P.G.H. BIJKER, G.E. GERATS, J.G. VAN LOGTESTIJN, P.A. KOOLMEES and T. FRANSEN

Department of the Science of Food of Animal Origin, Faculty of Veterinary Medicine, The University of Utrecht

Methods to determine the bone content and the size of the bone particles in mechanically deboned pork (M.D.P.)

Quality control of mechanically deboned pork (M.D.P.) involves the determination of bone content and size of bone particles in the product. A simple and reliable method has been developed to determine routinely the bone content of M.D.P. The method involves the dissolving of the fat and protein in M.D.P. in alcoholic KOH at 95-100°C till only hard bone residues consisting of calcified hard bone particles remain. With the aid of a light microscope the size of the bone particles in these hard bone residues can be determined.

The KOH method was shown to be effective in monitoring M.D.P.

At present Dutch regulations state that M.D.P. may contain a maximum of 1% bone and bone particles may not exceed 1.0 mm in size. Based on experimental evidence and practical experience we now propose that the regulations should be changed to allow a maximum of 0.4% hard bone residue (equivalent to the present 1% clean bone content) determined by the KOH method, and that 90% of the bone particles should be less than 1.0 mm in size and non greater than 3.0 mm.

P.G.H. BIJKER, G. E. GERATS, J.G. VAN LOGTESTIJN, P.A. KOOLMEES und T. FRANSEN

Fachgruppe für Lebensmittel tierischer Herkunft, Utrecht Nierderlande.

Methoden für die Bestimmung des Knochengehaltes und der Grösse der Knochenpartikel in mechanisch entbeintem Fleisch.

Bei der Beurteilung der Kwalität von Separatorenfleisch spielen der Knochengehalt und die Grösse der Knochenpartikel eine wichtige Rolle. Eine einfache und zuverlässige Methode ist entwickelt worden für ein schnell durchführbares Verfahren zum quantitativen Nachweis von Knochenpartikeln in mechanisch entbeintem Fleisch. Das Prinzip dieses Verfahrens beinhaltet das Lösen der Fette und Eiweisse mittels alkoholischer KOH bei 95-100°C bis nur noch ein harter Knochenrest zurückbleibt. Dieser Knochenrest besteht aus den kalzifizierten Partikeln. Anschliessend kann auf einfache Weise mit Hilfe eines Lichtmikroskops der Diameter der Knochenpartikel bestimmt werden.

Der KOH Methode zeigte sich als eine geeignete Methode für die Bestimmung des Knochengehalts in mechanisch entbeintem Fleisch.

In der heutigen niederländischen Gesetzgebung ist dem Knochengehalt im Separatorenfleisch ein Maximum gestellt von 1% während die Knochenpartikel eine Grösse von 1 mm nicht überschreiten dürfen.

Auf Grund unserer Untersuchungen schlagen wir vor in der Gesetzgebung einen harten Knochenrest, bestimmt mittels der KOH Methode, von maximal 0,4% zuzulassen, was mit dem heutigen 1% normalen Knochengehalt übereinstimmt. Um der Realität keine Gewalt anzutun sollte weiterhin aufgenommen werden, dass 90% der Knochenpartikel nicht grösser sein dürfen als 1,0 mm und dass keine grösser sein dürfen als 3 mm.

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Dept. Science of Food of Animal Origin, Fac. of Veterinary Medicine, Utrecht

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1. Introduction

In the Netherlands an estimated 2.5 - 5 million kg of mechanically deboned pork is produced per year. When mechanically separating meat from bone, invariably a small quantity of bone remains in the meat. This quantity depends on the type of machine, the way the machine controls are set (amount and time pressure is applied, diameter of the filter holes), the source of the bones used, etc. The size of the bone particles is determined mainly by the diameter of the filter openings.
The larger particles can be noticed by the consumer of the meat products. According to Dutch regulations mechanically deboned meat that is to be used for meat products intended for export may contain a max. of 1% bone and 0.25% Ca, with no bone particles being larger than 1 mm. However, what falls under the heading bone is not further defined. There are no specific E.E.C. regulations pertaining to mechanically deboned meat. Although in the U.S.A. the use of mechanically deboned meat is strictly regulated, bone-content is not. The Ca-content ($\leq$0.75%) and the size of the bone particles (98% < 0.50 mm, 100% < 0.85 mm) are, however, controlled.
The purpose of this paper is to give a review of the research that has been done in our Department over the past few years to develop a good and simple method to determine the hard bone residue and the size of the bone particles. In addition the results of research into hard bone residue and the size of bone particles in mechanically deboned meat, produced in Holland, are presented. In connection with this the possibility of meeting the present standards shall be discussed.

2. Literature

2.1. Physical, biochemical and chemical methods have been developed to measure the bone content of mechanically deboned meat.
An example of a physical method is the procedure where the bone particles are allowed to sediment in a saturated salt solution (1,13,18,22). A disadvantage of this method is that the finer bone particles do not sediment but remain attached to the meat particles. By using X-ray techniques the number of bone particles can only be determined qualitatively (12,17) or semi-quantatively (22).
Biochemical methods depend on dissolving the fat- and protein components by digestion. For this purpose enzymes, such as papain, pancreatin, trypsin and pepsin are used. Digestion is usually followed by sedimentation in chloroform (7,10). The disadvantage of this method is the very long time required for the analysis (20) and the poor solubility of collagen connective tissues.
The chemical methods determine, indirectly, the bone-related increase in Calcium- and ash content or, directly, the bone content by dissolving fat and protein in a lye solution.
In most cases the determination of Calcium is used (5,9,14,15,21). This method has a few disadvantages:
a) For the calculation of the bone content of mechanically deboned pork or beef a conversion factor of 4 must be used (2) for mechanically deboned poultry a factor of 5 (11); for young hens, 6.25; and for old hens, 4.55 (9). One of the draw-backs of this method is that the Ca-content of the bone varies with the origin and age of the bones (4,6,16).
b) An increased Ca-content may also be caused by substances orther than bone.
c) The determination of the Ca-content requires expensive apparates, which is not always available in routine laboratories.
d) This method gives no indication of the size of the bone particles.
A second chemical method used to determine the bone content is based on dissolving protein and fat in a lye solution (3,8, 19,20). This method, based on an existing starch determination, has been further developed by our Institute to the present 'KOH-method'.

2.2. The KOH method

The method involves the dissolving of fat and protein in a KOH-alcohol solution at 95°C during 60-90 minutes. Only the calcified hard bone particles remain in suspension. These are separated from the solution, dried and then weighed (hard bone residue). With this method, the original quantity of clean bone in the mechanically deboned meat is calculated using a conversion factor t. This factor 't' consists of the factors r and s, where $t = r \times s$. The factor r corrects for the loss of moisture from dry bone to clean bone, while the factor s corrects for the loss of protein and fat from hard bone residue to dry bone (see diagram 1).

Diagram 1. The composition of bones.

Muscle tissue				
Connective tissue				
Fat				
Periosteum	Moisture			
Compact bone	Protein	Clean bone		
Spongy bone	Fat		Dry bone	
Cartilage	Calcium structures			Hard bone residue
Marrow				

The dry weight content of clean pork bone appeared on the average to vary from 71.5% in the costa, 73.0% in the femur, 74.7% in the humerus to 75.8% in the scapula.

In clean bone samples the factor s appeared to vary from 1.52 ± 0.01 for slaughter pigs, to 1.41 ± 0.01 sows and to 1.50 ± 0.01 for 1-2 year old boars.

The reproduceability of the method was evaluated by analysis of 88 meat (minced meat) samples to which had been added a known amount of clean bone, originating from slaughter pigs (64 samples) and sows (24 samples). The correlation coefficient between the % of bone added and the % of bone recovered was 0.99.

Schulze 1977 (19), calculated the factor s to be 1.59. He also found no significant differences between the amount of added clean bone and the amount of clean bone determined by the KOH-method ($p > 0.05$).

From these results it can be concluded that:

1) the KOH-method is a simple and trustworthy method to determine the hard bone residue in mechanically deboned pork;
2) the hard bone residue can be precisely defined as the quantity of dry bone particles that remain on the filter, after the mechanically deboned meat has been subjected to the KOH-method;
3) the hard bone residue gives a good indication of the quantity of clean bone in mechanically deboned meat;
4) further research to determine the magnitude of the factors r and s is not considered to be of any value.

It was proposed that the quality control of bone content of mechanically deboned meat should be based on the amount of hard bone residue for which standards should be set.

If 1% clean bone is set as a limit, than the hard bone residue should not exceed 0.4 - 0.5, depending on the type of bone used to obtain the mechanically deboned meat.

Considering that the given percentages of dry, clean bone material are on the high side (as a result of evaporating moisture when obtaining clean bone), 0.4 should be chosen.

An important advantage of the KOH-method is that the hard bone residue can also be used for determining the size of the bone particles.

<u>EXAMINATION OF MECHANICALLY DEBONED PORK PRODUCED IN HOLLAND</u>.+

3. <u>Material and methods</u>

<u>Sampling</u>

In 1978, each time 5 or 10 samples of about 500 gram mechanically deboned pork were taken from each of 8 production plants.

+ This research was financially supported by the Veterinary Inspection for Public Health.

Each sample originated from one pressing and the bone sort used was accurately recorded.
Cealed and packed in plastic bags the samples were taken to the laboratory, where they were homogenised and processed as rapidly as possible.
Determination of hard bone residue was done according to Bijker et al. (1978) (3).
The determination of the size of the bone particles was done in the following manner: a small representative sample of the hard bone residue, obtained by the KOH-method, was evenly spread on a slide. The sample on the slide was examined under a light microscope equipped with a projection screen. Using a micrometer objective a grid with 100 μ divisions can be superimposed on the projection screen at a definite magnification (4 x 10). In this way the largest diameter of the individual bone particles can be measured accurately to within 100 μ. Per sample the largest diameter of 100 bone particles, chosen at random, were measured.
To get an impression of the reproduceability of the method, two independent workers each determined the size of the bone particles ten times in a random sample.

4. Results and discussion

The results of this study are given in tables 1, 2 and 3.

Hard bone residue (table 1)

Table 1 shows that most meat plants produce M.D.P. with a hard bone residue lower than 0.4%. The M.D.P. with a too high hard bone residue, produced by plant II, originated from the harder bones of sows. Plant III used a mixture of all types of bones. This explains the high standard deviation of 0.14. Plant V separated boiled pig's heads. This results in a much lower hard bone residue from warm boiled heads than that which is found in the M.D.P. from cold boiled heads.

Size of bone particles in the hard bone residue (table 2)

The results presented in table 2 show that in most samples 90% of the bone particles (larger than 100 μ) are smaller than 1 mm. However, 0.0 to 1.6% of the bone particles is larger than 3 mm.
On the average from all samples 90.6% of the particles was smaller than 1 mm, 98.2% smaller than 2 mm and 99.3% smaller than 3 mm. Unpublished results show that histological examination of these samples leads to about the same conclusions.

Reproduceability (table 3)

During the 10 times repeated sorting according to size of bone particles in a sample a variation coefficient of 3.3% was noted in the size group of 100-1000 μ.
This justifies the presumption that the sorting according to size can be said to be reasonably accurate.
Bone particles longer than 3 mm are sure to give problems for the consumer. A direct connection between the size of the bone particles and the amount of hard bone residue has not been found. Also no relationship was found between the type of bone and the size of the particles.

5. Conclusion

It is suggested that the standard for bone content in M.D.P. be as follows: the hard bone residue should not exceed 0.4 with 90% of the particles being less than 1 mm and none greater than 3 mm. In coming to this conclusion we have considered the interests of the consumer and the producer, as well as the harmless nature of the bone particles.

Table 1.

Hard bone residue in 80 M.D.P. samples, taken from 8 plants, determined according to the KOH-method (data presented as average percentages and standard deviation).

Meat plant	Type of machine	Bone type	Number	Hard bone residue %
I	Protecon	Ribs + backs	10	0.28 ± 0.06
II	Protecon	Sows' bones (mixture)	5	0.44 ± 0.15
II	Protecon	Mixture (porkers)	5	0.29 ± 0.03
III	Protecon	Mixture	10	0.62 ± 0.14
IV	Protecon	Ham	5	0.28 ± 0.07
IV	Protecon	Shoulder	5	0.31 ± 0.05
V	Hydrau	Boiled pigs' heads (warm)	5	0.05 ± 0.02
V	Hydrau	Boiled pigs' heads (cold)	5	0.40 ± 0.08
VI	Protecon	Ham + shoulder	5	0.12 ± 0.02
VI	Protecon	Ribs and backs	5	0.24 ± 0.06
VII	Protecon	Shoulder	5	0.13 ± 0.03
VII	Protecon	Ham	5	0.14 ± 0.01
VIII	Soeren	Ham + shoulder	5	0.19 ± 0.04
VIII	Soeren	Backs + ribs	5	0.30 ± 0.08

Table 2.

Distribution, in percent, of different sizes of bone particles found in mechanically deboned pork.

Meat plant	Number of samples	Class ranges			
		100-1000 μ in %	1000-2000 μ in %	2000-3000 μ in %	> 3000 μ in %
I	10	91.3	6.7	0.4	1.6
II	5	91.6	7.0	1.0	0.4
	5	92.6	6.0	1.2	0.2
III	10	90.7	7.9	1.0	0.5
IV	5	91.0	8.0	0.7	0.3
	5	89.9	8.1	1.3	0.7
V	5	86.0	10.4	2.6	1.0
	5	89.6	7.4	1.6	1.4
VI	5	95.6	4.0	0.4	0.0
	5	93.4	5.8	0.6	0.2
VII	5	92.0	7.0	0.8	0.2
	5	89.8	9.0	0.8	0.4
VIII	5	90.0	8.4	1.0	0.6
	5	85.6	11.2	2.0	1.4
		90.6	7.6	1.1	0.6

Table 3.

Distribution in percent of different sizes of bone particles of a 10 times repeated sorting (in one M.D.P. sample)

	100-1000 μ	1000-2000 μ	2000-3000 μ	> 3000 μ
10	94.9 ± 3.2	4.3 ± 2.1	0.7	0.2

6. Literature

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