Effect of Mechanical Deboner Head Pressure on Lipid Oxidation in Poultry Meat

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ABSTRACT

The oxidation rates of mechanically deboned poultry meat (MDPM) from whole breasts of roasters obtained under different deboner head pressures (40, 75, 120 and 150 lb/in2) were determined. Mechanical deboning significantly (P<0.05) increased fat, ash, calcium and iron content, and reduced moisture and protein levels, compared to hand deboning. The highest head pressure resulted in significantly lower fat and higher iron content than the other treatments and produced the lowest rate of oxidation. The lowest head pressure (40 lb/in2) resulted in the highest oxidation rate. Fatty acid analysis indicated that 150 lb/in2 caused a loss of linoleic acids with a resulting increase in the proportion of C16 fatty acids. Commercial MDPM samples prepared from broiler backs & necks showed significantly (P<0.05) higher oxidation rates than fowl frames and all of the mechanically deboned roaster meat samples except those deboned at 40 lb/in2.

Mechanical deboning offers a method of harvesting meat from parts left after hand deboning and/or from underutilized species of fish which otherwise would be wasted (6). Today, increased production of cut-up chicken and processed turkey meat provides considerable quantities of leftover parts suitable for mechanical deboning. Yields of mechanically deboned poultry meat (MDPM) range from 55% to 80% depending on the part deboned and the deboner settings. Whole frames give a somewhat higher yield than do parts such as necks, backs or wings. In 1984 more than 220 million kg of MDPM were manufactured in the United States (19). This quantity of MDPM by-product contributes significantly to the economy of the poultry industry. Mechanically deboned poultry meat is readily available for use in a variety of emulsified and non-emulsified products.

The composition of the final product is affected by the conditions used for mechanical deboning. Considerable quantities of lipids and heme components are released from the bone marrow and are subsequently incorporated into MDPM. This is reflected in differences in the chemical composition of MDPM reported by various researchers (6). Compositional differences can also be related to factors such as age of the bird, bone-to-meat ratio, cutting methods, skin content, processing conditions and protein denaturation during the deboning process. Satterlee et al. (17) for example, demonstrated that the skin content of the raw material markedly affected the fat content of the deboned product. Different types of deboners used on the same raw material (backs & necks) resulted in compositional differences in the final product (11). In general, if deboners are set for exceptionally high yields, the fat, ash and bone content are increased. Moreover, improper deboner settings may cause an excessive temperature increase, thereby denaturing proteins, resulting in protein loss into the residue (6).

MDPM is highly susceptible to oxidative deterioration. Cell disruption resulting from the shearing action of the deboner, excessive aeration during the process, and extraction of heme and lipids from bone marrow are the main reasons for a rapid development of rancidity (2,4,12). The important role of heme compounds as catalysts in free radical chain reactions in meat systems is well established (8,15).

Mechanical deboners produce products varying in particle size. Schnell et al. (18) reported that thiobarbituric acid (TBA) values of MDPM with a small particle size following processing increased more rapidly. This is to be expected, since small particle size exposes a greater surface area to oxidative environment and is indicative of increased cell disruption resulting in more enzymes and heme pigment release. Mast et al. (11) reported that MDPM obtained from different deboners showed different oxidation patterns during storage. The poultry industry is currently using leftover parts from hand deboning (i.e. backs, necks, frames) for mechanical deboning. In addition, an increased industrial interest in mechanical deboning of breast meat from older birds is apparent.

The objectives of this study were to evaluate the effect of deboner head pressure on the oxidation rate, yield and chemical composition of mechanically deboned breast meat from roasters, and to compare their oxidation rates to the oxidation rates of commercial MDPM obtained from broiler backs and necks and fowl frames. In addition, to compare...
the mechanically deboned breast meat composition to meat obtained by hand deboning.

**MATERIALS AND METHODS**

Mechanically deboned meat from the whole breasts (skin on, bone in) of fresh roasters (12 h after evisceration) was prepared using a small scale PDX-L mechanical deboner (Poss Ltd., Hamilton, Ontario). The PDX-L was equipped with a 10 cm deboning head set at 1 mm spacing. The machine is designed to process between 350 and 450 kg of product per hour, depending on the composition of the starting material. This laboratory model is also equipped with pressure transducers at the feed and deboning heads, and thermocouples at the feed and exit from the deboning head. The machine was equilibrated before the experiment by passing 25 kg raw material through the deboning head. Pressure was adjusted to 40, 75, 120 or 150 lb/in²; temperature at the exit port did not exceed 8°C. Yields were calculated from the total weight of meat and expelled bone produced during the test. In addition, four randomly selected whole breasts of roasters, from the above mentioned lot, were hand deboned and later ground in order to determine their chemical composition.

Fresh MDPM from broiler backs and necks and from fowl frames was obtained from a local processing plant within 12 h of evisceration. A large size commercial PDX-I mechanical deboner (Poss Ltd., Hamilton, Ontario) with a 0.5 mm plate gap was used. Yield values were not released by the company. All MDPM samples were packaged in 20 g portions in polyethylene bags (1.5 mil), sealed and stored at -18°C.

Malondialdehyde (MDA) was determined using a high performance liquid chromatography (HPLC) procedure (3). Three 20 g packages per treatment were analyzed each week for six weeks. The samples were thawed at room temperature for 1 h prior to analysis. The fatty acid composition was determined in duplicate at the beginning of the experiment using gas liquid chromatography (10) to determine the effect of deboning conditions on the fatty acid profile.

Proximate and mineral (calcium and iron) analyses of frozen MDPM and hand deboned poultry meat (HDPM) samples were carried out in duplicate (1). Statistical analyses were performed using the Statistical Analysis System (16). The General Linear Models procedure was used to perform analysis of variance and Duncan’s multiple range test was used to determine significant differences between treatments. Regression analysis was applied to the log transformed MDA data (transformation was carried out due to the nonhomogeneity of the variance) in order to compare oxidation rates.

**RESULTS AND DISCUSSION**

**Chemical composition**

The mechanical deboning process resulted in significantly (P<0.05) differences in the composition of breast meat relative to hand deboned breast meat (Table 1). Mechanical deboning resulted in significantly lower moisture and protein levels and a two-fold higher fat level. Incorporation of fat from bone marrow was the probable cause of the change in the moisture to fat ratio (14). Calcium and iron content were also significantly higher in the MDPM than in the hand deboned breast meat. These differences are attributable to more bone particles and bone marrow being incorporated into the MDPM (6).

Among the mechanically deboned breast meat samples, a deboner head pressure of 150 lb/in² resulted in a significantly (P<0.05) higher ash, calcium and iron content than 40 and 75 lb/in², and higher calcium and iron content than the 120 lb/in² treatment. The 120 lb/in² treatment produced no significant increase in ash, calcium or iron levels as compared to the 75 and 40 lb/in² treatments. The ash and mineral data correspond to the yield data (Table 1) which show that a pressure of 150 lb/in² resulted in about twice the yield of the lower pressures (82% vs. 42-45%). The higher yield is likely attributable to the presence of more bone particles and marrow. In addition, 150 lb/in² resulted in a product with significantly less fat and slightly more moisture than did lower pressures. The compositional changes observed in the samples processed at the greater pressure is probably due to a greater extraction of moisture from the carcass residues. There was also a significant decrease in linoleic acid in this product, indicating that it was the softer fat that was extruded.

**TABLE 1. Effect of deboner head pressure on the chemical composition and yields of mechanically deboned poultry meat (MDPM) and composition of hand deboned poultry meat (HDPM).**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pressure (lb/in²)</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Calcium (ppm)</th>
<th>Iron (ppm)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDBM from roaster breasts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>69.82b</td>
<td>20.65e</td>
<td>8.13b</td>
<td>1.05bc</td>
<td>582b</td>
<td>10.00b</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>70.37b</td>
<td>20.76c</td>
<td>7.88b</td>
<td>1.04bc</td>
<td>534b</td>
<td>11.70b</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>70.28b</td>
<td>20.10d</td>
<td>8.47b</td>
<td>1.12bc</td>
<td>568b</td>
<td>10.60b</td>
<td>42</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>71.05b</td>
<td>20.68d</td>
<td>6.78b</td>
<td>1.23d</td>
<td>764b</td>
<td>17.85b</td>
<td>82</td>
</tr>
<tr>
<td>HDPM from roaster breasts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>73.20c</td>
<td>23.67c</td>
<td>3.10b</td>
<td>0.94b</td>
<td>164a</td>
<td>6.25c</td>
<td>NA</td>
</tr>
<tr>
<td>MDPM from roaster backs and necks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>65.55c</td>
<td>16.42b</td>
<td>17.27c</td>
<td>1.19d</td>
<td>884d</td>
<td>25.00d</td>
<td>NA</td>
</tr>
<tr>
<td>MDPM from fowl frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>66.86d</td>
<td>12.93c</td>
<td>20.79d</td>
<td>0.73b</td>
<td>758c</td>
<td>16.25c</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Means in the same column with different superscripts are significantly different (P<0.05).
NA=not available.
Webb et al. (21) compared mechanically separated and hand separated tissue from Atlantic croaker. The hand deboned product had a higher moisture content which was attributable to exposure of the fillets to water during rinsing in the commercial operation. A higher incorporation of fat from skin and bone marrow occurred during machine separation. The shearing action of the mechanical deboner was believed to remove more fatty tissue from the skin than was obtained by hand skinning. Also, bone marrow apparently contributed to an increased iron content of the mechanically separated fish tissue. Froning and Johnson (7) reported that MDPM from whole fowl carcasses contained three times as much hemoglobin as hand deboned meat.

The two commercial MDPM samples prepared from broiler backs and necks and fowl frames had a significantly (P<0.05) different chemical composition from the samples prepared from breast meat. These products had at least twice as much fat as the mechanically deboned breast meat. However, these fat levels (15-20%) are more representative of the levels found in the majority of MDPM products sold today (6,11,19). Broiler MDPM prepared from backs and necks had significantly higher levels of ash, calcium and iron than fowl MDPM prepared from frames. These differences may be due to the differences in parts deboned and in the age of the birds. For example, softer bones from broilers (7-8 weeks old) resulted in more bone particles being incorporated into MDPM than from the well calcified bones of fowl (6).

**MDA analysis**

MDA values for the different MDPM samples are presented in Table 2. The lowest head pressure (40 lb/in²) resulted in the highest MDA values after one month of frozen storage, whereas the highest pressure (150 lb/in²) resulted in the lowest. Intermediate pressures (75 and 120 lb/in²) yielded intermediate MDA values which, by the end of the experiment, were significantly (P<0.05) lower than those obtained at 40 lb/in².

Regression analysis was applied to the log transformed MDA data versus time and the slopes for each treatment were compared. In the breast meat group the 40 lb/in² treatment showed a significantly (P<0.05) greater slope than any of the other pressures. The slope of the 75 lb/in² treatment was significantly greater than at 120 and 150 lb/in² which were not significantly different from each other.

- During the mechanical deboning process, lipid components form the bone marrow are incorporated into the product. Moerck and Ball (13) reported that bone marrow from 8 to 9 week-old broilers contained 46.5% lipids of which 98.4% were neutral lipids. On a weight basis, bone marrow contains a higher percentage of phospholipids and cholesterol than does other broiler tissue. These phospholipids are sensitive to lipid oxidation because of their high polyunsaturated fatty acids content (4).

The breast meat deboned at 150 lb/in² had the lowest fat content and the highest iron content (Table 1). Its low MDA values (Table 2) are attributable to its reduced concentrations of polyunsaturated fatty acids (Table 3). Total iron content is not necessarily a good indicator of the potential for lipid oxidation. The form of iron which is most catalytic has not been firmly established. Although both heme and non-heme iron catalyze lipid oxidation in meat (8), some researchers have reported that hemoproteins are the predominant catalysts (20, 22), whereas others have reported non-heme iron to be the major catalytic agent (9). Furthermore, various compounds in the tissues bind inorganic ions, thereby inhibiting their catalytic effect on lipid oxidation (8).

The two commercial MDPM products were significantly different in their oxidation rates. Their MDA values started to show significant differences by the 21st day; the MDPM broiler meat accumulated more than twice as much MDA as the fowl MDPM during the month of frozen storage. The broiler MDPM meat had a significantly higher iron and calcium content than the fowl meat (Table 1) indicating greater incorporation of bone particles and bone marrow during the deboning process. Total fat content was somewhat higher in the fowl MDPM than in the broiler backs and necks MDPM (Table 1); however, no significant differences in the fatty acid composition of these two MDPM products were observed (Table 3). The explanation for the

## Table 2. Effect of deboner pressure on malondialdehyde formation in mechanically deboned poultry meat (MDPM) stored at -18 °C.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pressure (lb/in²)</th>
<th>0</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MDPM roaster breast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>0.29&lt;sub&gt;b&lt;/sub&gt;</td>
<td>1.20&lt;sup&gt;g&lt;/sup&gt;</td>
<td>1.36&lt;sup&gt;g&lt;/sup&gt;</td>
<td>1.30&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.08&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>0.31&lt;sub&gt;g&lt;/sub&gt;</td>
<td>0.49&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.63&lt;sub&gt;c&lt;/sub&gt;</td>
<td>0.57&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.61&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.72&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>0.35&lt;sub&gt;a&lt;/sub&gt;</td>
<td>0.45&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.44&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.46&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.51&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.60&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>0.30&lt;sub&gt;a&lt;/sub&gt;</td>
<td>MD&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.48&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>MDPM broiler backs and necks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.29&lt;sub&gt;a&lt;/sub&gt;</td>
<td>0.36&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.61&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.40&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>MDPM fowl frames</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.34&lt;sub&gt;a&lt;/sub&gt;</td>
<td>0.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a,b</sup>Means in the same column with different superscripts are significantly different (P<0.05).
<sup>c</sup>MD=missing data.
TREATMENT Pressure Percent fatty acid of total  
--- Pressure MDPM roaster breast MDPM broiler backs and necks MDPM fowl frames 
1 40 23.0d 5.0e 5.7d 41.6d 22.1d 0.6f 1.0f 0.2d 0.9d
2 75 22.8e 5.3d 5.5d 41.5d 22.1d 0.9d 1.0e 0.3d 0.8e
3 120 24.7d 4.8d 6.4d 41.3d 20.6d 1.2d 1.2d 0.4d 0.8d
4 150 27.3d 9.5d 5.6d 39.9d 15.5d 1.1d 0.9d 0.0d 0.4d
6 20.1e 5.8e 5.7d 42.9d 22.8d 1.2d 0.9d 0.4d 0.5d
7 21.8e 5.1e 5.5d 42.4d 22.8d 0.8d 0.8d 0.15d 0.8d

*Each fatty acid expressed as a percent of total fatty acids. Each value is a mean of duplicate determinations.

Less lipid oxidation than a low pressure (40 lb/in²). Pressures within this range had intermediate effects.

ACKNOWLEDGEMENT

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REFERENCES