Understanding the theory and practice of meat content calculations

For many companies meat content analyses are part of everyday life. They usually do this to confirm the declarations their products have on their labels, but what does meat content actually mean?

For many years the gold standard was, and still is, the Stubbs & More method that is used to calculate meat content from analytical data.

Nowadays in the EU, the Commission Directive 2001/101 introduces a new definition of meat for labelling purposes in the EU that restricts the amount of fat and connective tissue that can be included as meat when the word 'meat' or a species name such as pork is in the declared list of ingredients.

Typically meat is analysed for nitrogen (protein), fat, ash, water, carbohydrate, salt and connective tissue content (collagen). Sometimes in meat products soya protein is assayed for. On other occasions qualitative identification is required (for example, kidney, heart, cereal, soya etc) and meat speciation is sometimes also undertaken. Most of these tests have their own ISOs.

After the analytical work has been undertaken calculations are then done to define things such as Added Water Content, Apparent Total Meat Content and Apparent EC Meat Content. Table 1 defines these and some other terms that are used.

The basic method of meat calculation (the Stubbs and More method) has changed little in almost a century. It is done by measuring the amount of nitrogen present and applying standard correction factors to determine the Apparent Fat Free Meat Content. This can then be converted to the Apparent Total Meat Content by applying an allowance for fat.

This approach can also be modified to take into account the presence of further more complex ingredients such as soya which contribute to the nitrogen component, but not to the meat protein component, of the product.

However, it should be noted that, although Nitrogen Factors are available for many meats, there are no universally accepted Nitrogen Factors available for cooked, cured or processed meats as its content can vary and so the meat contents of these are best expressed as 'apparent' or 'raw meat equivalent' contents.

The most widely accepted nitrogen factors are shown in Table 2. Nitrogen factors are the average nitrogen content for the fat free meats and, as such, represent a range of values and not a single exact value. For some meats more specific values are available for specific cuts. For example pork in general has a Nitrogen Factor of 3.50, whereas neck, leg, loin and belly have values of 3.38, 3.49, 3.66 and 3.50 respectively. Although this generally applies for meat and meat products that are mainly or wholly made up of meat, further corrections must be applied to more complex meat products, such as burgers and sausages, which often have significant sources of non-meat nitrogen.

Table 1. Meat definitions.

Added Water Content	The amount left after meat content, salt content, sugar content and the content of other ingredients has been deducted
Total Nitrogen	The total amount of nitrogen present irrespective of its source which may be meat or non-meat such as vegetables.
Non-Meat Nitrogen	Nitrogen present in product that is derived from non-meat sources
Apparent Total Meat Content	The estimate of total meat content by calculations based on the obtained analytical data. There is no correction for excess connective tissue or fat.
Apparent Total Fat-Free Meat Content	The meat content excluding any fat that is present in the product. Obtained by using nitrogen factors that have been derived on a fat free basis
Apparent EC Meat Content	Estimate of meat content derived from calculation based on results of product analysis. This includes restrictions on the amount of connective tissue and fat that may be allowed for labelling purposes.

If there is no excess connective tissue or fat the Apparent EC Meat Content has the same value Apparent Total Meat Content

Type of meat	Nitrogen factor
Lamb	3.50
Mutton	3.47
Beef	3.65
Veal	3.35
Pork general	3.50
Turkey whole	3.65
Chicken whole with skin	3.50

Table 2. Nitrogen factors.

The starting point of any analysis for meat content involves an analysis of the product for moisture, ash, fat and nitrogen contents. There are then two stages to calculating meat content. First, the nitrogen level is used to calculate the Apparent Fat Free Meat Content by applying the appropriate Nitrogen Factor (a).

To get the Apparent Total Meat Content the level of fat is then added (b).

(a)

$$\text{\% Apparent Fat Free Meat Content} = \frac{\text{\% Total Nitrogen} \times 100}{\text{Nitrogen Factor}}$$

(b)

$$\text{\% Apparent Total Meat Content} = \text{\% Apparent Fat Free Meat Content} + \text{\% Fat}$$

For whole meat, the total of the key components (% fat, % protein, % water and % ash) should be very close to 100% with most analysts working to 100±2%.

Typically, meat proteins contain 16% nitrogen, so, a factor of 6.25 (100/16) can be used to convert nitrogen content on analysis into protein content. However, some of the nitrogen in a meat product may not be meat derived and is known as Non Meat Nitrogen. If we do not take this into account, the meat content will be overvalued.

Soya is often used in meat products and is rich in protein which will contribute to the Non Meat

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Nitrogen. If we know the content of soya protein, then we can determine its contribution to the Non Meat Nitrogen (c).

In products, such as burgers and sausages, non-meat fillers, such as

c

$$\%\ \text{Nitrogen} = \frac{\%\ \text{Soya protein}}{6.25}$$

rusk, are used. In such cases, the amount of nitrogen contributed from the non-meat source is considered to be a fixed proportion of the carbohydrate content of that material.

The carbohydrate content is normally calculated by difference and is 100 less water, fat, protein and ash contents. Rusk has a Nitrogen Factor of 2.0 (d).

d

$$\%\ \text{Non Meat Nitrogen in rusk} = \frac{\%\ \text{Carbohydrate} \times 2.0}{100} = \%\ \text{Carbohydrate} \times 0.02$$

Having ascertained the various Non Meat Nitrogens we can then go on to calculate the Apparent Fat Free Meat Content (e).

e

$$\%\ \text{Apparent Fat Free Meat Content} = \frac{\%\ \text{Total Nitrogen} - \%\ \text{Non Meat Nitrogen}}{\text{Nitrogen Factor for appropriate meat type}}$$

In this equation the Non Meat Nitrogen can have one or more components such as soya protein and nitrogen from carbohydrates, but it should be remembered that soya protein will contribute to both of these – the actual protein to the former figure and the soya carbohydrate to the latter figure.

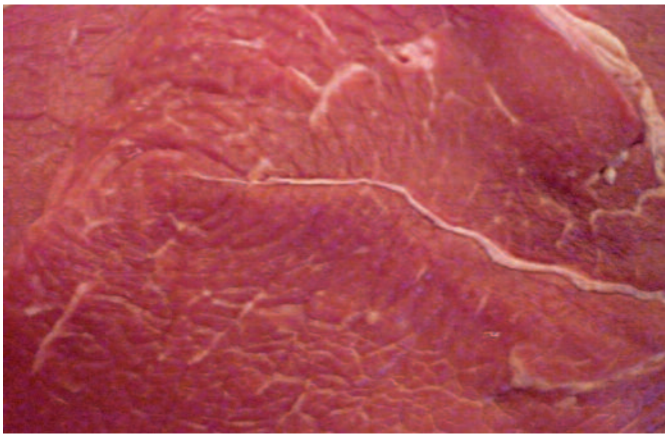
In manufactured products, as in meats, the % Apparent Total Meat Content is % Apparent Fat Free Meat Content plus % Fat. However, from a legislative view it may not be possible to count all of the fat towards the Apparent Total Meat Content (f).

f

$$\%\ \text{Apparent Fat Free Meat} = \frac{100}{100 - A}$$

Where A is 30, for pork, 25 for other mammalian meats and it is 15 for poultry.

In an EU context, lean meat content is no longer referred to by legislation and, therefore, has no legal basis. This is because it is not possible to determine lean meat content because of the variability of fat content in lean meat. For example, the lean meat from pork can naturally contain <5 to >12% fat. Lean meat contains some fat so, historically, this was assumed to be 10% and this was taken into account by multiplying the Apparent Fat Free Meat Content by 0.9.



The Apparent Total Meat Content of a product can be >100% and this arises by cooking or some other process which has removed moisture from the meat. For example, some continental sausages can have apparent meat contents as high as 175%. Even good old roast beef often has an equivalent meat content of >120%!

The EC Directive referred to earlier also restricts the amount of connective tissue that is allowed to be present in meat destined for use in meat products.

In most mammalian meats this is 25% but for poultry (and rabbits) it is just 15%. This Directive defines the connective tissue in terms of the ratio between collagen content, which is defined as hydroxyproline content x 8, and meat protein content.

Hydroxyproline is an amino acid which is present in animal protein collagen.

This then brings us to Connective Tissue Free Fat Free Meat Content which can be defined as shown (g).

g

$$\frac{\%\ \text{Total Nitrogen} - (\%\ \text{Carbohydrate Nitrogen} + \text{soya Nitrogen} + \text{Connective Tissue Nitrogen etc}) \times 100}{\text{Appropriate species Nitrogen Factor}}$$

This can then ultimately be used to calculate the amount of connective tissue which is not counted as meat. Hopefully all of the connective tissue can be accounted for by the meat unless bulking products such as skin have been used which often need to be declared.

Alternatively, whether connective tissue is in excess can be calculated by reference to the collagen/protein ratio which is the means used by the EC Directive to define the limit for connective tissue allowed in a specific product type (h).

h

$$\text{Connective Tissue Content} = \frac{\%\ \text{Collagen}}{\%\ \text{Meat Protein}} = \frac{\%\ \text{Hydroxyproline} \times 8}{\%\ \text{Meat Protein}}$$