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QUALITY ASSESSMENT OF PROCESSED MEAT PRODUCTS : SOME ANALYTICAL ASPECTS

Summary

The quality of meat products are primarily related to the nature of the material which is presented as "meat" in a processed product. Assessment of meat quality requires the use of a variety of analytical approaches and techniques to check the compliance of the product with the legal requirements and to determine the quantity and type of meat used.

Introduction

There can be no general accepted definition of what constitutes excellence in meat products since quality depends primarily on the subjective appreciation of the product judged by a population of consumers.

The quality of a meat product may be described under two headings, the first relating to the quality of the product in terms of consumer appeal whilst the second relates primarily to the nature and composition of the material which is presented as "meat" (1).

Quality judgment by consumers stems from a series of subjective tests relating to appearance, colour, flavour, tenderness, juiceness, e.a. of the finished product (table 1). These subjective assessments may be assisted through use of related physico-chemical parameters which can be objectively measured e.g. light-reflectance, pH-value, waterholding capacity, tenderometer testing. In evaluating a meat product the consumer expects that the meat should be of the prescribed composition, However, by processing the manufacturer is able to blend and to adjust the product to the desired organoleptical properties by incorporation of fat, colours, flavours, salts and other protein material so that consumers may not longer be aware of the quantity of meat in a product.

If sensory and hygienic aspects are sound, the quality of processed meat products should be evaluated in terms of its analytical composition. The analytical composition of the meat product should be described on basis of three main questions :
1. What is the composition of the meat product ?
2. How much "meat" is in the meat product ?
3. What sort and type of meat is used ?

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1. Composition of the meat product.

Meat products have been defined as "any product intended for human consumption containing meat" (2). Meat is "the striated muscle together with the connective tissue in which the muscle fibres are deposited and such intramuscular fat as cannot be trimmed off without breaking the muscle as a whole" (3). Processed meat products may thus be regarded as containing meat with varying proportions of fat together with non-meat ingredients such as starch, glucose, salts, e.a.. Analytically the quality of meat product should be described in terms of its muscle content.

The chemical composition of the major constituents of meat products, e.g. lean meat and fat, are shown in figure 1. In lean meat, water is the most abundant substance followed by protein. Lean meat may thus be regarded as a protein gel containing salts. Extensive measurements have shown that different muscles of the carcass have a mean ratio of moisture to protein (Feder number) ranging from 3.4 to 3.6 (4). For genuine meat products this ratio should not exceed 4 (5). Fresh muscle tissue contains practically no carbohydrate while its fat content ranges between 3 and 10%. Fat tissues are mainly constituted of triglycerides together with small amounts of protein associated with water (6).

Lean meat excludes visible fat but includes proportions of skin and connective tissue associated with that meat. Since the nutritive value of connective tissue is much less than that of muscle, the addition of an extra amount of connective tissue - as often practised - should not count towards muscle protein. Since the major proteins of connective tissue, collagen and elastin, are the sole proteins containing significant amounts of hydroxyproline (6), the amount of this amino acid in a hydrolysate of meat product is used as an index of its collagen content. Determination of total N-content by Kjeldahl allows calculation of the crude protein content (N x 6.25); from the hydroxyproline content (H %) the amount of collagen may be estimated (collagen = H % x 8). Muscle protein content is then estimated by the difference between total protein and collagen (5). The relative amounts of muscle protein in total protein may thus be accepted as an important parameter of meat quality.

In comminuted meat the organic non fat (100 - (% fat + % ash + % moisture) is almost identical with its protein content. In meat products the added carbohydrate is estimated from the difference between the "organic non fat fraction" and its crude protein content (table 3).

Processed meats vary widely in contents of major nutritive components depending on the specific nature of the meat and the processing procedure employed (2). The addition of extra fat to some products is a known practice which increases the eating quality particularly in modifying the dry leathery texture which can develop in all lean tissues. Thus in products such as sausages, frankfurters, salamis e.a.

fat levels are higher than in fresh meat and the levels of protein will thus correspondingly be lowered. However, the incorporation of extra amounts of fat - as a cheap meat substitute - in meat products is limited in fixing a fat/protein ratio for each product. In canned hams, the use of tripoly- and diphosphates in brine at levels of 0.5 %, allow addition of large amounts of water. Since most tissues have a P_2O_5/protein ratio of 0.019 - 0.025, the use of this index screens for addition of phosphates during the manufacturing process.

The quality of processed meats is thus described in terms of its muscle protein content and the ratio fat/protein. For cooked meat products the amount of added water is limited by its Feder value (table 4).

Alternatively, in the Anglo-Saxon regions some of these requirements are described in terms of its "meat content" calculated by the Stubbs and More formula as :

$$\text{"meat content"} = \text{"lean meat"} + \% \text{ fat} = \frac{\% \text{ N} \times 100}{N_F} + \% \text{ fat} \quad (7),$$

where N is the nitrogen corrected for ingredients and N_F is a factor appropriate to the meat (N_F = 3.45 for pork or 3.55 for beef) (1, 4). Since fat contributes to the meat content, a minimum lean meat content is prescribed (7). However, additional connective tissue in meat products is not regulated and may count towards the meat content (8).

Since the amount of intramuscular fat in lean meat is variable (1 - 18 %) and the protein - nitrogen includes nitrogen from the added fat, estimation of the amounts of lean meat and fatty tissue in a meat product should be based on "standard" values of these meat components (7 , 9). A tentative formula derived by Pearson allows calculation of the lean meat content (L_M) of the product (10) :

$$\% L_M = \frac{100\, N_T - FEXT.N_F.\left(\frac{100}{F_F} - 1\right) - 2C}{N_F \left(1 - \frac{F_L}{F_F}\right)}$$

where C = percentage of dry carbohydrate (by difference).
N_T = percentage of total nitrogen in the product.
FEXT = percentage of total fat extracted from product.
N_F = nitrogen factor of meat species used.
F_L = "standard" percentage of fat in lean meat.
F_F = "standard" percentage of fat in fatty tissue.

A simular approach in calculating the relative amounts of lean meat and fatty tissue in sausages has been proposed in the German Federal Republic (11, 12, 13).

Quality assessment on basis of the described parameters assume that meat products are the result of a genuine manufacturing process. However, meat technologists may display their skill in substituting meat proteins through other proteins of vegetable or animal origin (table 5) (14). Moreover, analytical determination of muscle protein content has been made more difficult by legislation allowing inclusion of blood plasma, casein or soya proteins which are estimated as "meat protein".

Injection of dissolved amino acids, proteins and modified starches in brine into whole meat pieces are becoming common practice, misleading consumers and elementary meat product control. These practices often face the analyst with the problem how much "meat" represents the meat product.

2. How much "meat" is in the meat product ?

From analysis of meat products it is evident that muscle protein is currently replaced by various meat extenders indicating that taste and appearance are no accurate guides in estimating the amount of meat in the product. The presence of non meat protein in meat products is generally detected through use of serological or electrophoretic methods.

Serological techniques have been developed for identification and quantitative evaluation of blood plasma, egg albumin, soy protein and casein in meat products (15, 16, 17). However, application of these methods is limited by denaturation of proteins during processing (17).

Electrophoresis of polypeptides, extracted from meat products, on polyacrylamide in presence of sodium-dodecyl-sulphate, have been used for quantitative detection of soy protein (18), casein and egg-white in heated meat products (19). The patterns of soya and meat proteins are different and it was claimed that one soya band could be used to give quantitative results for protein concentrate in a meat soya mixture (20). In studying different extracting procedures we were able to concentrate the casein and soy protein from heated meat products (fig. 2) (21). SDS-electrophoresis of the extracts in presence of an internal standard (Cytochrome c) allowed to determine quantitatively 0.2 % of casein or 1 % soy protein in meat products heated to 100° C during 20 min (fig. 3). However, no distinct electrophoresis patterns have been observed in meat products to which yeast or bacterial proteins were added.

The ideal approach in estimating the meat content would consist in determining the amount of specific muscle proteins in meat extracts. However, muscle proteins are denatured to different extends during processing and heating so attention has turned towards determination of a specific amino acid, 3-methyl-histidine, which is only present in the contractile proteins of muscle (22). The ratio of the

3-methyl-histidine content to that of lean tissue protein should allow estimation of the true muscle protein on the meat product (23). However, it has been shown that the proportion of methylated histidine molecules in myosin varies from one muscle to another whereas the 3-methyl-histidine content of actin is constant (24).

3. What sort and type of meat is used ?

Many comminuted meat products are manufactured by blending one meat species with other meats. Replacement of a substantial proportion of one meat species through cheaper ones or offal would pass unnoticed to the consumer. This practice asks for methods to control the identity of meat in a product even if all protein has been proven to be muscle protein. Inclusion of a certain type of meat species may result in rejection of a meat product on ethic or religious considerations. Regulations in most countries accept that, if the meat in the product is named, it should either represent all or the majority of the meat present (8). For other meat products, the composition should reflect traditional manufacturing practices so that the consumer should get the kind of meat he expects.

Control of the identity in fresh comminuted products should present no problems since precipitin tests or combination of immunological and electrophoresis techniques (rocket electrophoresis) allow to discriminate the serum albumins from meat extracts of different aniaml species (15, 8). By radial immunodiffusion (25) or by electrophoretic migration of meat extracts in agarose containing albumin antiserum (Laurell technique) (26), 5 % foreign meat species can be detected in meat extracts. Quantitation of the amount of adulterant is at variance (± 20 %) as the amount of serum albumin extracted also depends on the meat cuts examined (27).

Species identification by isoelectric focusing of aqueous extracts of raw skeletal muscles of different animal species has been reported recently (28, 29). Distinct electrophoretic patterns of closely related meat species were obtained (e.g. beef, lamb, goat) and it was claimed that the method enables differentiation according to age (29). However, these methods are only applicable to mildly processed products. Curing and heat treatment denatures sarcoplasmatic proteins to different extends, preventing species specific protein detection. The only valuable approach in identifying meat species in heat processed products resides in the determination of species specific heat stable components in the meat products.

Detection of chicken meat in meat products was performed in determining the amount of dipeptides anserine and carnosine in meat products (30). Since the ratio of anserine to carnosine in chicken meat is at least 20 times that observed in pork, replacement of pork meat through at least 10 % of lean chicken meat would result in a significant increase of the anserine/carnosine ratio of the finished product. However, the method is time consuming and admixture of sheep,

goat or beef meat decreases the sensitivity of the method owing to the higher anserine/carnosine levels observed in those species.

Characterisation of meat species by fatty acid analysis using gas liquid chromatography has been repeatedly reported (1). Horse fat would be identified in high content of linolic and linoleic acids and pork fat might be identified by the characteristic levels of linolic and arachidonic acids when compared with beef or lamb fat. Since feeding regime significantly affects the fatty acid composition of pork (31, 32, 33), any discrimination of species on basis of fatty acid analysis seems of doubtful value.

Striking differences in the distribution of fatty acids within the triglycerides were noticed between the fat of pigs and most mammalian fats using pancreaslipase (33) or stereospecific analysis (34, 35). In contrast to most mammalian fats, where the unsaturated fatty acids tend to concentrate at position 2, pork fat shows a preferential esterification of palmitic acid at position 2 of the triglycerides. Due to the large variability in the proportions of fatty acids incorporated in position 2, only mixtures containing at least 30 % of beef fat in lard could be discriminated (36). Recently, we found that beef, pork, horse and hen fat are characterized by different, but close correlationships between the incorporation of certain fatty acids into the 2-position and the corresponding content of fatty acids in the total triglycerides. On basis of these relationships, which may be typical for the species studied (37), appropriate factors were selected allowing estimation of fat adulteration by other species. From the total fat content and after pancreatic lipase analysis of the triglycerides isolated from meat, the relative percentages of pig fat in other fats was determined (table 6). Assuming a typical fat percentage for one of the meat species, the relative proportion of the meat species in the product was calculated (37).

Conclusion

There is no doubt that the detailed control of processed meat products requires an expert analysis. Analytical problems in assessing the quality of processed meat products are numerous and complex and require a variety of the analytical approaches to check the compliance of the product with requirements and to determine the quantity and type of meat used.

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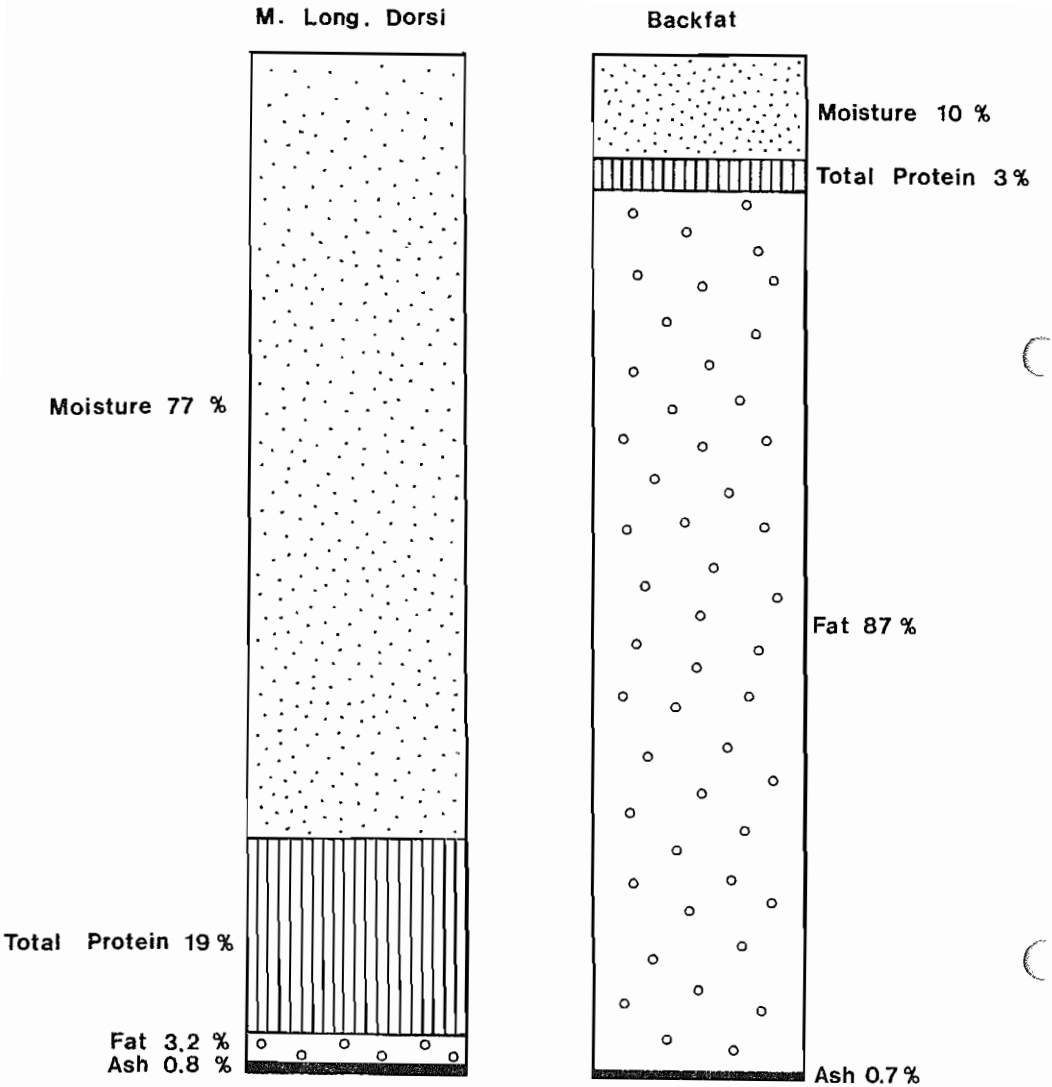
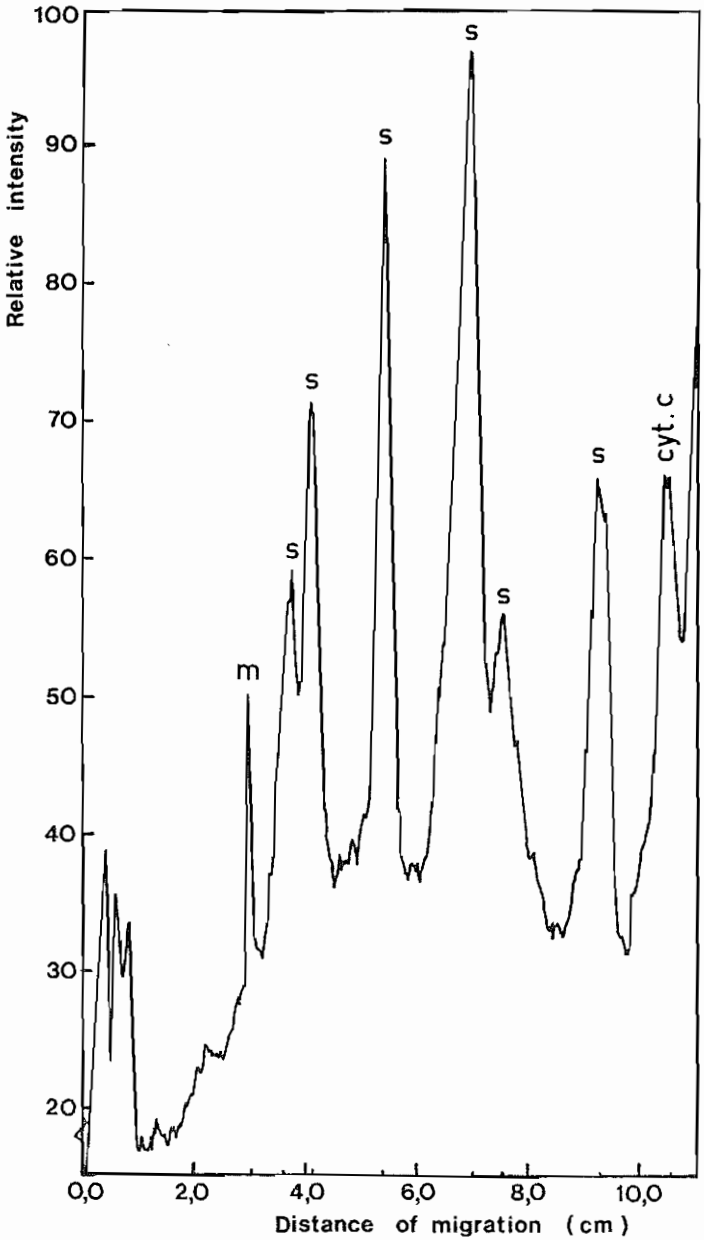


Fig. 1 : Chemical composition of musculus L. Dorsi and Backfat (pig)



s = soy - protein

m = meat - protein

Fig. 2 : Spectrum of protein bands in cooked ham with 3% soy after NaCl extraction and SDS-Acrylamide Stacking Gel Electropho

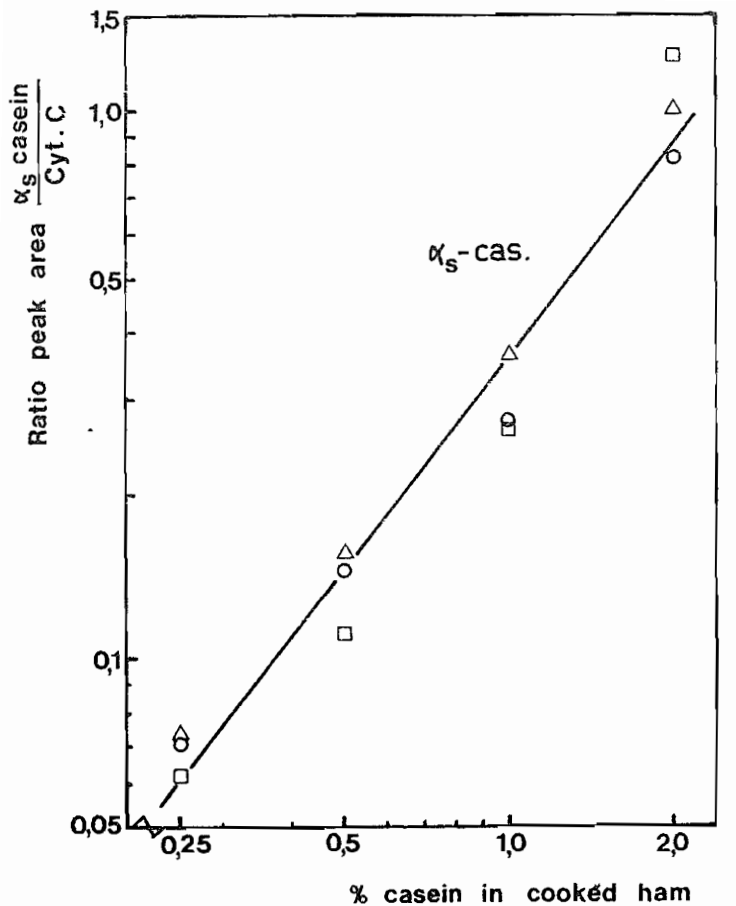


Fig. 3 : Quantitative determination of casein in cooked ham by SDS-Acrylamide Stacking Gel Electrophoresis (21)

TABLE 1

Attributes in quality evaluation of meat products

ANALYTICAL COMPOSITION	ORGANOLEPTIC CHARACTERISTICS	PHYSICO-CHEMICAL PARAMETERS	BACTERIOLOGICAL QUALITY + PROCESSING
Moisture	Colour	Light-reflectance	Hygiene
Protein (collagen)	Tenderness	Tenderometer	Salting
Fat	Consistence	Water-holding capacity	Heating
Carbohydrates	Juiciness	pH-value	Drying
Minerals	Flavour	Aw-value	Smoking
Vitamins		Oxydation (fats)	
Additives			
Residues		SHELF-LIFE	
Nutritional value			

QUALITY EVALUATION

TABLE 2

Hydroxyproline, proline and glycine content (g/100 g of protein) of meat, connective tissue and some meat analogs

AMINO ACID	BEEF	PORK	COLLAGEN	ELASTINE	CASEIN	SOYA
Glycine	7.1	5.0	26.6	28.9	2.0	4.1
Proline	6.0	4.5	14.4	17.0	10.6	5.5
Hydroxyproline	0.1	0.1	12.8	1.9	<0.1	<0.1

TABLE 3

Some relationships between the major constituents in meat and meat products

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MEAT

Meat = Protein + Moisture + Fat + Ash

% Organic non fat = 100 - (% moisture + % fat + % ash) = % protein

The "Feder number" = $\frac{\%\ \text{moisture}}{\%\ \text{organic non fat}} = \frac{\%\ \text{moisture}}{\%\ \text{protein}}$

MEAT PRODUCTS

Meat Product = Protein + Moisture + Fat + Ash + Carbohydrates

% Organic non fat = 100 - (% moisture + % fat + % ash) = % protein + % carbohydrate

% Organic non fat - % protein = % carbohydrate

Feder number = $\frac{\%\ \text{moisture}}{\%\ \text{protein}}$

TABLE 4

Some chemical parameters used in quality evaluation of meat

Feder number	$= \frac{\text{Moisture \%}}{\text{Total Protein \%}}$	(≤4)
Connective tissue (%)	$= \frac{\text{Collagen \%}}{\text{Total Protein \%}} \times 100$	(≤15)
Fat/protein ration	$= \frac{\text{Extractable Fat \%}}{\text{Total Protein \%}}$	(≤3)
P_2O_5-index	$= \frac{\%P_2O_5}{\text{Total Protein \%}} \times 100$	(≤2)

TABLE 5

Meat protein analogs used in manufacture of meat products

SOURCE	PRODUCTS	SOURCE	PRODUCTS
Milk	Milk powder	Eggs	Egg albumin
	Casein	Wheat	Wheat gluten
	Whey proteins	Yeast	Yeast protein
Blood	Plasma	Bacterie	Bacterial protein
	Cell protein	Diverse	Protein hydrolysate
Soya	Soy flour, grist		
	Soy protein concentrate		
	Isolated soy protein		

TABLE 6

Detection of fat adulteration (%) at the 95 % confidence interval

FAT	ADULTERATED WITH %			
	PIG	BEEF	HORSE	HEN
Pig	—	10	9	11
Beef	22	—	36	44
Horse	20	24	—	51
Hen	20	40	44	—