MECHANICALLY SEPARATED MEAT OF BROILER BREEDER AND WHITE LAYER SPENT HENS

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ABSTRACT: There are approximately 90 millions of hens housed in Brazil, that concluding their production cycle, become available for slaughter. The poultry industry has economical interest in the use of spent hen meat through adequate processes. This review evaluates the quality of mechanically separated spent hen meat by chemical and functional characteristics, such as proximate composition, collagen, cholesterol, bones, calcium and iron contents, fatty acid profile, pH and emulsifying capacity, and as raw material for sausage production. The mechanical separation of meat might be a good alternative use for spent hen carcasses.

Key words: MSM, chemical composition, cholesterol, functional characteristics

INTRODUCTION

The number of confined hens in Brazil is as large as 60 million commercial egg-layers and 30 million broiler breeders. Broiler breeders produce commercial broilers with high hybrid vigor for meat production. They are heavy birds (3-to-4-kg) with satisfactory amount of meat in the breast and thighs. However, they also have a lot of subcutaneous and abdominal fat. Cornish and Plymouth Rock are basically the two most used breeds of broilers. On the other hand, the white commercial layers are small birds, weighing up to 1.5 kg, with little meat. They are raised apart of males to produce eggs. The most common breed used is the White Leghorn, which produces white eggs.

According to Lyons (2001), the volume of biological material, costs of labor and transportation associated to the slaughtering of laying hens make it one of the main economical and environmental problems of poultry industry. According to the author, there are approximately 320 million confined layers in the U.S.A., which value about US$ 2.69 each, 55% of which are slaughtered annually. At the end of the production cycle, the value per bird is reduced to US$ 0.07, and commercial layers and broiler breeders are then normally slaughtered and made available for the production of concentrated broths, domestic consumption in soups and stews. (Ajuyah et al., 1992; Voller-Reasonover et al., 1997). Farms have difficulty selling these birds with reasonable profit. Grunden et al. (1972) reported that depreciation of hens was the second highest cost in the egg production industry, behind only the cost of the feed. Kondaiah & Panda (1987) affirm that one of the main needs of poultry farming is the upgrade of spent hens.

Another area for the use of these poultry is the production of sausages, using mechanically separated hen meat (MSHM) (Mott et al., 1982; Lee et al., 1997; Grunden et al., 1972; Jantawat & Dawson, 1980). Mechanically-separated chicken meat (MSCM) is made from the deboning and cutting of parts with lower commercial value, such as the back and the neck (Barreto, 1995), while the production of MSHM is normally made from the whole carcass. With the objec-
Mechanically separated meat

Early deboning or mechanical separation machines were developed for fish in Japan in the late 1940s, as a result of the need of the fish processing industry of using meat from several species of fish that were underutilized, and the increasing demand for products that could be produced with mechanically separated fish meat. The mechanical separation of poultry began in the late 1950s in the U.S.A, but for different reasons. The consumer preference for chicken cuts instead of whole chicken and, later on, the demand for chicken fillets and convenience products, such as nuggets, hamburgers and marinated cuts, required the finding of ways to use backs, necks, and bones left overs from manual deboning processes. These parts make up about 24% of the edible part. From there on, the mechanically separated meat of poultry became available and started to be used in the manufacture of several products, such as sausages, bolognas, salamis and dry soups (Field, 1988; Froning, 1981).

In every deboning process, after the removal of the usual meat cuts, there is always an amount of meat which is firmly attached to the bones. Mechanically separated meat is a product resulting from the mechanical separation of the meats attached to these bones. Normally the mechanical separation is made for bones of irregular shape, more difficult to be manually deboned, such as vertebral column and neck. However, other bones with attached meat, or whole carcasses, can be submitted to mechanical separation.

Chemical composition of mechanically separated poultry meat

With the introduction and increasing use of mechanically separated meats in the elaboration of sausages and other industrialized products, many questions arose regarding their nutritional value for human consumption. Studies on the most diversified characteristics of these meats were carried out on contents and quality of proteins, lipids and minerals, bone content, lipid and pigment stability, pathogenic and spoilage bacteria, among others, proved that consumption of MSMs does not jeopardize human health and can prevent the wasting of large amounts of minerals, lipids and animal protein. Next, some aspects of the chemical and nutritional composition of MSMs that can influence their use for the elaboration of sausages will be discussed.

Proximate composition

Mechanical deboning of poultry affects the proximate composition of resulting meat. Considerable amounts of lipids present in the raw material are incorporated in the MSMs, diluting protein and increasing the lipid contents of the deboned tissues. These lipids include those present in the bone marrow, the subcutaneous fat, the skin and the abdominal fat, excluding the fat of the viscera removed during the slaughtering process. Moreover, the proximate composition can vary according to the settings and type of machine used for the mechanical separation (Froning, 1981).

Table 1 presents the proximate compositions of MSMs from several sources. The lipid content of the MSM is really higher and the protein contents are lower in MSMs in comparison to fillets, diluting protein and increasing the lipid contents of the deboned tissues. These lipids include those present in the bone marrow, the subcutaneous fat, the skin and the abdominal fat, excluding the fat of the viscera removed during the slaughtering process. Moreover, the proximate composition can vary according to the settings and type of machine used for the mechanical separation (Froning, 1981).

| Raw material                        | Protein | Fat  | Moisture | Ash | References          |
|------------------------------------|---------|------|----------|-----|---------------------|
| Hen MSM                            | 15.5    | 19.0 | 63.8     | 1.3 | Hamm & Young (1983) |
| Hen MSM                            | 15.4    | 20.4 | 62.5     | 1.2 | Mott et al. (1982)  |
| Hen MSM                            | 14.2    | 26.2 | 60.1     | n.a.| Grunden et al. (1972)|
| Hen MSM                            | 13.9    | 18.3 | 65.1     | n.a.| Froning (1981)      |
| Chicken back w/skin MSM            | 8.5     | 30.4 | 60.0     | 0.6 | Pollonio (1994)     |
| Chicken back w/o skin MSM          | 12.4    | 15.0 | 70.1     | 1.1 | Pollonio (1994)     |
| Chicken back and neck MSM          | 9.3     | 27.2 | 63.4     | n.a.| Grunden et al. (1972)|
| Chicken back and neck MSM          | 13.4    | 14.4 | 72.2     | n.a.| Essary (1979)       |
| Hen breast fillets                 | 23.1    | 3.4  | 72.1     | 1.2 | Kondaiah & Panda (1987)|
| Hen thigh fillets                  | 19.5    | 8.8  | 69.9     | 1.0 | Kondaiah & Panda (1987)|

Table 1 - Proximate composition of manually deboned hen meat and MSMs of hens and chicken (fresh weight basis).

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Collagen content

High contents of collagen in any meat can negatively influence its technological and nutritional characteristics, since collagen is a protein with inferior functionality and low nutritional value because of its poor balance of amino acids. However, as collagen is strongly attached to the bones, very little of it goes through the ridges of the deboning machines and, consequently, little collagen is incorporated to MSMs (Field, 1988). Nonetheless Al-Najdawi & Abdullah (2002) evaluated collagen contents in manually and mechanically deboned meats of whole and skinned hens, and observed higher contents of collagen in the MSMs (3.45 and 3.00% for whole and skinned carcasses, respectively) in comparison to the meats of manually deboned hens (1.60 and 0.85% for whole and skinned carcasses, respectively).

The content of the amino acid hydroxyproline is an index of the amount of connective tissue in a meat has been considered by several researchers. According to Babji et al. (1980), hydroxyproline contents was higher in the MSM of cooked hen (0.76 g 100 g^-1 of tissue) in comparison to the MSM of chicken back and neck (0.37 g 100 g^-1 of tissue), because cooking facilitates the removal of collagen. This report was confirmed by Hamm & Young (1983) who, next to other raw materials, compared the MSM of raw and cooked hens. There was a small elevation in the content of hydroxyproline for the cooked hen’s MSM (0.38 g 100 g^-1 of tissue) in comparison to the raw hen’s MSM (0.36 g 100 g^-1 of tissue). However, even with this increase, the content of hydroxyproline was close to that found for the MSM of chicken (0.30 g 100 g^-1 of tissue), unlike the values found by Babji et al. (1980).

Fatty acids Profile

Amongst the fatty acids profile of meats, the high levels of unsaturated fatty acids are usually associated to poultry. Unsaturated fatty acids are regarded as beneficial to human health. However, they are more prone to oxidation, causing losses in sensorial quality of meats during the storage.

Several authors evaluated the profile of fatty acids in MSMs with the purpose of comparing it to those found in manually deboned meats, according to the incorporation of the lipids of the bone marrow and the skin of the poultry. Mott et al. (1982) compared the MSM of whole hens with the MSM of skinned hens, and found higher concentrations of unsaturated fatty acids in the first. On the other hand, according to Moerck & Ball (1974), the composition of fatty acids in the marrow and in the MSM of chicken was similar to that of the breast, thigh and skin. Jantawat & Dawson (1980) compared mechanically and manually deboned hen meats, and also found very close fatty acids profiles, as shown in Table 2.

Cholesterol content

A potential aspect of concern by consumers is the cholesterol content, which is higher in MSMs than in manually separated meats as a result of the inclusion of the bone marrow material, which has high cholesterol concentrations. Ang & Hamm (1982) analyzed cholesterol.

Table 2 - Fatty acids profile of mechanically separated meats of chicken and hens and in meat of hen breasts.

| Fatty acids       | MSM hens w/skin | MSM hens | Light hen meat | Dark hen meat |
|------------------|----------------|----------|----------------|---------------|
|                  |                |          | MSM\(^i\) | Manual\(^i\) | MSM\(^j\) | Manual\(^j\) |
| **Saturated**    |                |          |            |               |            |               |
| Lauric C12:0     | -              | -        | 1.6        | 1.6           | 1.2        | 1.6           |
| Miristic C14:0   | 1.1            | 0.9      | 2.2        | 2.8           | 2.5        | 2.8           |
| Palmitic C16:0   | 26.3           | 21.2     | 23.3       | 21.4          | 20.7       | 17.4          |
| Stearic C18:0    | 4.4            | 4.1      | 7.5        | 10.4          | 8.4        | 11.5          |
| TOTAL SATURATED  | 31.8           | 26.2     | 34.6       | 36.2          | 32.8       | 33.3          |
| **Monounsaturated** |              |          |            |               |            |               |
| Palmitoleic C16:1| 7.1            | 5.4      | 5.7        | 6.8           | 7.4        | 10.1          |
| Oleic C18:1      | 41.8           | 45.5     | 34.9       | 32.7          | 32.7       | 28.5          |
| **Polyunsaturated** |              |          |            |               |            |               |
| Linoleic C18:2   | 19.3           | 22.1     | 23.2       | 22.4          | 25.4       | 25.5          |
| Linolenic C18:3  | Tr             | 0.8      | 1.5        | 1.9           | 1.7        | 2.5           |
| Arachidic C20:4  | -              | -        | Tr         | Tr            | Tr         | Tr            |
| TOTAL UNSATURATED| 68.2           | 73.8     | 65.3       | 63.8          | 67.2       | 66.6          |

\(^i\) Mott et al. (1982): MSM of spent layers without skin; \(^j\) Mott et al. (1982): MSM of whole carcasses of spent layers; \(^k\) Jantawat & Dawson (1980); \(^l\) MSM gotten from the keel of hen breasts; \(^m\) Fillet manually deboned hen breasts; \(^n\) MSM from back and neck; \(^o\) Manually deboned thighs and wings meat
The calcium content has generally been used as a measure of the bone content in MSMs. Ang & Hamm (1982) found much higher calcium contents (53 – 91 mg 100 g⁻¹ sample) in MSMs from different cuts (chicken neck, with and without skin, and back) than in manually deboned meats from the same cuts (17-34 mg 100 g⁻¹ sample). Grunden et al. (1972) reported that the MSM from whole carcasses of spent layers presents higher calcium contents than the MSM from chicken backs and necks, and turkey backs. Recently, Al-Najdawi & Abdullah (2002) evaluated the mineral contents of several manually and mechanically deboned meats of whole or skinned hens and found much higher calcium contents in the MSMs (162.5 and 230.0 mg 100 g⁻¹ of whole and skinned carcasses, respectively) in comparison to manually deboned hens (16.75 and 13.50 mg 100 g⁻¹ of whole and skinned carcasses, respectively).

The determination of bones (or calcium content) in MSM is a form of controlling the yield of mechanical separation processes. A high bone content means that the pressure used in the deboning process was too high or that the meat to bone ratio was too low (Beraquet, 2000).

The size of the bone particles is determined by the size of the mesh of the deboning “sieve”. The Brazilian legislation (Brasil, 2000) establishes that 98% of bone particles must have a maximum size of 0.5 mm and maximum width of 0.85 mm. Koolmes et al. (1986) found that between 84.8 and 97.5% of bone particles of MSMs obtained through different deboning machines were smaller than 1.0 mm.

**Technological aspects**

The main use of the MSM, a soft texture material, is in the production of a meat batter as, sausages and Mortadella. In annexes II, III and IV of Normative Instruction n°. 04, of March 31, 2000 (Brasil, 2000), the Technical Regulations of the Identity and Quality of Mortadella and sausages were approved, establishing the limits to the addition of MSM. Table 4 presents data on some of the characteristics of the products for which the use of MSM is allowed. This regulation allows the use of up to 60% of MSM in substitution of the meat raw material in some types of emulsified sausages. The problem with the use of large ratios of MSM in meat products is the low stability of this raw material, which is very prone to lipid and pigment oxidation as well as microbial growth.

In addition to the protein and fat contents, some technological aspects, such as pH, water holding capacity and emulsifying capacity, are the main factors affecting the technological quality of MSM. The functionality of myofibrillar proteins determines the quality of the meat emulsion formed, mainly regarding the texture, the yield of the process, and the emulsion stability. However, oxidized lipids, which can be present in the MSMs, can cause

| Cholesterol | Mechanical deboning | Manual deboning |
|-------------|---------------------|-----------------|
| Neck without skin | 94 | 75 |
| Neck with skin | 109 | 94 |
| Back | 95 | 81 |

¹Ang & Hamm (1982)
protein polymerization and insolubilization, polypeptide chain rupture, amino acid destruction, and formation of products with protein addition. These interactions influence negatively the functional properties of the meat. The higher the instability of the material in regard to lipid oxidation, as in the case of the MSMs, the greater the effects on the functionality. In systems with high water activity or aqueous solution, proteins form crossed links among themselves in the presence of peroxidized lipids, with simultaneous loss of solubility. Reactions between malonaldehyde, a by-product of the lipid oxidation, and free amino groups of proteins, lead to the formation of irreversible covalent links, with a consequent loss of the solubility of proteins (Pollonio, 1994).

**Hydrogenionic potential (pH)**

Generally, MSMs present higher pH than manually deboned meats, in general as a result of the incorporation of red marrow, in wich pH ranges from 6.8 to 7.4 (Field, 1988). According to Beraquet (2000), the pH of manually deboned meat lies between 5.8 and 5.9 for the breast and 6.2 and 6.3 for the thigh, whereas MSMs have values between 6.5 and 7.0. These high pH values favor the water holding capacity, but, on the other hand contribute to the increase in the bacterial load, speeding up the spoilage process.

**Water holding capacity (WHC)**

This property is related to the weight loss and final quality of the product in which the MSM is used, as a result of the formulation, processing, storage, cooking and freezing. The MSM increases the WHC of the products, for it has a higher pH than the manually deboned meats. Calcium, magnesium, iron and copper decrease the WHC. The presence of the conjunctive tissue, in which the main protein is collagen, makes the WHC decrease when heated at temperatures of 60-65°C, causing shrinking, deficient skinning, unstable emulsions, gel formations and wrinkling of the external skin of the emulsified products. Freezing decreases the WHC of the MSM, especially when done slowly (Field, 1988).

**Emulsifying capacity**

MSMs have been widely used in the emulsified sausages production. Therefore, the emulsification capacity is an important attribute of these meats. The determination of this functional property generally follows the methodology described by Swift et al. (1961), based in the amount of oil that a meat is able to emulsify. The values are generally expressed in mL of oil per 2.5 g of meat. Variations in the emulsifying capacity of a MSM may result from its composition, quality and amount of proteins, protein denaturation, freezing and storage. The content of fat in MSM is the main factor that affects its capacity of emulsification.

Froning et al. (1973) studied the influence of the skin content of MSM on several functional properties and observed that as there was an increase in the addition of skin to the carcasses (0; 16.8; 28.9 and 38.9%) before the mechanical separation, there was a proportional increase in the content of fat in MSM (15.3; 24.6; 29.8 and 33.6%), and a reduction in the emulsifying capacity (182, 148, 133 and 127 mL oil 2.5 g-1 MSM). The increase in the skin level did not cause a significant increase in the collagen content of the MSMs.

Regarding the proteins quality, McMahon & Dawson, quoted by Froning (1981), determined the soluble protein content in manually and mechanically deboned turkey meat. The percentage of these proteins was lower in the MSM than in the manually deboned meat. The emulsifying capacity was higher in the manually deboned meat but, on the other hand, the MSM presented greater water holding capacity.

**Sensorial quality of sausages made with hen MSM**

In general, differences in the flavor (aroma and taste) of products added up to 20% of MSM are not noticed, making them even more acceptable at times for being softer and juicier. However, with storage, the change in the flavor is more quickly detected than in products with no addition of MSM. This change has been described as a residual flavor of liver and has been attributed to the marrow.

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Table 4 - Some Identity and Quality Characteristics of Meat Products containing MSM.

| Products                      | Humid.1 (max.) | Fat2 (max.) | Calcium2 (max.) | MSM3 (max.) |
|-------------------------------|---------------|------------|-----------------|-------------|
| Bologna                       | 65            | 30         | 0.9             | 60          |
| Bologna                       | 65            | 30         | 0.3             | 20          |
| Poultry bologna               | 65            | 30         | 0.6             | 40          |
| Cooked sausages               | 60            | 30         | 0.3             | 60          |
| Sausages                      | 65            | 30         | 0.9             | 60          |
| Vienna or Frankfurt Sausages  | 65            | 30         | 0.6             | 60          |
| Poultry sausage               | 65            | 30         | 0.9             | 60          |
| Cooked hamburger              | ---           | 23         | 0.45            | 30          |
| Cozida meat balls             | ---           | 18         | 0.45            | 30          |

Source: Beraquet (2000)

1Fresh weight basis; 2Dry weight basis; 3Mechanically separated meat of (animal species)
Baker et al. (1984) carried out a sensorial evaluation of the global acceptance in a 9-point scale (9 = excellent and 1 = poor) for hamburgers elaborated with manually deboned meat of chicken thigh (GrTh) and mechanically separated Leghorn hens meat (MDSL), and reported that the sensorial panel rated 7.0; 6.0 and 5.2 the products elaborated with 100% GrTh, 50%/50% GrTh/MDSL and 100% MDSL, respectively. Angel (1987) compared a sausage elaborated with 100% MSM from whole carcasses of egg layers to sausages of two commercial brands, using a 9-point scale (1 = I extremely liked it, and 9 = I extremely disliked it). The two commercial brands were rated 2.65 and 3.42, whereas the sausage with 100% MSM was rated 4.02, which is within the acceptability limits and very close to the two commercial brands.

As to the texture, products with over 30% of MSM are generally considered to present graininess (Field, 1988), due to bone particles. When MSM of whole carcasses of hens is used, these particles are mainly from thighs, which are highly calcified and break into small particles during the grinding in the deboning machine and are incorporated to the MSM (Grunden & Mac Neil, 1973).

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