Effects of washing on the properties of mechanically deboned meat

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INTRODUCTION

The production of mechanically deboned meat (MDM) is interesting from an economic standpoint and also serves as a source of additional animal protein. However, by their very nature such products are extremely perishable, which makes necessary proper processing and storage at cold temperatures.

Cold storage of MDM, depending on the refrigeration process applied, is limited chiefly by two factors, microbial growth and oxidation of lipids, leading to changes in the physical and chemical properties as well as in the sensorial properties of the product that make it unacceptable for consumption.

In this respect, there have been attempts to improve microbiological quality by subjecting both the raw material (1) and the MDM (2) to treatment by heat, by washing the dressed carcasses with an antiseptic solution (1), by subjecting the MDM to specially modified atmospheres (3), and by adding bactericidal and bacteriostatic agents, The oxidation of lipids is inhibited by physical treatment such as centrifuging (4) and modified atmospheres (3) (5) and by chemical processes based on the use of antioxidants, plant extracts, polyphosphates, and other compounds (1) (6) (7).

Washing of MDM is a technical process with a bearing on these problems that acts to enhance the stability of such products by bringing about a reduction in the initial level of microorganisms present in the meat (reduced still further if antiseptics are added to the wash water), in the amount of enzymes (both intrinsic and bacterial in origin) present, as well as in the concentration of hemoproteins. Furthermore, washing likewise results in the bleaching and deflavouring of the MDM, which means that it can be incorporated more readily and in greater into those products into which it is finally transformed, and/or that it can be employed in other products in which the sensorial properties of MDM would otherwise restrict its use (7) (8) (9) (10).

One of the most important problems encountered in washing is the loss of component substances, which reduces the yield. The objective of the present experiment was to assess the effects of washing on MDM by analyzing the properties of the end product and relating them to the conditions of the processing it had undergone.

MATERIALS AND METHODS

Following conventional deboning, the MDM was removed from the backbone of pigs kept for 72 hours at 0ºC. Manual deboning was carried out immediately prior to mechanical deboning, which was performed using a Protecon MRS-40P deboner at a pressure of 100 atm. The rise in the temperature of the meat during mechanical separation was 7º.

The MDM was then kept at 0ºC until use.

Washing was performed by mixing the MDM with iced water and stirring occasionally. The MDM/water ratios tested were 1/2 and 1/5, and the washing times were 0 and 15 minutes.

Dewatering was effected by placing the aqueous MDM suspension in a cloth bag made of a coarse muslin-like fabric and then centrifuging in a centrifugal dewaterer until the continuous flow of liquid draining off stopped.

Analyses were performed on both the initial MDM and on the washed lots to determine the moisture, fat, total nitrogen, and ash contents (11), total pigment content (12), phosphorous content (13), and the calcium, magnesium, iron, zinc, sodium, potassium, manganese, and copper contents, by atomic absorption spectrophotometry using a Beckman model 1248 spectrophotometer.

Fatty acid composition was analyzed by extracting the lipids, methylated according to UNE standard 55118, using the method of Bling and Dyer (14). Gas-liquid chromatography was carried out on a 5 m x 0.25 mm Perkin-Elmer F-30 column filled with 10% ethyleneglycoladipate (EGA) solution. The temperature was 250ºC in the injector, 200ºC in the detector, and 170ºC in the column, with a nitrogen flow rate of 3 ml/min.

The soluble protein was extracted following Ironside and Love (24), and the nitrogen content was measured as per Kjeldahl.

Water retention capacity was measured in accordance with Dhillon and Maurer (17), but the MDM was allowed to standing at 1ºC instead of at 4ºC. The results are expressed in terms of ml of liquid released. Cooked drip loss was measured according to Bito (18).

Emulsion capacity (EC) was determined using the procedure of Webb et al. (15), modified through the use of a 5% ClNa solution. An aliquot of 10 ml was mixed with 40 ml of water and 10 ml of olive oil in an Osterizer blender, with electrodes. Emulsion stability (ES) was analyzed in accordance with the technique of Kijowski and Niewiaroswicz (16), the emulsion comprising 85 ml of water and 20 ml of olive oil added to a suspension of 20 ml of MDM in a 5% ClNa solution, with 175 ml of oil blended in by homogenization.

The effect of washing on the presence of microorganisms was determined by a viable germ count (VGC) (19), while the effect of washing on oxidative rancidity was determined using the 2-thiobarbituric acid (TBA)index (20). In addition, sensorial analysis of quality was conducted by a panel of tasters composed of six partially trained members. For the sensorial analysis hamburgers were made from a mixture of minced pork and 30% MDM. After grilling, taste, texture, and overall acceptability were rated in accordance with the following criteria. Texture: 5-hard, 4-somewhat hard, 3-normal, 2-soft, and 1-very soft. Taste and overall acceptability: 5-very good, 4-good, 3-fair, 2-borderline, and 1-poor.

RESULTS AND DISCUSSION

The yield of MDM after washing together with the results of the analyses of the moisture, total nitrogen, fat, and ash contents, as well as the loss of dry matter by substance are presented in Table I. MDM loss during washing increases with the MDM/water ratio and decreases with washing time. With regard to the MDM/water ratio, these results may be due to the higher solubilization of certain substances (ash and total nitrogen) and to fat loss; in relation to the washing time, the results may be due to protein insolubilization during the washing process, as shown in Table V. Washing removes a large part of the protein fraction, which is replaced by water, giving rise to a higher moisture content in washed MDM than in its unwashed counterpart. Washing of MDM results in losses of some 50% in total nitrogen x 6.25 and of from 44 to 72% in the ash content. Fat loss is much lower.

The mineral content of the MDM is given in Table II. From this table it can be seen that all the minerals are present in normal amounts for this type of meat, except for Ca and P, which are appreciably lower than the values given in the literature (10) (23).

Washing results in a substantial loss of minerals, though there would seem to be no loss of Ca, Cu, and Mn. While the MDM/water ratio does not seem to affect the amount of P, for Na, K, Mg, Fe, and Zn losses fluctuated between 29.1% (for Zn) and 60% (for K). Washing time had hardly any effect on losses and it was found that in some cases the 1/5 (15') lot gave higher values than the 1/5(0') lot. Therefore mineral losses during washing were mainly dependent on the MDM/water ratio, making allowance for differences caused by changes in the moisture content of the MDM.

Both heme and nonheme iron are present in MDM (Table III). Heme iron loss was observed to be independent of both the amount of water and washing time, and thus the effects of these factors on the total iron content was a result of action on nonheme iron. Consequently, under the conditions of this experiment, bleaching caused by the decrease in the heme pigment content would not appear to be dependent on either the amount of water or the washing time.

Table I. Proximate analysis of MDM

Analysis	Lot			
	Unwashed	1/2(0')	1/5(0')	1/5(15')
Moisture content (%)	56.63	62.82	57.97	59.44
MDM loss (%)	-	17.34	24.25	19.82
N x 6.25 (%)	13.36	7.04	8.37	8.17
N x 6.25 loss (%)*	-	49.77	52.07	46.25
Fat (%)	27.20	28.51	33.30	29.33
Fat loss (%)*	-	0	6.34	5.11
Ashes (%)	0.95	0.40	0.36	0.33
Ash loss (%)*	-	44.21	71.57	69.47

Table II. Mineral content (mg/100 g)

Mineral	Lot			
	Unwashed	1/2(0')	1/5(0')	1/5(15')
Na	90.00	29.90	17.50	18.30
K	190.30	81.10	33.00	34.50
Ca	65.80	72.10	59.00	71.00
Mg	17.00	10.50	7.10	8.70
P	47.30	26.90	26.40	24.30
Fe	3.46	2.34	1.37	1.54
Zn	3.11	2.16	1.53	2.02
Cu	0.19	0.17	0.19	0.11
Mn(μg/g)	0.20	0.20	0.19	0.19

* The percent loss was calculated on the basis of the post-wash yield and the initial and final composition of the MDM.

The result obtained from the analyses of the fatty acid content of the MDM (Table IV) are similar to the data reported by Ockerman et al. (10). The fluctuations registered for the different washing techniques suggest that fat loss in the 1/5(0') and 1/5(15') lots is negligible and that consequently the product undergoes no significant change with respect to its initial composition.

The slight rises in the pH level (Table V) on washing are due to the loss of soluble mainly acid substances that would offset the decrease in the pH level to be expected on the partial elimination during washing of the marrow extract, which is responsible for the high pH level in this type of meat (1).

Table IV. Analysis of fatty acids from MDM lipids

Acid	Lot			
	Unwashed	1/2(0')	1/5(0')	1/5(15')
C_{14}	1.12	1.18	1.28	1.28
C_{16}	21.75	20.91	22.68	22.37
$C_{16:1}$	3.33	3.18	3.28	3.45
C_{17}	0.46	0.40	0.40	0.42
$C_{17:1}$	0.39	0.30	0.25	0.25
C_{18}	11.15	12.00	11.88	11.37
$C_{18:1}$	48.80	49.40	48.30	48.37
$C_{18:2}$	9.60	9.61	9.05	9.68
$C_{18:3}$	0.35	0.40	0.37	0.29
$C_{20:1}$	1.48	1.53	1.50	1.53
$C_{20:2}$	0.47	0.67	0.56	0.56
$C_{20:3}$	0.34	0.37	0.30	0.37

Each fatty acid expressed as percent of total fatty acids

Table V. Properties of MDM

Analysis	Lot			
	Unwashed	1/2(0')	1/5(0')	1/5(15')
pH	6.58	6.61	6.87	6.78
Protein solubility (%)	67.08	62.16	62.83	54.88
WRC	2.45	18.5	10.1	13.42
Cooked drip loss (%)	19.69	37.46	30.73	31.68
EC	44.15	40.15	41.49	38.85
TBA	0.115	0.063	0.085	0.081
VGC	$2.38.10^7$	$1.09.10^7$	$8.42.10^6$	$8.99.10^4$

WRC - Water retention capacity

EC - Emulsion capacity (ml of oil/g of MDM)

VGC - Viable germ count

Initial protein solubility in the MDM was 67.08% (Table V), which is low compared to the same level in pork. This indicates that the processing to which the raw material was subjected when producing the MDM (high pressures, increased temperature, etc.) results in the denaturation of proteins. Although washing leads to a loss in soluble protein, washed out by the water, the soluble protein/total protein ratio is not dependent on the amount of water used, perhaps because a ratio of 1/2 is in itself high enough to dissolve and remove the soluble portion. On the other hand, the length of time the MDM remains in contact with the wash water does seem to affect soluble protein loss, which attained 54.88%.

The reduction in the water retention capacity (WRC) and the increase in cooked drip loss (Table V) followed similar trends, due to the combined action of several different factors. The loss of soluble proteins in the wash water, which occurs readily at higher pH levels (21), the increased moisture content, and protein insolubilization all favour a decrease in the WRC and an increase in cooked drip loss, whereas a rise in the pH level tends to produce the opposite effect. Differences observed in these parameters in function of the MDM/water ratio at a washing time of 0 minutes are due primarily to differences in the moisture content and in the total nitrogen x 6.26 (Table I), in addition to the pH-related action; at the same time, no protein insolubilization was observed. The greater the amount of water used in washing, the greater the losses (total nitrogen x 6.25, fat, ashes), although the concentration of protein was higher in lot 1/5(0') (Table I) due to the MDM yield on washing and the moisture content. With regard to the effect of washing time, a decrease in WRC and an increase in cooked drip loss occurred in response to the loss of soluble substances, the moisture content, and, to a large extent, the decrease in protein solubility (Table IV).

Washing of the MDM reduces emulsion capacity. The results obtained (Table IV) indicate that the EC follows a trend similar to that for protein solubility loss, in that variation in the EC in response to the MDM/water ratio is low, whereas it becomes more pronounced as washing time is increased. This is because some of the changes undergone by the MDM during washing have a marked effect on the EC. In this regard, there are changes in the pH level (16) (22), a reduction in the protein fraction making up the continuous phase of the emulsion, and alterations in the electrostatic balance (22), together with changes in the fat content.

The results obtained for emulsion stability (ES) were not significant and for this reason have not been included.

With respect to changes in the TBA index (Table V), washing removes part of the compounds formed by the autooxidation of lipids, thus offering the possibility of reducing sensorial detection of rancidity by lowering the concentration of the substances that cause it.

Washing of MDM enhances microbiological quality, which improves in direct proportion to the amount of water used and becomes even more pronounced as washing time is increased (Table V), since microorganisms are washed away.

From the results of the sensorial analysis by the panel of tasters (Table VI), it can be seen that washing considerably affects the sensorial properties of MDM. With regard to taste, all the lots were rated average to good; washing lowers the MDM rating for this property, basically as a result of the loss of soluble substances. As for the remainig two properties tested, washing does not affect

Table III. Iron content of MDM (mg/100 g)

	Unwashed	1/2(0')	1/5(0')	1/5(15')
Total iron	3.46	2.34	1.37	1.54
Total iron loss (%)	-	32.36	60.40	55.49
Heme iron	1.50	0.69	0.73	0.71
Nonheme iron	1.96	1.65	0.64	0.83
Heme iron loss (%)	-	54.00	51.33	52.66

Table VI. Sensorial analysis

Lot	Taste	Texture	Overall acceptability
Unwashed	3.87 ± 0.76	2.75 ± 0.50	4.12 ± 0.85
1/2(0')	3.00 ± 0.81	2.50 ± 0.50	3.37 ± 0.47
1/5(0')	3.12 ± 0.62	2.87 ± 0.25	3.37 ± 0.47
1/5(15')	3.16 ± 0.75	2.62 ± 0.47	3.50 ± 0.57

the perception of the texture, but it does affect the overall acceptability, which is lowered by washing.

In view of the results obtained, washing leads to a diminishing of the sensorial properties of the product, so that taste, for example, is rated negatively as a result of deflavouring, which, on the other hand, offers certain technical advantages.

In conclusion, washing of MDM affords certain advantages, such as enhanced microbiological quality, deflavouring, bleaching, and the elimination of fats and of other causes of the alteration of fats, inasmuch as losses in the composition and in the physical and chemical properties of the product can be compensated for.

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