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Some aspects concerning the Feder number of meat products

by

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1. INTRODUCTION

Of late years a number of discussions have started on the backgrounds of the analysis of meat products, in particular concerning the Feder number (6, 13, 16, 22).

With a view to the efforts made to harmonize the various legal requirements for meat products in the countries of the E.E.C., a survey of this matter will be given.

2. BACKGROUND OF THE FEDER NUMBER

The Feder number is a well-known and generally accepted term in many European countries. It was introduced by E. FEDER in 1913 (7) and is a measure for the quantity of water calculated on the quantity of organic non-fat in a meat product.

What is the reason that this term found acceptance in the long run?

When we go through the old literature on this subject (2, 3, 4, 7, 8, 9, 10, 11, 20, 21, 24), it appears that the problem of adding water to meat products was also known in the early years of this century. Already at that time the authorities wanted to restrict this addition as much as possible.

The German regulations ordered that most meat products should not contain more than 70 per cent. of water at a maximum (7, 20). So much importance was even attached to the exact determination of this water content that they did not confine themselves to the direct method of water determination, but the water content was first of all calculated from the formula 100 - % (protein + fat + ash). It is doubtful, however, whether by this more complicated way in the analysis a more accurate figure was found than by direct determination.

Anyhow, this 70 per cent. limit was not satisfactory. This is clear, though, if one remembers that the water content of a product first of all depends on the quantity of added water, but on

the other hand, too, of the quantity of water already present in the starting material. This is most striking in the case of back fat (which is also meat in terms of law) if we realize that it contains about 90 per cent. of fat and about 9 per cent. of water, whereas in lean meat there is about 8 per cent. of fat and about 72 per cent. of water. So proportionally more water can be added to starting material containing much fat than to material containing little fat until the 70 per cent. limit will be reached. 91

Water is chiefly present in fat-free tissue, i.e. in muscle and lean meat. Therefore it is to be expected that there may be a rather strong correlation between the water content and the content of organic non-fat. It is this reasoning from which Feder, too, started, in doing which he supplied all those who had to do with meat and meat products with a new term. He considered organic non-fat to be the bearer of the water and he defined this quantity as being equal to 100 - % (water + fat + ash). At the same time he alleged that in meat the ratio of the percentages of water and of organic non-fat (later on called the Feder number) is rather constant, never exceeding 4 and even seldom exceeding 3.5. Therefore he assumed the value of 4 as the limit value for meat.

Feder based this value on findings from literature and from his own investigations of meat samples. Of the 333 samples quoted by him 67 per cent. had a Feder number lower than 3.5, whereas only 7 samples exceeded 4. Of the 42 samples examined by Feder himself there were even 40 with a Feder number lower than 3.5, i.e. more than 95 per cent.

From this it appears that a Feder number of 4 should certainly not be considered as an average for meat. Analyses from the past few years, too, show this. A survey of a number of data is rendered in table 1 (the figures are calculated from various parts of the animals mentioned).

Table 1. Survey of mean Feder numbers for meat

	Number of samples	Feder number average	min.	max.	Ref.
Bulls	41	3.31	2.10	4.12	(5)
Pigs	7	3.37	2.90	4.12	(5)
Calves	410	3.49	3.29	3.68	(13)
Pigs	666	3.31	3.11	3.51	(13)
Pigs	669	3.41	3.24	3.60	(13)
Pigs	37	3.93	3.62	4.80	(14)

When we see these figures we have difficulty in escaping the impression that the figure of 4 was rather arbitrarily chosen by Feder, though he was well aware that it was meant to be a limit value, not an average. All this is getting the more open to argument when Feder, starting from his findings, takes his next step from meat to meat products and in praxis wishes to maintain the same limit value of 4 for them. He asserted that to a meat product showing a Feder number exceeding 4, an undesirable quantity of water had been added (in which case it should be regarded as an adulteration of the meat product). The minimum percentage of added water in the final product then amounts to: % water - 4x % organic non-fat.

Very soon Feder's proposals met with some criticism. SCHENK and BURMEISTER (20) applied the method proposed by Feder on various types of sausage and on the whole they could affirm his conclusions. From their results it did not become clear, however, why the old 70 per cent. limit for the water content was less correct than the new Feder number of 4. The theoretical background of the determination by Feder is more correct, it is true, but the question where the limit should be put is not answered. SEEL (21) remarked that adding water to meat in making meat products is as essential as adding spices, and consequently the water/organic non-fat ratio for meat products must be naturally another than for meat. Besides, there are products containing little or no meat (e.g. black pudding and liver-sausage). According to him the calculation of the added water content from the Feder number does not fit in with practice, on account of the strongly varying water contents of the processed starting materials. It is otherwise not clear to him why Feder, instead of the organic non-fat content, did not take the protein content, which is practically the same. BAUMANN and GROSZFELD (2, 3) thought the general scheme of Feder's investigation correct, though they do not agree with his final conclusions. For they, too, have asked themselves why instead of organic non-fat, Feder did not determine the protein content. By making one direct determination the examination will be less circuitious and more accurate, whereas they suppose that the water/protein ratio will be as constant a factor as the Feder ratio. They also point out that the addition of starch gives rise to mistakes in the indirect analysis of the organic non-fat. Finally they, too, doubt whether the factor 4 marks the exact limit, the more so if this limit is accepted for meat as well as for meat products. Calculations from

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Feder number = 4 results in the minimum added water content only; consequently it would be better to assume a lower average Feder number in order thus to be able to calculate the presumable addition.

Feder (9, 10, 11) did not agree with Seel's remarks and Baumann and Groszfeld's suggestion. The only thing he did was giving an adjustment to his method by incalculating the starch, too, for starch-containing meat products: % organic non-fat = 100 - % (water + fat + ash + starch).

Even now it is still incomprehensible why Feder did not adopt Baumann and Groszfeld's suggestion to determine the water/protein ratio. From an analytical point of view this suggestion was indeed attractive and seen theoretically it was equivalent to his own. For what else can 100 - % (water + fat + ash + carbohydrates) be than protein?!

In later years far more serious criticism was uttered against Feder's method. GRAU (13) judges that the protein content should be used rather than the uncertain and indistinct concept : organic non-fat. STAS (22) even comes to the conclusion that she does not deem the Feder number the most correct basis to get an opinion of the quantity of water added to meat products. In particular she points out the analytic problems inherent to the Feder method. In the Feder number the mistakes in the finding of four analyses gives a summation. By means of the customary polarimetric determination of starch, moreover, the carbohydrates naturally existent in meat, added in one form or another or proceeding from the break-down of starch, are left out of the determination, in consequence of which flattering Feder numbers are being found. The best method to obtain an insight of the addition of water, according to Stas, is to determine the water/protein ratio.

3. APPLICATION OF THE FEDER NUMBER AND OTHER METHODS

It may be useful to verify how far Feder's proposal has been applied in various countries.

In the Meat and Meat Products Regulations under the Netherlands Food Law Feder's original proposal was adopted, i.e. the complicated analysis, with the limit value of 4. It is not known to us why the Netherlands are the only country that has officially introduced this test method.

In Germany the Feder method has also been used since 1925, but there are no distinct or uniform requirements for a limit value (16).

In the United States of America the added water content in meat products is calculated by means of the formula: % water - 4x % protein, which more or less corresponds with Baumann and Groszfeld's suggestion.

In France Feder's proposal was not accepted (6). There they adhered in fact to the regulations also in force in Germany in the early years of this century. For in France it had been a requirement since 1912 that the water content should not be allowed to exceed 75 per cent., but then calculated on the fat-free product. For smoke-dried products 85 per cent. is the limit. Not long ago it was proposed to take the starch content of meat products into account by calculating the moisture content on the fat-free and starch-free product.

In England STUBBS and MORE (23) suggested a method in 1919, by which the meat content in a meat product can be calculated, which method was adopted by the Society of Public Analysts (1) in 1952. The meat content is calculated from the formula

$$\frac{\%\ \text{nitrogen} \times 100}{\text{nitrogen factor}} + \%\ \text{fat}$$

if necessary with a correction for the nitrogen content of filler. The water added in the process of making the product is calculated from 100 - (% total meat + % adding materials), in which the percentage of cereals is: 2 x [100 - (% water + % fat + % ash + % protein)]. There have been many discussions on the magnitude of the nitrogen factor in the formula and many investigations have been made (14, 17, 18, 19). Furthermore the requirements for the meat content in the various products are not the same: for luncheon meat is 80 per cent. a minimum, for sausages containing beef a minimum of 50 per cent., for sausages containing pork meat 65 per cent. at a minimum (12).

From this survey it appears that no uniform solution has been found to the problem of determining afterwards, by means of analysis and calculation, if not too much water has been used in the manufacturing of meat products. In principle there is some relationship among the several solutions found, but there is no direct correspondence. It is also difficult to say which of the recommended methods is the right one. Actually none of them are satisfactory.

This last-mentioned fact appears a.o. from the data in table 2. The findings stated here have partly been copied from STAS' publication (22), for the other part they have been calculated by us from the figures mentioned by her. Stas calculated the Feder number

and the meat content (by Stubbs and More) in 17 meat products analysed by her. The average values as well as the maximum and minimum values for them have been stated. Then the values of the water/protein ratios and the findings by the French method (both with and without starch correction) have been given. And besides: the average figures and the spreading of the percentages of added water calculated by the methods mentioned (Feder number and water/protein ratio based on the limit value of 4).

Table 2. Average findings of the calculation of added water in 17 meat product samples

	values found			calculated % added water		
	mean	min.	max.	mean	min.	max.
Feder number	4.0	3.5	5.0	-0.4	-8.9	12.6
Water/protein	4.3	3.5	5.8	3.6	-7.3	21.4
Meat content	82.1	66.0	92.8	10.4	2.4	23.0
Water on fat-free basis	74.0	72.5	76.2	-	-	-
Water on fat-free and starch-free basis	76.9	74.3	80.4	-	-	-

It appears from the table that the average Feder number used according to the Feder method just comes up to the requirements made in the Netherlands. The mean values of the meat content and water on fat-free basis also meet the requirements made in England and France respectively. It is remarkable, though, that according to the Feder method no water has been added, even water has been extracted, whereas according to the Stubbs and More method an average of 10.4 per cent. of water should have been added. Naturally it is difficult to say afterwards which of the two findings is correct. It is even impossible to say whether either of them is correct. That the latter alternative is possible after all, might be derived from the great differences between the minimum and maximum values. The same thing can be said of the findings by the water/protein method.

How unsatisfactory all this is, may appear from the following example. Starting from the same recipe and the same material we made a sausage which was smoked and cooked; we also made a canned product of the same material, which was sterilized (neither product contained any starch). For both products 15.5 per cent. of water was added to the emulsion. The analytic findings according to the methods mentioned above have been summarized in table 3, whereas the calculated added water contents, too, have been given there.

Table 3. Findings of the calculated added water content in sausage and canned product

	Sausage		Canned meat product	
	value found	calculated % of added water	value found	calculated % of added water
Feder number	4.0	0	4.2	3.2
Water/protein	4.1	1.9	4.5	7.1
Meat content	89.4	10.6	84.7	15.3
Water on fat-free basis	76.7	-	77.9	-

It appears that the sausage came up to the Feder limit value of 4, and to the English and French requirements for smoked products, but that the non-smoked canned product only came up to the English requirement. Most remarkable are again the calculated findings for the added water. They are very varied both in the sausage and in the canned product, depending on the method of calculation used. According to the two calculations of Feder number and water/protein ratio, from 0 to 7.1 per cent. of water should have been added, according to the Stubbs and More calculation from 10.6 to 15.3 per cent. In reality however, 15.5 per cent. had been added, as was known.

4. HARMONIZATION OF REQUIREMENTS

Finally the improtent question remains, to what extent the established methods discussed above offer a practicable basis for the judgment of the quality of meat products.

This question is so important especially now, because in the space of a common market there is a trend for harmonization of the regulations in the countries of the E.E.C. About two years ago none of the countries concerned were likely to exchange their own methods for those used in the other countries.

From the side of the Netherlands great activity has been developed in order to remove the existing contrasts. A number of chemists of the Netherlands meat industry in co-operation with the Central Institute for Nutrition and Food Research T.N.O. have critically examined the existent rquirements for the water content and reported on it to the representatives in the CLITRAVI. It was agreed upon that none of the requirements are completely decisive for the quality of meat products. One of the recommendations is that the E.E.C. countries should accept the water/protein ratio as a general

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basis, as from a chemical point of view this ratio has a better and more efficient foundation than the other methods. Further it gives a better indication to what extent a meat product in its chemical composition differs from meat as understood in the regulations. Then, taking into account the various requirements in different countries, the limit value of 4.5 for the water/protein ratio was recommended for a great number of meat products coming into the E.E.C. traffic.

This proposal is also based on the large quantity of analytic data provided by the Netherlands meat processing industries. Part of these data have been incorporated in table 4. The average Feder numbers of 14 different products from 11 separate Netherlands factories are shown here. Besides, the average Feder number of all 5495 samples was calculated.

Table 4. Average Feder number of 14 Netherlands kinds of meat products

Product	Number of factories	Number of samples	Average Feder number
Liver sausage ("Berliner")	8	185	3.3
Liver sausage ("Saks")	9	256	3.5
Liver sausage ("Haags")	9	268	3.6
Liver paste	9	745	3.6
Smoked cooked sausage	6	118	3.5
Smoked cooked sausage ("Hamsausage")	5	72	3.8
Smoked cooked sausage	9	205	3.8
Smoked uncooked sausage ("Gelders")	9	837	3.7
Cooked sausage ("Breakfast sausage")	7	696	3.9
Cooked minced meat	9	732	3.8
Fried minced meat	9	300	3.9
Luncheon sausage	4	418	3.8
Luncheon meat	9	497	3.9
Smoked luncheon meat	8	166	4.5

The resulting figure of 3.8 lies a little below the official Netherlands limit value of 4. Besides the Feder number, the protein content, too, had been determined in an great number of the samples, so that with the help of these findings the water/protein ratios and the differences between these ratios and the Feder numbers could be calculated. The average findings of these calculations have been stated in table 5, for 2654 samples divided over 18 products.

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Table 5. Average difference between $\frac{\text{water}}{\text{protein}}$ and Feder number in 18 Netherlands kinds of meat products

Product	Number of samples	$\frac{\text{water}}{\text{protein}}$ - Feder number
Liver sausage ("Berliner")	48	0.2
Liver sausage ("Saks")	44	0.3
Liver sausage ("Haags")	69	0.1
Liver sausage ("Hausmacher")	13	0.1
Liver paste	431	0.3
Smoked cooked sausage	50	0.1
Smoked cooked sausage ("Hamsausage")	10	0.1
Smoked cooked sausage	48	0.3
Luncheon sausage	37	0.1
Smoked uncooked sausage ("Gelders")	433	0
Cooked sausage ("Breakfast sausage" in cans)	241	0.3
Cooked sausage ("Breakfast sausage" in casings)	21	0.2
Cooked minced meat	400	0.3
Fried minced meat	73	0.5
Luncheon sausage	366	0.4
Luncheon meat	230	0.3
Smoked luncheon meat	98	0.2
Luncheon meat ("Parijzer")	22	0.1
18 products	2654	0.24

The average difference of all these products amounts to 0.24, with divergences of between 0 and 0.5. This shows that for many meat products the water/protein ratios lie some tenths (maximum 0.5) higher than the corresponding Feder numbers. This is to be explained from the fact that by means of the customary methods of analysis (e.g. the polarimetric determination of starch and the fat-determination by means of extraction) the meat product components are not fully quantitatively determined in consequence of which the calculated organic non-fat content is mostly a little higher than the protein content determined by means of the accurate Kjeldahl method. STAS (22), too, observed these differences; for comparison see table 2. If the original Feder number limit value of 4 is maintained (which requirement is higher than the one made in France e.g.) the requirement for the water/protein

ratio will consequently have to be higher at any rate. Considering the spreading of the differences, the limit value of 4.5 provides a sound basis then.

During the discussion of the Netherlands proposals in the sphere of the E.E.C. it appeared that GRAU (Germany) already preferred the water/protein ratio determination to the Feder number (compare (13)).

On the part of France the technical objection was raised a.o., that for the present they are not equipped for the protein content determination as a routine method. In addition they were of opinion that the suggested standard would go hand in hand with a loss of quality, in particular because of the possibility of increasing the fat content. But this objection can also be raised under the present French regulation; it does not guarantee that the fat content will remain restricted either.

In our opinion, however, it is certainly recommendable to consider whether the fat/protein ratio should not give a better impression of the quality of meat products (not the least with a view to the nutritional value) than the water/protein ratio does. This has been pointed out both by LINDNER (15,16) and GRAU (13). A definite answer to this question is not to be given for the present.

5. CONCLUSION

From these comments it may appear that the water/protein ratio provides a better base for the inspection of the qualitative composition of meat products than the values customary in most countries as yet.

This expedient is recommended to be adopted in all E.E.C. countries in order to harmonize the several national regulations. It would be desirable, however, that other countries going to carry on trade with the E.E.C. should do so, too, thus relieving the task of the laboratories of the national export inspections and industries, as well as the task of information officers in the complicated matter of international legislation.

The problem whether in addition to the water/protein ratio other qualitative values should be limited, ought to be studied more closely.

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6. SUMMARY

In the scope of the efforts made to harmonize the legal requirements for meat products in the E.E.C. countries, a survey is given of the backgrounds and criticism of the Feder number as a basis for the judgment of the composition of these products and for the calculation of the water added. The requirements existent in various countries in this respect are discussed, as well as the present progress on the road for harmonization. International adoption of the water/protein ratio as a common starting-point is recommended.

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