KONGRESS-DOKUMENTATION

WISSENSCHAFTLICHE BEITRÄGE
PROCEEDINGS

III

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EUROPÄISCHER FLEISCHFORSCHER-KONGRESS
BUNDESREPUBLIK DEUTSCHLAND, KULMBACH

4.–8. September **1978**

HELSINGIN YLIOPISTO
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KONGRESS-DOKUMENTATION

WISSENSCHAFTLICHE BEITRÄGE
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24. Europäischer Fleischforscherkongreß
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Contents

Contents

Contents

Contents

Contents

Contents

H

2. SYMPOSIUM

DIE VERWENDUNG VON BLUT IN NAHRUNGSMITTELN

UTILIZATION OF BLOOD FOR HUMAN CONSUMPTION

Die Verwendung von Blut und anderen Proteinen in Fleischprodukten

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Im Verhältnis zu der schwedischen Gesamtproduktion von Blut wird ein grosser Prozentsatz für den menschlichen Verbrauch verwendet. Ausser der Verwendung von Vollblut in traditionellen Produkten wie Blutpudding und Blutwurst gebraucht man das Plasma - nass oder trocken - in Fleischprodukten. In der schwedischen Fleischindustrie verbraucht man etwa 6500 Tonnen nasses Plasma pro Jahr. Wie auch andere Proteine wie Sojaproteine und Kaseinate werden Plasmaproteine als funktionelle Ingredienzen benutzt. Auch wenn man dieselbe Qualität des Endproduktes durch verschiedene Ingredienzen erreichen kann, können sie getrennte Funktionen in dem Fleischsystem haben. Die Funktion der Blutproteine im Verhältnis zu den Funktionen anderer Proteinsysteme wie Sojaproteine, Molkeproteine und Kaseinate wird deshalb besprochen werden.

The utilization of blood and other proteins in meat products

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In relation to the total production of blood a high percentage is used for human consumption in Sweden. Apart from the use of whole blood in traditional products like blood pudding and blood sausage the plasma in wet or dry form is used in meat products. When calculated as wet plasma about 6500 ton per year is used in the Swedish meat industry. Similar to other proteins such as soy proteins and caseinates plasma proteins are used as a functional ingridient. Although the same quality of the final product can be achieved by various ingridients they may have different functions in the meat system. The functions of blood proteins will therefore be discussed in relation to the functions of other protein systems such as soy proteins, whey proteins, and caseinate.

H 1:2

L'utilisation du sang et des autres protéines dans les produits d'alimentation

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En relation avec la production totale de sang, un grand pourcentage est utilisé pour la consommation en Suède. Mise à part l'utilisation du sang entier pour les produits traditionells tels que le boudin et certains puddings, le plasma séché ou non est utilisé dans les produits d'alimentation. 6500 tonnes de plasma non séché sont utilisées, par an, en Suède, dans l'industri alimentaire. De même que les autres protéines telles que les protéines et les caéines de soja, les produits du plasma sont utilisés comme ingrédients fonctionells. Alors que la même qualité d'un produit final peut être atteinte par des ingrédients variés, ceux-ci peuvent avoir des fonctions bien différentes dans le système d'alimentation. C'est pourquoi la fonction de ces protéines du sang sera discutée en relation avec les fonctions des autres systèmes de protéines du petit-leit et les caséines.

Применение протеинов крови и других протинов для изговления мясных продуктов

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Значитемьный процент от общей продукции крови идет в швеции на употребпене ее как одного из компонентов пищевых продуктов. Помимо употребения всей крови для изготовления традиционных продуктов, таких как колбаса и сосики, употребпяется плазму как во влажном так и в сухом виде для изготовления мясных продуктов. Согласно ориентировочным подсчетам, шведскя мясная промышленность употребляет около 650 тонн влажной плазмы в год. Подробно другим протеинам, таким как соевые протеины и казеинаты, упоребляется плазма как функциональный ингредиент. Хотя одинакове качества конечного продукта могут быть достигнуты при помощи различных ингредиентов, однако их функции в пищевой системе могут быть различны. Следовательно, будут функции протеин крови рассматриваться в отношении к функциям других протеиновых систем, таких как соевые протеины, сыворотные протеины и казеины.

The function of blood proteins and other proteins in meat products

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Introduction

Protein ingredients are chosen for use in meat products partly because of their functional properties. Apart from the commonly used milk and soy proteins, blood protein is an interesting alternative and frequently used by the Swedish meat industry in the form of blood plasma.

The annual use of blood in food is about 10 000 tons in Sweden. About 3 000 tons/year are used directly in traditional products like blood pudding and blood sausage. The rest is separated into plasma and a red blood cell concentrate. When the blood has been refrigerated and transported to a blood protein plant, the plasma phase makes up about 55% or ca 3 900 tons/year, and the blood cell concentrate 45% or 3 100 tons/year. The plasma is used in meat products either frozen or dried.

Part of the red blood cell concentrate is dried and used as an alternative to fresh blood. It is also possible to obtain a decolorized protein hydrolysate (1) or a decolorized globin product (2) (3) from the red blood cell fraction. As neither of these are in commercial use as functional ingridients only plasma will be discussed in this paper.

The discussion of functional ingredients can be rather confusing because it is possible to obtain meat products with exactly the same fat and water binding properties from proteins with completely different functional properties (4). It is therefore important to know the functional property(ies) of a special ingredient that contributes to the final structure of the finished food product.

The aim of this paper is to compare the water binding properties of plasma proteins with milk and soy proteins and to show how these proteins contribute to the final structure of a model meat product. Only water binding will be discussed in this paper. Too little is still known on how emulsion characteristics can be used to predict properties of meat products (3) (5). Of the proteins discussed caseinate is often used especially because of its emulsifying properties. Variations in processing conditions will affect the functional properties of a protein product (6) (7). In spite of this, the differences between plasma proteins, caseinates, whey proteins, soy protein isolates, and texturates are so big that some generalization can be made.

Materials

Protein preparations. The following protein preparations have been used in this study. The conversion factor N x 6.25 has been used to calculate the protein content from N-analysis, if not otherwise stated.

Plasma products. Ultrafiltrated frozen plasma (UFF), protein content 11.8%; frozen plasma, protein content 6.5%; spraydried plasma powder (SPP), proteint content 67%. All plasma products were obtained from Ellco Protein AB, Kävlinge, Sweden.

Soy protein isolates. A soy protein isolate produced under mild conditions in pilot plant scale (SPI), protein content 94%; Promine-D from Central Soya, protein content 85%; Purina 500 E from Ralston Purina, protein content 87%.

Textured soy protein. VMRI (Nabisco), protein content 51%.

Caseinates. Sodium caseinate (DMV) spraybland, protein content 88% (N x 6.38); EM 6 sodium caseinate (DMV), protein content 88% (N x 6.38).

Whey protein concentrates. Ultrafiltrated spray dried WPC produced on pilot plant scale: WPC-1, protein content 48%; WPC-2, protein content 62%; WPC-3, protein content 51%. Gelfriltrated, spray dried WPC produced on pilot plant scale: WPC-4, protein content 71%.

Model meat system. A meat batter was made where the meat was replaced by various amounts of proteins. In all systems the water content was kept constant at 60% and the fat content at 22%. In this paper micrographs are shown containing 6% Purina 500 E, 6% soy protein texturate, and 2% blood protein or 30% wet plasma. Half frozen plasma was added instead of ice water.

Methods

The methods for functional characterization have been described elsewhere, solubility (8), viscosity (6), swelling (9), and gelation (9).

The structure of the meat systems was evaluated by a technique previously used by Schut (10), slightly modified as described below.

The meat sample was fixed in 3% glutaraldehyde for at least 15 hours. Small pieces were then frozen in liquid nitrogen and sectioned at -30°C to a thickness of 10 µm. Sections mounted on microscope slides were first treated with Van Giesons stain for 7 min; which stained the protein yellow and connective tissue pink. The sample was washed with ethyleneglycol and counterstained with Sudan Black for 12 min. which stained the fat blue. Excess of color was washed with ethyleneglycol.

Results and discussion

Functional properties of unheated systems

Plasma can be used in a wet or dry form. If dried the drying process has an effect on the functional properties. During drying the protein can be partly denatured and aggregated. When severe drying conditions are used the protein will be completely denatured and loses important functional properties. The drying conditions are important for properties such as solubility and gelling. If mild conditions are used the solubility is high and independent of pH as can be seen from Table 1. Denaturation and/or aggregation during drying cause a decrease in solubility which is most pronounced in the isoelectric region. In our experiments minimum solubility was obtained around pH 5. Delaney et al. (11) observed minimum solubility around pH 4.

Similar solubility behaviour can be expected from simple protein systems without complex quaternary structures such as whey proteins. Table 2 shows the solubility at three different pH of whey protein concentrate prepared under different conditions. The isoelectric region of whey proteins is around pH 4.5.

The more complex soy proteins and caseinates have a stronger pH dependent solubility. In Figure 1 the solubility of SPP as a function of pH can be compared with the that of sodium caseinate and Promine-D.

Plasma protein can thus be said to have a high solubility throughout the whole pH range. At neutral pH around 7, the addition of salt up to 1.0 M will have little influence on the solubility of plasma proteins. In the isoelectric region around pH 5 the solubility can be expected to increase somewhat and at pH below the isoelectric region the solubility can be expected to decrease (3) (8) (11).

Plasma products have low viscosity and poor swelling ability as compared to caseinates and soy protein isolates as can be seen in Table 3. Whey protein concentrates and plasma protein products are similar also in this respect. The viscosity and swelling ability is dependent on processing conditions to some extent. Plasma - SPP and WPC-4 had lower solubility than plasma - UFF and WPC-2 due to aggregation during processing. As can be seen from Table 3, even if the data are poor, plasma - SPP and WPC-4 had higher swelling abilities than plasma UFF - and WPC-2.

The swelling of plasma proteins, WPC and caseinate is different in character to the swelling of the commercial soy protein isolates. To soy protein isolates the swellling is restricted by interparticular forces and the particle structure is resistant to several hours' swelling. In the case of the other group swelling is the first step in a solvation process and the particle structure is quickly destroyed. This is illustrated in Figures 3 and 4. The particle diameters before swelling were 50 - 100 /um.

The differences discussed in functional properties are important for the behaviour of the protein products in a meat system. To summarize, the functional properties of unheated plasma proteins in the pH range 5 - 7 are characterized by high solubility, low viscosity, and poor swelling ability. The same holds true for whey protein concentrates. Caseinate is characterized by high solubility and high viscosity. Soy protein isolates have generally lower solubilities, high viscosity, and high swelling ability.

The functional properties of plasma means that when a plasma product is added to a meat system the viscosity will decrease or remain unchanged depending on the amount of plasma added and the composition of the meat system. As the protein is highly soluble it will not be possible to identify any particles from the plasma in the meat system. On the other hand if a soy protein isolate is added one would expect to see swelled particles in the meat system.
Meat batters where part of the meat protein was replaced by plasma protein, soy protein isolate (Purina 500 E), and textured soy protein, were investigated in a light microscope. Figure 5 shows a reference without any added proteins. Figure 6 shows a batter which contains 30% wet plasma or 2% plasma protein. It is not possible to identify any plasma particles and the batter looks much more smeary than the reference batter.

Figure 7 shows a batter which contains 6% soy protein isolate (Purina 500 E). The presence of swelled particles are easily identified. Another type of soy protein product frequently used by the meat industry is textured soy protein. By texturization a structure is obtained which contributes to the texture and can hold water to some extent. Textured proteins are easy to identify by microscopy as seen in Figure 8, which shows a batter containing 6% textured soy protein. In all these model systems meat was replaced by protein products but the fat and water content were kept constant.

This far only unheated systems have been discussed. Before heat treatment plasma proteins make no contribution to the waterbinding properties. Caseinate contributes by its high viscosity. Soy proteins contribute by viscosity and swelling properties.

Functional properties of heated systems

The real function of plasma proteins with regard to water binding is their excellent gelling properties. Before heat treatment whey and plasma proteins have similar properties. After heat treatment plasma proteins form firm elastic gels at relatively low concentrations. Whey proteins can also form gels but the gel network is much coarser than that of plasma proteins and water is easily pressed out of the gel structure. Plasma proteins form gels at protein concentrations of 4 - 5% whereas protein concentrations of 7 - 8% are necessary for gels to form from whey or soy proteins. Caseinate lacks the ability to gel by heat treatment.

The gel strength of plasma protein gels is dependent on several parameters such as protein and salt concentration, pH, temperature, time of heating, and the prehistory of the protein. The importance of some of these parameters is shown in Table 4. Gel strength was measured by two methods. Both are crude and can only give relatively measures.

The following criteria for gel formation have been made. Brookfield values should exceed 1000 and the material should resist penetration. It can be seen that heating at 75°C was necessary for gels to form at 4% protein concentration. At all concentration levels salt had a positivie effect on gel strength.

Similar data for a soy protein isolate and a whey protein concentrate are given in Table 5. Salt has a positive effect on the gel strength of whey proteins. A positive salt effect on the gel strength of protein gels is what one generally expects. However, salt has a very special effect on the gelation of soy proteins and the gel strength decreases by salt addition (13) (14).

The temperature necessary for gel formation of plasma proteins is in the range 70 - 75°C depending on protein concentration, prehistory of the protein, and salt concentration. This is a very critical temperature range for meat products that are usually cooked at 70°C. If plasma is used as a functional ingredient care should be taken so that the required heat treatment is obtained for gelation to occur. If not, plasma will not contribute to water binding properties. Also soy proteins have good gel properties but the gelation mechanism is different from that of plasma proteins and soy proteins contribute to the water binding also without heat treatment (13).

After heat treatment of the model sausages it is more difficult to identify the presence of plasma proteins and soy protein isolate under the light microscope. Figure 9 - 12 give some examples. In all the meat systems the structure has been somewhat affected due to freezing of the sausages before preparation.
Figure 9 shows a micrograph of a reference sausage without protein addition. The magnification is lower for the heated sausages than for the unheated batters previously shown. Figure 10 shows a micrograph of a sausage containing 2% plasma protein (30% wet plasma). The protein matrix looks very much the same as in the reference sample. The only sign of the presence of another phase is the fine network that is present in some of the voids. This network has probably been formed due to ice crystal formation in the plasma phase during freezing.

It is also more difficult to find discrete soy protein particles after heat treatment of the meat systems. The soy and meat protein network have been better combined. Regions with high concentration of soy proteins are still to be found as can be seen in Figure 11.

Textured proteins are not effected by heat treatment and are easy to identify in cooked products as can be seen in Figure 12.

Summary

Some examples of the functionality of blood plasma proteins relative to soy and milk proteins have been shown. The discussed protein products are frequently added to improve the waterbinding properties as well as texture and fat binding properties of meat products. Although incorporation of these proteins can give meat products with the same waterbinding properties, different functional properties of the protein ingredients may contribute to the waterbinding properties of the final meat products. The important functional properties of plasma proteins are their good gelling properties. Plasma proteins do not contribute to the waterbinding of meat systems without heat treatment. The gelation temperature was found in the range 70 - 75°C. Therefore it is important to control the heating process carefully in order to obtain the desired functionality.

Acknowledgements

The technical assistance of E. Olsson, L. Svensson, and L-Å. Johansson is gratefully acknowledged.

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Table 1
Solubilities of 1% plasma proteins at various pH in dest. water

pH	4	5	6	7	9
UFF	97	90	90	93	98
SPP(*1)	97	99	100	100	100
SPP	93	70	86	95	96
SPP(*2)	67	73	77	80	80

(*1) and (*2) From Delaney et al (8)

Table 2
Solubility of 1% whey protein dispersions at various pH in 0.2 M NaCl solution

pH	4.5	7.0	9.0
WPC-1	96	98	98
WPC-2	87	100	99
WPC-3	38	50	51
WPC-4	64	79	88

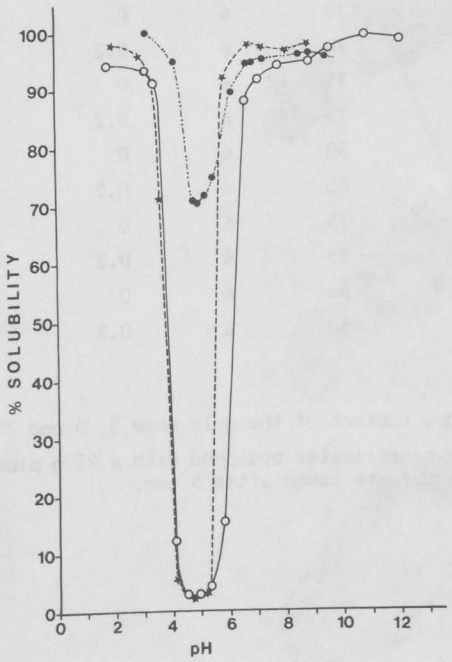

Figure 1. The solubility in dist. water as a function of pH for; -●- plasma protein - SPP; -*- sodium caseinate; -o- soy protein isolate - SPI.

Table 3
Apparent viscosity and swelling ability in 0.2 M NaCl

Protein product	Apparent viscosity (cp) of 12% dispersions at shear rates $100\ s^{-1}$	$300\ s^{-1}$	Swelling ability ml/g
Plasma - UFF			0.4
Plasma - SPP	7 - 15	7 - 15	1.2
WPC-2			0.8
WPC-4			1.8
Soy protein isolates			
SPI	30	25	~ 3.0
Promine-D	70	50	3.9
Purina-500 E	165	90	5.7
Sodium caseinate			
spraybland	130	110	~ 5
EM 6	650	600	-

Table 4
Gel strength of plasma protein gels as a function of protein concentration, salt addition and temperature

% protein[1]	Temp. °C	pH	NaCl M	Gel strength Brookfield poise	Gel strength[2] mm penetration
2.4	80	6	0	176	-
2.4	80	6	0.2	360	-
4	70	6	0	480	-
4	70	6	0.2	560	-
4	75	6	0	1400	-
4	75	6	0.2	3200	6.4
4	80	6	0	3500	6.5
4	80	6	0.2	4400	4.6
5.6	75	6	0	8400	2.7
5.6	75	6	0.2	9600	1.8
5.6	80	6	0	12000	1.9
5.6	80	6	0.2	14800	1.5

1) The dry content of the gels were 3, 5 and 7%.

2) A SUR-penetrometer equipped with a 25 g plunger and with a diameter of 20 mm was used. Readings were taken after 5 sec.

Table 5
Gel strength of soy and whey protein gels.

% protein	Temp °C	pH	NaCl M	Gel strength Brookfield poise	Gel strength mm penetration 3)
Promine D ~9.5 1)	70	7	0	2320	-
	70	7	0.2	-	-
	80	7	0	3680	5.4
	80	7	0.2	80	-
Promine D ~11.5 2)	70	7	0	4953	3.4
	70	7	0.2	-	-
	80	7	0	7610	2.4
	80	7	0.2	1500	7.2
WPC-4 ~7.5 1)	70	7	0	-	-
	70	7	0.2	60	-
	80	7	0	154	-
	80	7	0.2	2200	4.2
WPC-4 ~9.0 2)	70	7	0	-	-
	70	7	0.2	560	-
	80	7	0	3700	8.1
	80	7	0.2	6600	3.5

1) Dry content 10%
2) Dry content 12%
3) A SUR-penetrometer equipped with a 25 g plunger and with a diameter of 20 mm was used. Readings were taken after 5 sec.

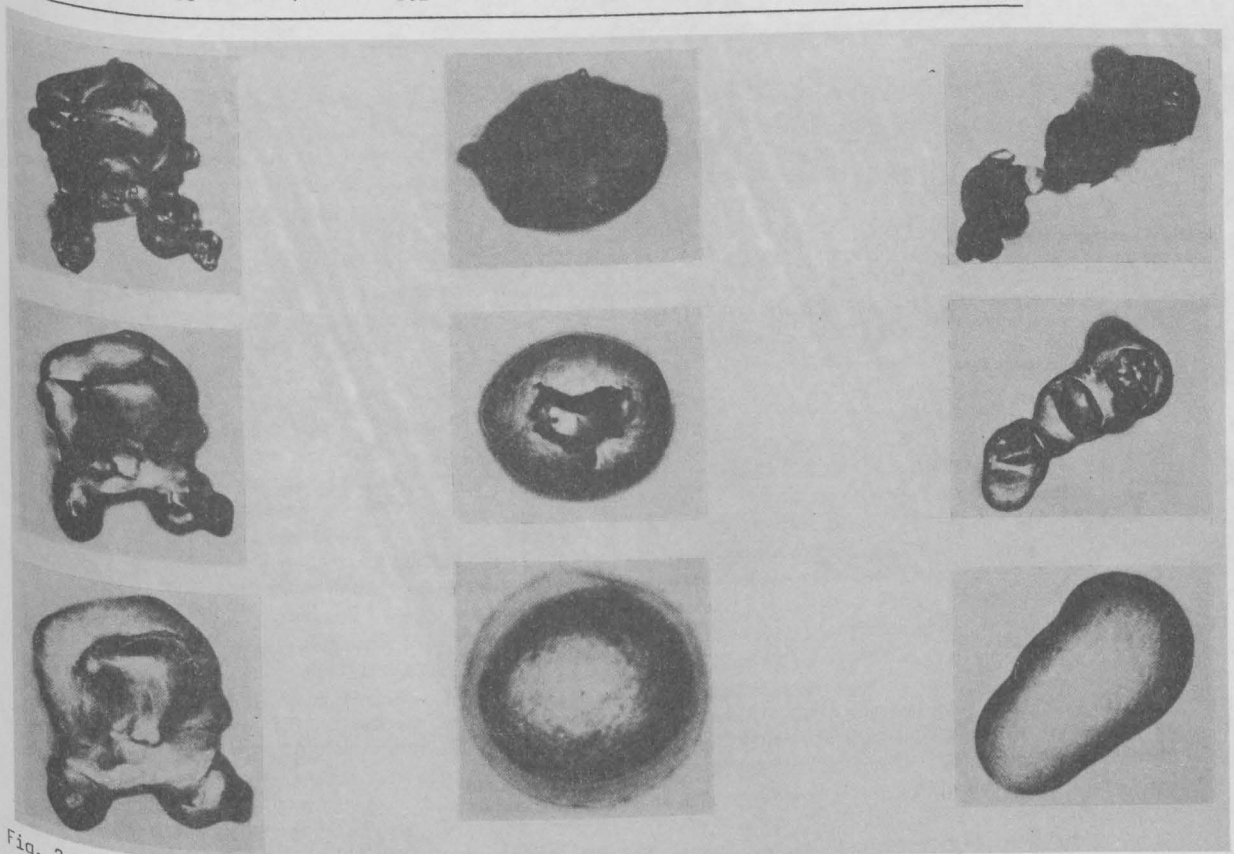

Fig. 2. Micrographs of Promine-D made after 0, 1 resp. 5 hours of swelling.
From Hermansson 1972 (9)

Fig. 3. Micrographs of WPC-4 made after 0, 5 resp. 30 min of swelling.
From Hermansson 1972 (9)

Fig. 4. Micrographs of caseinate (spray dried) made after 0, 5 resp. 30 min of swelling.
From Hermansson 1972 (9).

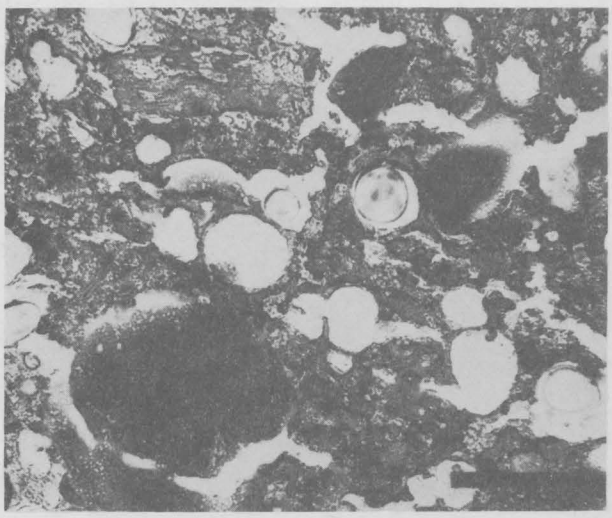

Fig. 5. Light micrograph of a reference meat batter without added protein ingredients. The length of the line corresponds to 100 /um.

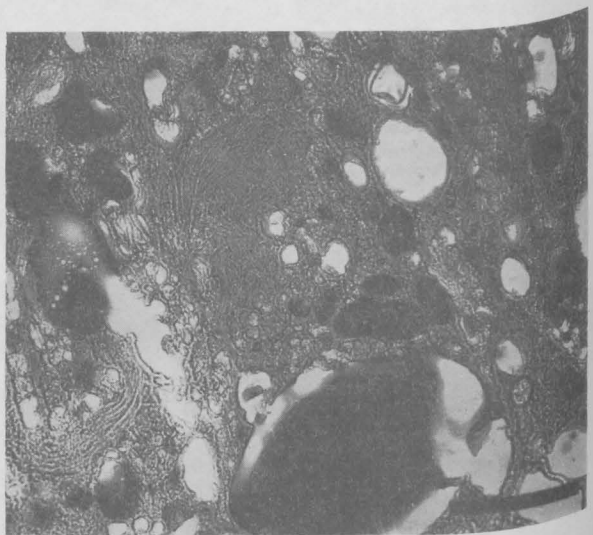

Fig. 6. Light micrograph of a meat batter with 30% wet or 2% plasma protein. The length of the line corresponds to 100 /um.

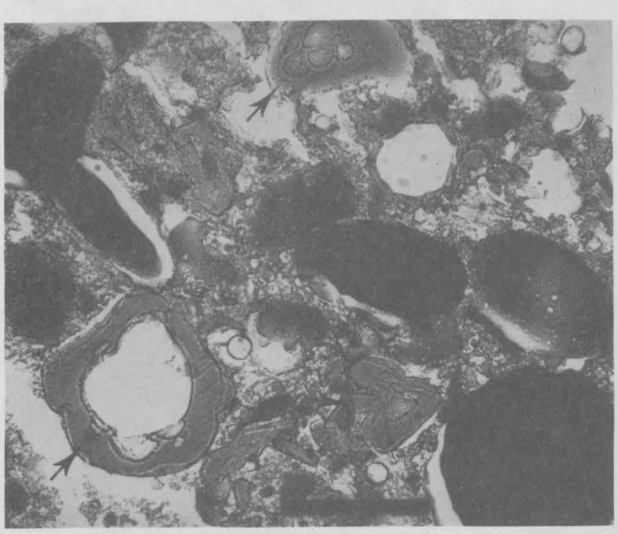

Fig. 7. Light micrograph of a meat batter with 6% soy protein isolate (Purina 500 E). The arrows show the presence of swelled soy protein particles. The length of the line corresponds to 100 /um.

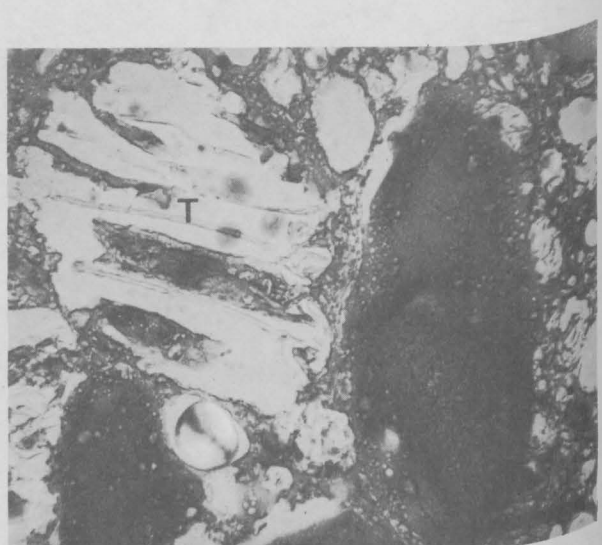

Fig. 8. Light micrograph of a meat batter with 6% textured soy protein. One textured particle is shown (T). The line corresponds to 100 /um.

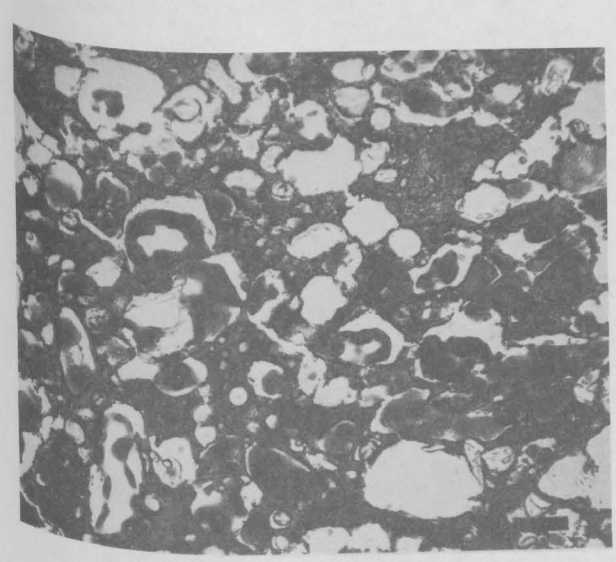

Fig. 9. Light micrograph of a reference sausage without added protein ingredients. The length of the line corresponds to 100 /um.

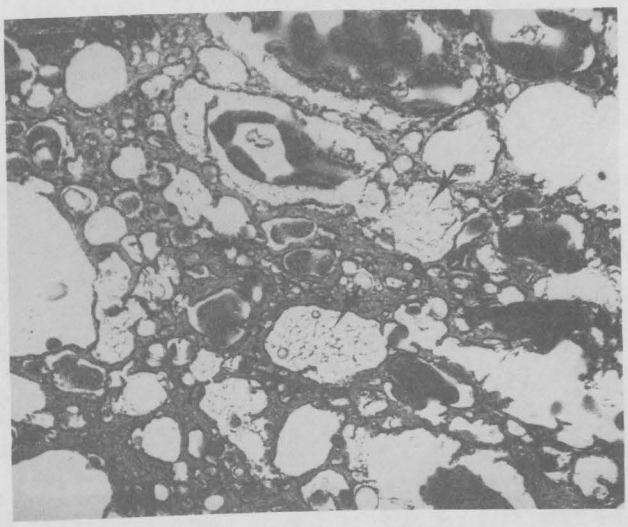

Fig. 10. Light micrograph of a sausage containing 2% plasma protein. The length of the line corresponds to 100 /um.

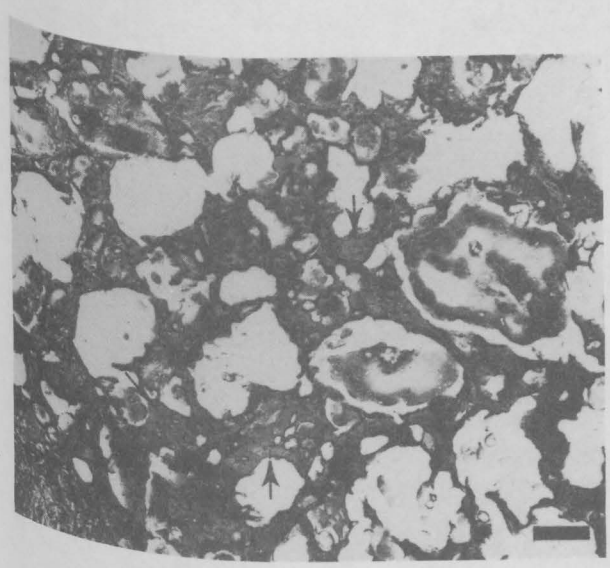

Fig. 11. Light micrograph of a sausage containing 6% soy protein isolate (Purina 500 E). The presence of soy protein particles is shown by arrows. The length of the line corresponds to 100 /um.

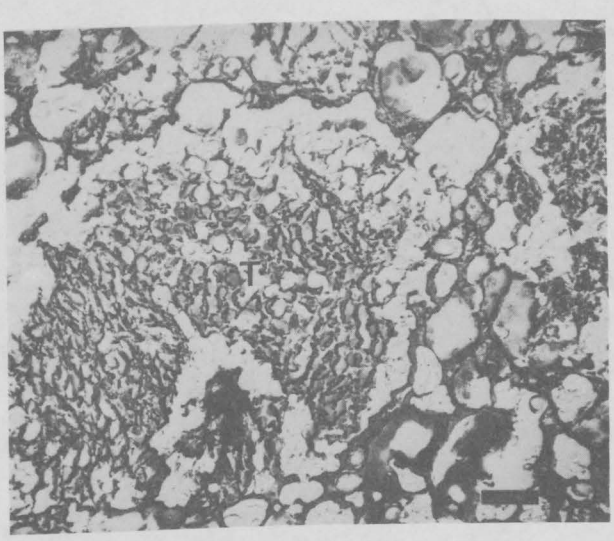

Fig. 12. Light micrograph of a sausage containing 6% textured protein. The length of the line corresponds to 100 /um.