Effects of frozen storage on hamburgers containing different proportions and types of mechanically recovered meat

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Introduction

The use of mechanically recovered meat (MRM) in the manufacture of numerous meat products is becoming more and more widespread, and the addition of correct proportions of MRM either does not affect, or can even enhance, the acceptability level of such products. However, certain alterations have been found to take place in MRM and MRM-containing products during frozen storage, and the effect of such alterations will depend on the source of the MRM, the product to which it has been added, the amount employed, etc. Oxidation of lipids is more extensive in poultry MRM than in MRM from red meat, though it tends to vary from species to species (Field, 1981), with pork MRM presenting the most problems. While no changes occur in the TBA index in beef and lamb MRM during frozen storage, pork MRM underwent oxidation, which was accompanied by a marked loss in acceptability, when added to frankfurters (Meiburg et al., 1976). The rate of lipid oxidation has been closely associated with the total polyunsaturated fatty acid content of mechanically recovered beef, pork, and turkey (Field, 1981). Marshal et al. (1977) observed that, while frankfurters made with 40% lamb MRM enjoyed high acceptability levels, frankfurters containing the same proportion of pork MRM received low acceptability ratings. Pork MRM has been found to exhibit poor colour stability and lead to the rapid deterioration of preservatives (Newman, 1980-81).

Generally speaking, the addition of beef or lamb MRM does not adversely affect meat products, whereas the addition of pork MRM tends to lower their stability and acceptability.

Since information on the stability of frozen MRM-containing hamburgers is scanty or lacking entirely, an experiment was designed and carried out to study the effect of frozen storage on pork hamburgers containing varying proportions (0, 10, 20, and 30%) and types (from backbone, ribs, and legbones) of mechanically recovered pork (MRP).

Materials and Methods

The mechanically recovered meat was obtained with a Protecon MRS-20P apparatus operating at 210 atm using three types of bones as the source material: backbone, ribs, and legbones (femur, tibia-fibula, hip bone, scapula, humerus, ulna, and radius).

The hamburger meat formulations were prepared by homogenizing ground pork (orifice diameter: 5 mm) in a Hovart blender together with a suitable amount of MRP so as to obtain the final proportions shown in Table 1. The hamburgers (1.2 cm thick) were made from 75 g of the homogenized meat formulations using a hand hamburger press, frozen at -40 ºC in a plate freezer, vacuum packed, and stored at -18 ºC for 220 days.

Table 1. Proportions and types of mechanically recovered pork in the ground pork formulations

% ground pork	% MRP	Lot identifier
100	0 (control)	C
90	10 (from backbone)	10 B
80	20 (from backbone)	20 B
70	30 (from backbone)	30 B
80	20 (from legbones)	20 L
80	20 (from ribs)	20 R

The cooking loss and shear strength (measured with a Kramer shear cell) of the hamburgers were obtained using the method described by Jiménez-Colmenero et al. (in press). The colour measurements were performed using on three thawed hamburgers (3 ºC for 16-18 hours) using a HunterLab model D25A-9 colourimeter.

The 2-thiobarbituric acid (TBA) index, obtained following Lemon's method (1975), was taken as the measure of oxidative rancidity.

Sensory analysis of the hamburgers was carried out by a taste panel composed of six semi-trained members of the laboratory staff using a step scale. The thawed hamburgers (3 ºC for 16-18 hours) were cooked at 200 ºC for 15 minutes in a convection oven and then rated by the taste panel using a category scale. The properties rated were: "liver" flavour (5 = strong, 1 = none); rancidity (5 = very rancid, 1 = not rancid); juiciness (5 = very juicy, 1 = very dry); hardness (5 = very hard, 1 = very soft); and overall acceptability (5 = very pleasant, 1 = very unpleasant).

The degree of significance among the means was found by analysis of variance using an F test. Linear regression of shear strength on the proportion of MRP added was performed, and the coefficient of determination and degree of significance were calculated. The degree of significance for the correlation between shear strength and hardness as rated by the taste panel was found using Lamotte's tables (1981).

Results and Discussion

Table 2 summarizes the results for total cooking loss and the water and fat released during cooking. The figures given are the means, since no significant differences were found with time over the storage period.

Frozen storage had no significant effect on the total cooking loss for either the proportion or the type of MRP used.

Table 2. Mean cooking loss for hamburgers over the frozen storage period[1]

Formulation	Cooking loss: Total (%)	Water (%)	Fat (%)
C	28.6	26.7	1.6^{a}
10 B	27.7	25.8	1.8^{ab}
20 B	28.2	26.1	2.0^{ab}
30 B	27.1	25.2	2.3^{ab}
20 L	27.4	24.6	2.7^{b}
20 R	28.5	25.9	2.7^{b}

1 - Each value is the average of 20 measurements (four replications made at each of five different times during the storage period

a,b - Different letters in the columns indicate significant differences ($P < 0.05$)

Initially, adding more than 10 % MRP caused the amounts of water retained and fat released during cooking to increase (Jiménez-Colmenero et al., in press). A similar tendency was observed during frozen storage, but no significant differences were found in the amount of water released in function of either the percentage or the type of MRP employed. In contrast, the amount of fat released did depend on the source of the MRM; while it also increased with the proportion of MRP added, the increase was not significant. In any event, the differences observed in this parameter cannot be explained exclusively by the different amounts of fat in the hamburgers (C = 2.8%; 10 B = 4.4%; 20 B = 8.8%; 30 B = 10.2%; 20 L = 10.3%; and 20 R = 10.0%). Adding MRP increased the fat binding capacity of the ground pork, and it emained constant throughout the storage period. Seideman et al. (1977) reported that MRM-containing beef patties retained higher percentages of fat than did patties made from hand-boned beef only. The fact that the water holding capacity did not show variation indicates that protein denaturation and aggregation due to freezing and frozen storage did not take place.

The effect of frozen storage on the colour of the hamburgers is shown in Table 3. No significant differences were found in the L (lightness) and b (yellowness) values at different times during storage, and hence Table 3 contains the mean values for the entire storage period for each of the formulations.

The addition of MRP to the hamburgers resulted in a significant decrease in the L (lightness) value and a significant increase in the a (redness) value, which varied with the proportion and type of MRM. The b (yellowness) value was found to depend only on the type of MRP used (formulation 20 L). The variations in the colour of the hamburgers that take place when MRP is added are due to differences in the amount of hemo pigments obtained from the bone marrow. As a result, MRP from legbones is darker in colour (lower lightness and yellowness values and higher redness values). The differing fat contents of the hamburgers may also affect the colour.

Table 3. Effect of frozen storage on HunterLab colour measurements of the hamburgers

Formulation	L^1 lightness	a^2 (redness) Days in storage: 0	30	60	120	220	$\bar{X}$	b^1 yellowness
C	34.9_{t}	10.7^{a}_{t}	9.8^{b}_{t}	9.7^{b}_{t}	9.6^{b}_{t}	9.2^{b}_{t}	9.8_{t}	9.1_{t}
10 B	34.2_{tw}	12.0^{a}_{w}	11.3^{b}_{w}	11.3^{b}_{w}	11.2^{b}_{w}	10.5^{c}_{wx}	11.3_{tw}	9.2_{t}
20 B	33.1_{x}	12.7^{a}_{x}	12.3^{ab}_{xy}	11.7^{bc}_{xy}	11.3^{cd}_{w}	11.0^{d}_{x}	11.8_{wx}	9.1_{t}
30 B	33.4_{wx}	12.9^{a}_{x}	12.7^{ab}_{y}	13.1^{a}_{y}	12.3^{b}_{xy}	10.9^{c}_{x}	12.4_{wx}	9.5_{t}
20 L	29.7_{y}	14.1^{a}_{y}	14.2^{a}_{z}	13.9^{a}_{z}	12.5^{b}_{y}	11.2^{c}_{x}	13.2_{x}	8.6_{w}
20 R	33.1_{x}	11.5^{a}_{w}	11.9^{a}_{x}	11.8^{a}_{x}	11.6^{a}_{wx}	9.9^{b}_{tw}	11.3_{tw}	9.2_{t}

1 - No significant differences found with storage time for parameters L and b; each value is thus the average of 60 measurements (12 replications at each of 5 storage times)

2 - For each storage time shown, each value is the average of 12 replications

a,b,c,d - The means on the same row for a given parameter with different superscripts are significantly different ($P < 0.05$)

t,w,x,y,z - Means in the same column with different subscripts are significantly different ($P < 0.05$)

Frozen storage brought about a significant decrease in the a (redness) value in the hamburgers due to oxidation of the myo globin and metamyoglobin. Hemo pigment concentration in the hamburgers does not seem to be the only factor leading to the decrease in redness during storage, since at the end of the storage period the decline in the a value was similar in all the hamburgers except those made with MRP from legbones, in which it was higher.

The results of the shear strength analysis are presented in Table 4. Initially, adding MRP caused a drop in the shear strength of the hamburgers, depending on the proportion rather than on the source of the MRP. Consequently, it was possible to establish a linear relationship between shear strength and the proportion of MRP ($r^2 = 0{,}85$ $P < 0.001$). It would therefore appear that the primary factor affecting hardness was the physical structure of the MRP, though the varying fat contents of the hamburgers were also a factor. No significant differences were found in the shear strength of the hamburgers with storage time except in formula tion C (control), in which slightly lower values were observed at 60 and 120 days. This lack of variation in the shear strength values over storage was in line with the results obtained for cooking loss, and reflect little alteration in the proteins.

Table 4. Effect of frozen storage on the shear strength of the hamburgers (kg/g)[1]

	Days in storage				
Formulation	0	30	60	120	220
C	4.4^{a}_{w}	4.0^{ab}_{w}	3.7^{b}_{w}	3.7^{b}_{w}	4.2^{a}_{w}
10 B	3.7_{x}	3.6_{wx}	3.7_{w}	3.3_{wx}	3.6_{x}
20 B	3.1_{y}	3.2_{xy}	3.0_{x}	3.0_{xy}	3.2_{xy}
30 B	2.8_{y}	2.8_{y}	2.5_{x}	2.8_{y}	2.5_{y}
20 L	3.0_{y}	3.1_{xy}	2.7_{x}	2.8_{y}	3.0_{y}
20 R	3.0_{y}	2.9_{y}	2.9_{x}	2.9_{y}	2.8_{y}

1 - Each value is the average of six replications

a,b - Means on the same row with different superscripts are significantly different ($P < 0.05$)

w,x,y - Means in the same column with different subscripts are significantly different ($P < 0.05$)

Table 5. Changes in the 2-thiobarbituric acid (TBA) index for the hamburgers during frozen storage (μM malonaldehyde/100 g of formulation)[1]

	Days in storage		
Formulation	0	60	220
C	0.32^{a}_{w}	0.43^{ab}_{w}	0.66^{b}_{wx}
10 B	0.60_{x}	0.44_{wx}	0.56_{w}
20 B	0.60_{x}	0.59_{wxy}	0.73_{wx}
30 B	0.46^{a}_{y}	0.65^{ab}_{xy}	0.85^{b}_{xy}
20 L	0.51^{a}_{xy}	0.73^{ab}_{y}	0.94^{b}_{y}
20 R	0.53^{a}_{xy}	0.60^{a}_{wxy}	0.93^{b}_{y}

1 - Each value is the average of three replications

a,b - Means in the same row with different superscripts are significantly different ($P < 0.05$)

w,x,y - Means in the same column with different subscripts are significantly different ($P < 0.05$)

The results of the 2-thiobarbituric acid index are shown in Table 5. The addition of MRP brought about an initial rise in the rancidity index in the hamburgers. Oxidation increased over the storage period except in the case of formulations 10 B and 20 B. While there are in fact significant differences between the TBA index values for the different types and proportions (30%) of MRP, these were very slight and were of no practical importance. As a result, rancidity was not detected by the taste panel. These results were obtained despite the fact that, as expected, the hamburgers contained different proportions of fat and hemo pigments depending on the amount and source bones of the MRP.

No significant differences were found in the sensory parameters rated during the storage period, hence Table 6 shows the mean values only. In contrast to the results of the present experiment, Cross et al. (1978) observed that the length of time in frozen storage did have a significant effect on the flavour, juiciness, and hardness and desirability of ground beef patties containing mechanically deboned beef.

Table 6. Mean results of the sensory analyses of the hamburgers performed over the frozen storage period[1]

Formulation	"Liver" flavour	Juiciness	Hardness	Overall acceptability
C	1.2	2.0	3.4	3.0
10 B	2.6	2.7	3.0	3.0
20 B	2.8	2.9	3.0	3.0
30 B	3.5	3.1	2.5	2.7
20 L	3.7	3.4	2.2	2.4
20 R	2.7	3.0	2.8	2.7

1 - No significant differences were found among the parameters tested over the storage period, so each value is the mean of 30 tastings (five tests times six tasters)

Throughout the storage period the MRP gave the hamburgers a "liver" flavour that increased with the proportion of MRP added, except in the case of formulation 20 L; this may be due to the presence of bone marrow. The taste panel did not perceive any rancid taste in any of the formulations over the storage period.

Adding MRM resulted in an increase in the juiciness and a decrease in the hardness of the hamburgers. The increased juiciness was not reflected in the total cooking loss or in the amount of water released, and it is therefore thought likely that it was caused by the higher amounts of fat released during cooking. There was a positive correlation between shear strength and hardness as evaluated by the taste panel ($r = 0.58$; $P < 0.01$).

Except for the hamburgers containing MRP from legbones, which had a more readily distinguishable "liver" flavour, the highest juiciness value, and the lowest hardness value, overall acceptability for the different formulations during storage was similar to that for the control formulation (0% MRP).

Under the conditions of the present experiment, freezing and frozen storage of MRP-containing pork hamburgers did not lead to any distinct alterations in their properties. Consequently, the stability of such hamburgers is not a factor limiting the use of mechanically recovered pork. Moreover, both the proportion and the type of MRP selected can enhance the acceptability of the hamburgers to which it is added.

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