the same row with no common superscript differ significantly (P<0.05)
SE: Standard error

Mechanical separation of hen carcasses resulted in meat of higher (P<0.05) ash content for MSM of layers than MSM of broiler breeders (Table 1). Both ash values are higher than those found for HSM. The high ash values in MSHM are probably the result of bone particles incorporated into the meat.

Under the current Brazilian quality standards (MINISTÉRIO DA AGRICULTURA E ABASTECIMENTO BRAZIL, 2000), MSM must contain at least 12% protein and maximum 30% fat. Despite the fact that the protein content was slightly higher (P<0.05) and the fat content was lower (P<0.05) for mechanically separated laying hen meat, the MSHM analysed in this study complied with the Brazilian legal requirements for these components.

The pH values found in this study (Table 1) fell within the range reported by other authors. These values were lower than those found by RIVERA and co-workers (2000), who obtained pH of 6.83 for MSM prepared from chicken fronts, half-frames, breasts and rib cages. As stated earlier, the higher pH value in MSM's is due to the incorporation of bone marrow, a part of the carcass that presents high pH values when compared to most of the other parts of the carcass. These high pH values contributed to an increase in the microbiological perishability of the MSMs, however, it improves the water holding capacity (WHC).

The calculated moisture to protein ratios for MSM from broiler breeders (3.6) and MSM from layers (3.8) are relatively high compared with skeletal muscle and suggest that less additional water is likely to be retained by the ingredients during processing.

2.2. Calcium and iron

Calcium contents were used as an indicator of the amount of bone in the meat. High calcium content is usually associated with a high amount of bone fragment in the product. The Brazilian quality standards establish that the calcium content of MSM must not exceed 1500 mg/100 g, the same maximum calcium level that has been laid down in European standards (BERAQUET, 2000). Table 1 shows that the MSM of layers analysed in this study exhibited higher calcium levels ($P<0.05$) than the MSM of broiler breeders. These results are probably due to the fact that the laying hens were older (18 months) and consequently had greater bone calcification and lower meat/bone ratios than carcasses of broiler breeders, thus confirming the higher ash values for this hen type. The calcium levels for MSM of layers and spent broiler breeders (1240 and 750 mg/100 g, respectively) were well below the maximum permitted values. HENCKEL and co-workers (2004) analysed the calcium contents of MSM obtained from different parts of chicken carcasses and reported values varying from 355 to 1233 ppm for backs and breast parts. These values were similar to those found in our study. AL-NAJDAWI and ABDULLAH (2002) obtained 230 mg/100 g Ca for "spent" Leghorn chickens and CROSLAND and co-workers (1995) reported 240 mg/100 g using a Protecon Auto Deboner (PAD) machine with operating conditions of 280 bar for 6 s. The different levels of calcium in mechanically separated chicken meat can be better explained by the lower degree of calcification in younger birds in comparison to older birds such as spent hens.

The iron values of the two types of MSHM presented no difference ($P>0.05$) (Table 1) and the results are in accordance with HENCKEL and co-workers (2004) who found similar iron content for MSM of breast parts to those that we observed in our study (2.24 mg iron/100 g). AL-NAJDAWI and ABDULLAH (2002) reported 4.2 mg/100 g for MSM of "spent" Leghorn chickens, which was higher than the results obtained for either of the MSHM from this study. These higher contents may be due to variations in the composition of the raw materials or to the mechanical separation settings. The mechanical settings could contribute to the release of bone fluids, haem pigments and calcium phosphate that contain iron, from the porous bones as a result of the high pressure exerted on the bone material during the extraction process (CROSLAND et al., 1995).

2.3. Bone content and bone particle size

MSM of layers presented a higher total percentage ($P<0.05$) of bone content than broiler breeders (Table 2). The difference may be due to the layers' higher bone/meat ratio, since the same extraction output was obtained for both types of MSHM (nearly 70%). Therefore, the higher degree of calcification of laying birds lead to increased fragmentation of the bones when the carcass parts were passed through the meat/bone separator, thereby resulting in higher levels of bone particles in the MSM. These levels are below those observed in our study when compared with the corresponding 0.975% bone content in MSM from spent Leghorn chickens (AL-NAJDAWI & ABDULLAH, 2002).

Table 2. Bone content and bone particle size of the mechanically separated meats (MSM) of white layer hens and broiler breeder hens

	Bone content (g/100 g sample)		Bone particle size		
	Means	SE	<0.50 mm	0.50–0.85 mm	>0.85 mm
MSM of white layers	1.25[a]	0.10	89.85[a]	6.94[a]	2.98[a]
MSM of broiler breeders	0.78[b]	0.08	92.32[a]	6.91[a]	2.35[a]

n=3
Means within a column with no common superscript are significantly different ($P<0.05$)
SE: Standard error

According to FIELD (1988), the average calcium concentration of poultry bones is about 37%. Based on this figure, the bone content can be calculated by multiplying the calcium level by 2.7. When converted by this method, the bone contents of MSM of the layers and of the broiler breeders found in this study were 1.23 and 0.81, which are very close to those obtained with the direct weighing method.

The size of the bone particles in the MSHM analysed in this study exceeded the maximum size permitted by the Brazilian quality standards (MINISTÉRIO DA AGRICULTURA E ABASTECIMENTO BRAZIL, 2000) which establishes that 98% of the bone particles must not be greater than 0.5 mm and that no particle may exceed 0.85 mm. The results in Table 2 show that about 90% of the particles were smaller than 0.5 mm, but about 3% exceeded the maximum limit of 0.85 mm for MSHM of the layers. However, our results are close to the values reported in the literature. BERAQUET (2000) reports that from 74.4 to 89.5% of the bone particles contained in MSM made from different parts of chicken carcasses were smaller than 0.5 mm and from 0.5 to 4.1% exceeded the legal maximum limit of 0.85 mm.

2.4. Collagen content

For MSHM, low collagen contents are desired due to the low content of essential amino acids in collagen when compared to muscle proteins, which subsequently results in overall lower nutritional values. The values found in this study for collagen content were lower ($P<0.05$) for MSM of broilers breeders than for MSM of layers (Table 1), which is probably due to the lower meat/bone ratio of the layers. Collagen can be derived from the skin and is a major protein component of the bone, thus, if the MSHM of layers have higher amount of bone particles, this will be reflected in higher collagen content. According to HENCKEL and co-workers (2004), MSM of chicken breasts and backs parts contained 1.11% and 1.36%, respectively, which are lower than our values.

This may be explained by the large amount of thigh meat in the MSHM used in this study, which was obtained from carcasses with thighs without the breasts. The thigh meat has higher collagen content due to the large amount of tendons. CROSLAND and co-workers (1995) found similar collagen values (1.7%) for MSM of hen backs when compared to those found for MSM of broiler breeders.

2.5. Fatty acid profile

There was no significant difference (P>0.05) in the total fatty acid profiles between the two types of MSM determined in this study (Table 1). The highest proportion of fatty acids found was represented by 16- and 18-carbon long chains (Table 3). These values were found to be quite similar to the fatty acid profiles observed by MOTT and co-workers (1982) in MSM from whole carcasses of spent layers (26.2% saturated and 73.8% unsaturated fatty acids) and in carcasses without skin (31.8% saturated and 68.2% unsaturated fatty acids). The fatty acid profiles observed by JANTAWAT and DAWSON (1980) in both chicken MSM and HSM presented lower proportions of unsaturated fatty acids (approximately 65% for both meats) than those found in the MSM of layers (75.89%) and broiler breeders (72.82%) analysed in this study. MSHM contained higher percentage of polyunsaturated fatty acids than broiler *Biceps femoris* (10.74%) (WATTANACHANT et al., 2004). These higher values are probably because both kinds of MSM are composed of thighs, drumsticks and backs. This shows that the higher the contents of unsaturated fatty acids in the meat, the higher its nutritional value, however, unsaturated fatty acids are also highly susceptible to oxidation.

Table 3. Fatty acid profiles found for the MSMs of laying and breeding hens (% of the total fatty acids identified)

Fatty acid	MSMCL	MSMBB
Saturated		
Miristic C14:0	0.26	0.57
Pentadecanoic C15:0	Tr	0.04
Palmitic C16:0	16.70	20.47
Margaric C17:0	Tr	0.08
Stearic C18:0	5.49	4.88
Arachidic C20:0	1.66	1.13
Monounsaturated		
Palmitoleic C16:1	2.45	3.54
Oleic C18:1	37.25	40.45
Eicosenoic C20:1	Tr	0.04
Polyunsaturated		
Linoleic C18:2	35.98	28.68
Linolenic C18:3	0.13	0.11
Arachidonic C20:4	0.08	Tr

MSMCL: mechanically separated meat of commercial layer hens
MSMBB: mechanically separated meat of broiler breeders
Tr: traces

2.6. Cholesterol level

The cholesterol concentrations were higher (P<0.05) for layers than for broiler breeders (Table 1). Cholesterol can be released from the bone marrow by mechanical deboning, thus increasing the cholesterol concentration in MSM. The variations in the fatty acid content and in the higher percentage of cholesterol could also be affected by the body fat and skin. JANTAWAT and DAWSON (1980) evaluated spent hen meat MSM and found cholesterol contents between 73.5 to 110.0 mg/100 g. Similarly, AL-NAJDAWI and ABDULLAH (2002) found cholesterol contents of 122.5 mg/100 g for MSM of spent Leghorn chickens. The results of the cholesterol levels found for both MSHMs in our study were lower than those reported by other authors.

3. Conclusions

The MSHMs of broiler breeders and commercial layers showed contents of fat, protein and calcium within the levels allowed by the Brazilian Quality Standards. Moreover, the content of collagen, cholesterol and unsaturated fatty acids did not impair the processing and consumption of these meats. Bone particle sizes were found to be greater than those allowed by the Brazilian Standards, therefore care should be taken in the preparation of the MSHM utilised for processed foods.

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