THE EFFECT OF SOME FUNCTIONAL PROPERTIES OF ADDED PROTEINS ON PROPERTIES OF MEAT SYSTEMS

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Functional properties of proteins for foods can be defined as physico-chemical properties providing a certain amount of information about how a protein will act in a food system. However, few systematic investigations have been made on how these properties can be correlated with properties of complex food systems. For meat systems properties giving information on the water binding ability are very important. This paper will deal with some functional properties depending on water-protein relations and their effect on properties of meat systems where unconventional proteins have been added. The functional properties to be discussed are solubility, swelling, sorption, viscosity and gelation properties. Different kinds of proteins were incorporated to various levels into meat systems and changes in water binding properties and texture studied. Very good correlations were obtained between differences in functional properties and differences in the properties of the meat systems.

L'INFLUENCE DE QUELQUES QUALITÉS FONCTIONNELLES DE PROTÉINES AJOUTÉES SUR LES QUALITÉS DES SYSTÈMES DE VIANDE

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On peut définir les qualités fonctionnelles des protéines alimentaires comme des qualités physico-chimiques en état de donner des informations spéciales comment une protéine va opérer dans un système alimentaire. Cependant, ce sont seulement un petit nombre de recherches qui sont faites sur la corrélation de ces qualités avec les qualités des systèmes alimentaires. Les qualités qui donnent de l'information sur la capacité de liaison d'eau sont très importantes pour l'étude des systèmes de viande. Cette étude ici s'occupe de quelques qualités fonctionnelles qui dépendent de la relation entre de l'eaur et de la protéine ainsi que l'effet de ces qualités sur les qualités des systèmes de viande, auxquels des protéines qui ne sont pas conventionnelles ont été ajoutées. Les qualités a être discutées sont celles de la solubilité, du gonflement, de la sorption, de la viscosité, et de la congélation. Des protéines différentes étaient incorporées dans les systèmes de viande aux niveaux divers et les changements de la liaison d'eau et de la texture étaient étudiés. De très bonnes corrélations étaient obtenues entre les différences des qualités fonctionnelles et les différences des qualités dans les systèmes de viande.

H3:2

DIE EINWIRKUNG VON EINIGEN FUNKTIONELLEN EIGENSCHAFTEN BEI ZUSATZPROTEINEN AUF DIE EIGENSCHAFTEN DER FLEISCHSYSTEME

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Die funktionellen Eigenschaften der Nahrungsmittel-Proteine können als physikalisch-chemische Eigenschaften bezeichnet werden, die Auskunft über die Wirkungsweise eines gewissen Proteins in einem Nahrungsmittelsystem, geben können. Es sind aber auf diesem Gebiet nur wenige systematische Untersuchungen gemacht um festzustellen, wie diese Eigenschaften mit den Eigenschaften der komplexen Nahrungsmittelsysteme in Wechselbeziehung stehen. Eigenschaften, die Auskunft über das Wasserbindungsvermögen geben, sind besonders für Fleischsysteme sehr wichtig. Diese hier bekanntgemachte Untersuchung befasst sich damit einige funktionelle Eigenschaften festzustellen, die von der Wechselbeziehung Wasser-Protein abhängig sind sowie ihre Einwirkung auf die Fleischsysteme und zwar dann, wenn nicht-übliche Proteine zugesetzt werden. Die funktionellen Eigenschaften, die besprochen werden, sind diejenigen bei: Löslichkeit, Quellung, Sorption, Viskosität und Gelatinierung. Verschiedene Sorten von Proteinen wurden stufenweise in die Fleischsysteme eingeführt und die Veränderungen des Wasserbindungsvermögens und des Gewebes studiert. Sehr gute Auskunft über die Wechselbeziehung zwischen den Veränderungen der funktionellen Eigenschaften und den Eigenschaftveränderungen der Fleischsysteme wurde erreicht.

ВЛИЯНИЕ НЕКОТОРЫХ ФУНКЦИОНАЛЬНЫХ СВОЙСТВ ДОБАВЛЕННЫХ БЕЛКОВ НА СВОЙСТВА МЯСНЫХ СИСТЕМ

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Функциональные свойства белков для пищевых продуктов можно определить как физико-химические свойства, дающие определенное количество сведений о действии белка в системе питания. Однако только незначительное количество систематических исследований было проведено на тему корреляции этих свойств со свойствами сложных пищевых систем. Для мясных систем являются особо важными свойства, дающие информацию о водосвязывающей способности. Эта статья рассматривает некоторые функциональные свойства, зависимые от соотношения вода- белок и влияние их на свойства мясных систем, к которым были добавлены нешаблонные белки.
Обсуждаемые здесь функциональные свойства это растворимость, набухание, сорбция, вязкость и желирование. К мясным системам добавлялись разные сорта белка до различных уровней и исследовались водосвязывающие способности и структура ткани. Были получены очень хорошие корреляции между различиями в функциональных свойствах и свойствах мясных систем.

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INTRODUCTION

The development of new protein products is the subject of intensive research at various locations all over the world. Many functional properties such as solubility, swelling, viscosity, gel, foam and emulsions properties have been investigated but there is still not enough information on how these properties can be correlated with properties of complex food systems to which proteins have been added.

The processed meat industry is expected to have a high potential for protein products. In this investigation the effect of functional properties depending on water-protein interactions on moisture loss and texture properties of model meat systems and of a finished meat product have been studied. As meat products are complex and often difficult to control, well-defined model meat systems prepared under controlled conditions were used for the establishment of relationships between functional properties and moisture loss properties. The effect of percentage exchanged proteins on moisture loss were studied for raw meat systems and for meat systems heated to various temperatures. Three protein products of entire different character were incorporated namely a soy protein isolate Promine-D, a sodium caseinate and a whey protein concentrate (WPC).

FUNCTIONAL PROPERTIES

The functional parameters for the three protein products are summarized in table 1. The properties to be discussed are solubility, swelling, viscosity and gel strength. These properties are not independent and their relationships can be illustrated qualitatively or quantitatively (1, 2). Swelling, when defined as the spontaneous uptake of water, is the first step in the solvation process. If swelling is unlimited the protein will solvate; if not, swelling will proceed until it is limited by various intermolecular forces within the swollen sample. The former is the case for highly soluble low viscous protein products, the latter the case for denatured, aggregated or textured protein products.

Of the three protein products studied Promine-D has a limited type of swelling (3). As can be seen from table 1 Promine-D has a relatively low solubility even at high pH. The solubility is drastically reduced by the addition of salt at pH around 7 (4). The swelling ability is high in distilled water but is strongly reduced in salt solution. The same phenomenon occurs when viscosity is measured.

The full picture of the flow properties is given elsewhere (5). It should be added, however, that Promine-D dispersions in distilled water at concentrations above 8% have pronounced yield values and pseudoplastic flow. Yield values and deviations from Newtonian flow are reduced by the addition of salt.

When concentrated Promine-D dispersions are heated, gelation occurs. The gels are firm, elastic and have good water holding properties. A maximum in gel strength is observed in the temperature range 80 - 90°C. Salt delays gelation and causes changes in the gel properties.

Caseinate has a high solubility on the alkaline side of the isoelectric point. The solubility is little affected by salt. However, ultracentrifugation has shown that salt causes an aggregation which obviously is not reflected by the solubility properties. Sodium caseinate has a high initial swelling ability, but the swelling is unlimited and results in solvation. The high initial swelling is one cause for the difficulties to make caseinate dispersions. Contrary to the case of soy protein isolate, salt has an increasing effect on the viscosity. The flow characteristics of caseinate dispersions are entirely different to that of Promine-D. The flow was almost Newtonian and consequently no yield values were observed. Figure 1 shows the viscosity as a function of concentration for the three protein products. The viscosity of caseinate is extremely concentration-dependent with a logarithmic linear relationship over a broad concentration range. This concentration dependence is of importance for the behaviour of caseinate in meat system. Caseinate lacks the so important gelation ability on heating. This means that caseinate alone cannot thermally form a three-dimensional matrix, which can imbibe water, fat as well as other components.

WPC finally is highly soluble over the entire pH range in spite of the fact that the WPC preparation studied was partly denatured. Salt had no effect on solubility nor on swelling ability and viscosity. The swelling ability was low as well as the viscosity. Newtonian flow was observed in the range 4 - 12%. Thereafter the flow became more and more pseudoplastic. At very high concentrations (~ 20%) yield values were observed.

The whey protein concentrate forms gels when heated. The gels of whey proteins are less stable than those of soy proteins and water is easily pressed out. Salt has a favourable effect on gelation contrary to the effect on soy protein gelation.

Effect on model meat systems

When the effect of functional properties on meat systems were to be studied, model systems prepared under controlled conditions were used. To focuse all attention on the water-protein relations all visible fat was removed from the meat before it was ground and nothing but protein, water and salt were added. Two meat qualities common in minced meat products were used in order to avoid conclusions from a special case. They were beef brisket and pork shoulder. The quotient protein/water was kept constant at 0.2 throughout the experiments.

Figure 2 shows the effect of percentage exchanged protein on the moisture loss of the raw pork shoulder system. Similar results were obtained with the beef brisket system. 30% and 50% exchanged protein in this figure correspond to 5% and 8.3% added protein calculated on the total mixture. It is seen that the three protein products affected the moisture loss very differently. Incorporation of Promine-D gave the lowest moisture loss. Both incorporation of WPC and caseinate resulted in a high moisture loss. These differences can be explained by the previously discussed functional properties. Promine-D is characterized by a relatively low solubility, a high swelling ability and a high viscosity at neutral pH. Both caseinate and WPC are high soluble but caseinate has a higher viscosity and swelling ability. An attempt was made to correlate differences in functional properties with differences in moisture loss properties by a computational multiple regression procedure. The procedure involved the calculation and testing of all possible combinations of functional properties (1). Table 2 shows the correlation coefficients of the best statistical solution.

A very high total correlation coefficient of 0.99 was obtained with solubility in the first place explaining 79% of the variance and swelling and viscosity both explaining 10% of the variance. Of the functional properties solubility contributed positively to the moisture loss thus negatively to water retention. High swelling and viscosity data on the other hand are positive for water retention properties.

Addition of salt (1 - 4%) is known to increase the water binding properties of meat systems due to chloride binding and increased repulsive forces (6). As discussed previously salt affected the protein systems very differently. A meat system in which part of the meat protein is exchanged by one of the protein systems can therefore be expected to show complex behaviour with respect to water bindning properties.

Figure 3 shows the effect of salt on the moisture loss of the raw beef brisket systems without and with 50% exchanged or 8.3% added protein. Figure 4 shows the salt effect on the pork shoulder system at the same protein level.

The addition of salt had an enormous decreasing effect on the moisture loss in all the meat systems. The added proteins influenced the moisture loss differently in spite of the dominant salt effect. Most striking is the marked decrease in moisture loss for the caseinate meat systems. The only functional property to increase with salt concentration for caseinate is the viscosity and it is suggested that the highly viscous caseinate acts as a paste between the meat particles.

Exchange of Promine-D did not change the moisture loss properties of the beef brisket system. In the pork shoulder system exchange by Promine-D increased the moisture loss and the meat - Promine-D system showed a minimum at 4% NaCl. The moisture loss values for meat-WPC systems are high relative to those of the pure meat systems, but decreased with increasing NaCl-concentration.

When pure meat systems are heated, moisture loss normally increased with temperature to about 90°C. Figure 5 shows the effect of protein incorporation in the two meat systems as a function of heating temperature. The added proteins here make up 8.3% of the total mixture. The upper part of the figure shows moisture loss after heat treatment as a function of heating temperature, and the lower part of the figure the relative difference between moisture loss of protein meat systems and pure meat systems.

Contrary to the raw meat systems incorporation of WPC resulted in a lower moisture loss than incorporation of caseinate when heated at temperatures above 70°C. Both WPC and soy protein isolate but not caseinate have the ability to form gels when heated. For WPC 70°C is not a sufficient heating temperature for gels to form. For Promine-D gels formed at 70°C under the experimental conditions and the gel strength increased to a maximum at 80 - 90°C. In the meat systems the added proteins can interact with themselves or with the meat proteins to form a protein network that can imbibe water and reduce moisture loss.

Table 3 shows the correlation coefficients of the best statistical solutions when 8.3% and 5% protein of the total mixture was added. For the heat treated meat systems a very high correlation coefficient was obtained on the higher level with gel strength alone explaining 94% of the variance. Also on the lower level gel strength explained much of the variance but the correlation coefficients were somewhat lower than on the higher level due to small differences in moisture loss.

The influence of exchanged proteins on heat treated meat systems containing various amounts of salt differed from their influence on the raw meat systems. The drastic effect of caseinate disappeared on heat treatment and the caseinate meat systems showed the highest moisture loss. As can be seen in figure 6 the order was the same as in the absence of salt with Promine-D addition giving the lowest moisture loss at all salt concentrations studied. The difference between the behaviour of the caseinate meat systems before and after heat treatment is probably due to the high viscosity dependence on concentration. In the raw meat systems caseinate acted as a paste and its pasting property was improved by salt addition. When heated the meat shrinks, water is pressed out, the viscosity of caseinate is reduced and its function as a paste is partly lost. This would also mean that the function of caseinate is sensitive to the meat quality used. The more water released the less pasting property of caseinate is left.

Some examples have been given on the effect of functional properties on water binding properties of model meat systems. For a finished meat product texture is of prime importance and it was therefore of interest to see whether functional properties of added proteins also affected the texture properties of a complex meat product. Commercially produced meatballs with 4% added protein of the total mixture were investigated. The texture was investigated both by instrumental methods and sensory evaluation. Table 4 shows the effect of incorporation of Promine-D, caseinate and WPC on some of the texture measurements on meatballs.

The effect of protein addition on texture was similar in character as on the previously discussed water binding properties. Promine-D with its high swelling ability and gel strength gave the firmest texture and caseinate lacking the so important ability to form a three-dimensional network gave the lowest texture values.

From the results shown it can be concluded that a high solubility will reduce the water binding properties of raw meat systems and that the ability to form a protein network which can imbibe water is a very important property for the water bindning and texture of heat treated meat systems. The established relationships strongly indicate the use of functional properties as valuable tools for the optimization of processes for protein production as well as for food production but much research is still needed on the finding of relevant functional parameters of the proteins and of relevant parameters for production processes.

REFERENCES

1. Hermansson, A.-M. and Åkesson, C. 1975. Functional Properties of Added Proteins Correlated with Properties of Meat Systems. Effect of Concentration and Temperature on Water-Bindning Properties of Model Meat Systems. J. Food Sci. 40, 595.
2. Hermansson, A.-M. and Åkesson, C. 1975. Functional Properties of Added Proteins Correlated with Properties of Meat Systems. Effect of Salt on Water-Binding Properties of Model Meat Systems. J. Food Sci. 40, 603.
3. Hermansson, A.-M. 1972. Functional Properties of Proteins for Foods - Swelling. Lebensm.-Wiss. u. Technol. 5 (1) 24.
4. Hermansson, A.-M. 1973. Functional Properties of Proteins for Foods - Solubility. AULs halvårsskrift nr 2. Arbetsutskottet för livsmedelsforskning, Kemicentrum, Lund.
5. Hermansson, A.-M. 1975. Functional Properties of Proteins for Foods - Flow Properties. Texture Studies 5, 425.
6. Hamm, R. 1972. "Kolloidchemie des Fleisches", Paul Parey, Berlin, Hamburg.

Table 1. Some functional properties of Promine-D, sodium caseinate and WPC.

Property		Promine-D	Caseinate	WPC
Solubility (%) in 0.2M NaCl	pH			
	4.5	5	6	64
	7.0	27	91	79
	9.0	37	93	88
at pH 7	M NaCl			
	0	56	90	89
	0.2	28	91	83
	0.5	30	90	81
	1.0	37	90	81
Swelling (ml/g) max.	M NaCl			
	0	9.6	7.5	1.9
	0.2	3.9	5.0	1.8
	0.5	3.5	5.6	1.9
	1.0	3.5	5.4	1.5
Viscosity (cp) 12% at 42 s^{-1}	M NaCl			
	0	1045	75	7
	0.2	98	143	8
	0.5	75	254	6
	1.0	134	680	6
Gel strength (Brookfield poise) 12% (w/w)	M NaCl			
	0	7610	0	3700
	0.2	1500	0	6600
80^oC	0.5	440	6	7200
	1.0	90	20	4990
dist. water	Temp. ^oC			
	70	4950	0	3
	80	7610	0	3700
	90	8680	0	6460
	100	7690	0	8630

Table 2. Correlation of changes in functional properties with changes in moisture loss of raw meat systems.

Functional properties	Sign	Correlation coefficients	Explained variance
Solubility	+	0.89	0.79
Swelling	-	0.94	0.10
Viscosity	-	0.99	0.10

Table 3. Correlation of changes in functional properties with changes in moisture loss of heated meat systems.

Functional properties	Sign	Correlation coefficients	Explained variance
8.3% added protein or 50% meat proteins exchanged			
Gel strength	-	0.97	0.94
Swelling	-	0.98	0.01[a]
Solubility	±	0.982	0.003[a]
5% added protein or 30% meat proteins exchanged			
Gel strength	-	0.71	0.49
Swelling	-	0.79	0.13
Solubility	±	0.83	0.02[a]

[a]No significant contribution (95% sign. level)

Table 4. Texture difference between meatballs with 4% added proteins and without added proteins.

Protein added	Instrumental method Extrusion (kp)	Sensory evaluation on firmness (ranking)
Promine-D	+ 4.8	- 0.9
WPC	- 1.1	- 1.4
Caseinate	- 9.5	- 3.7

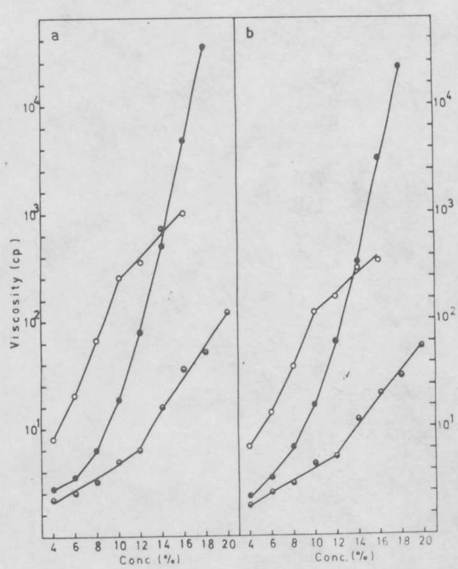

Fig. 1. Viscosity as a function of concentration in distilled H_2O at $D = 10\ s^{-1}$ (left) and $D = 100\ s^{-1}$ (right). (From J. Texture Studies 4. 425, 1975).

○ Promine-D

● Caseinate

◒ WPC

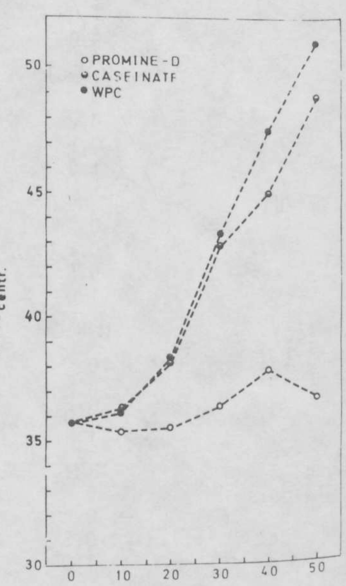

Fig. 2. Moisture loss for pork shoulder systems as a function of % exchanged protein. (From J. Food Sci. 40, 595, 1975).

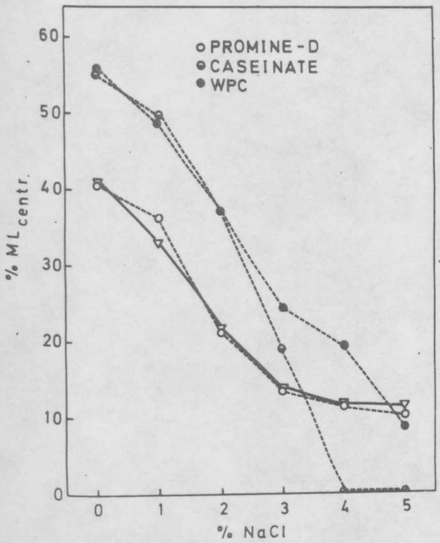

Fig. 3. Moisture loss of beef brisket systems without and with 50% exchanged protein as a function of NaCl concentration. (From J. Food Sci. 40, 603, 1975).

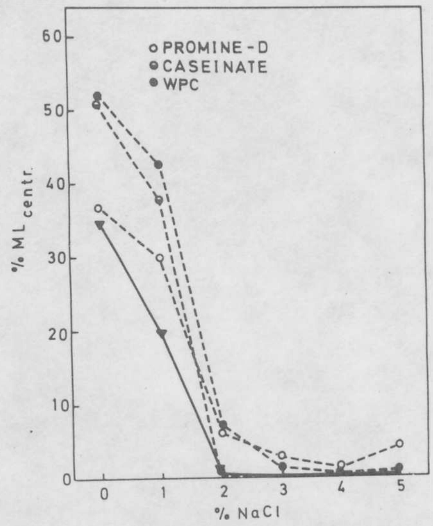

Fig. 4. Moisture loss of pork shoulder systems without and with 50% exchanged protein as a function of NaCl concentration. (From J. Food Sci. 40, 603, 1975).

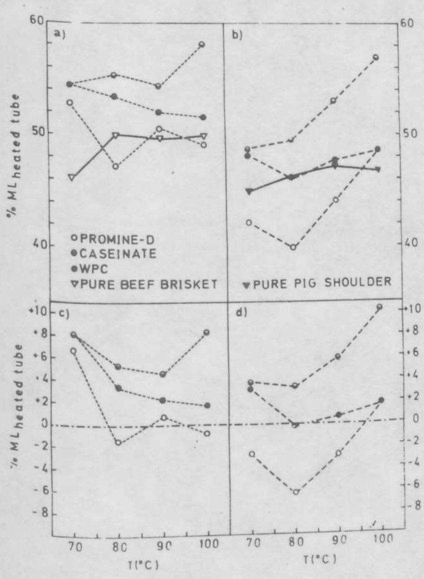

Fig. 5. Moisture loss as a function of temperature a) beef brisket and b) pork shoulder systems without and with 50% exchanged protein respectively. c) beef brisket and d) pork shoulder systems respectively where the effect of 50% protein exchange is plotted relative to the pure meat systems. (From J. Food Sci. 40, 595, 1975).

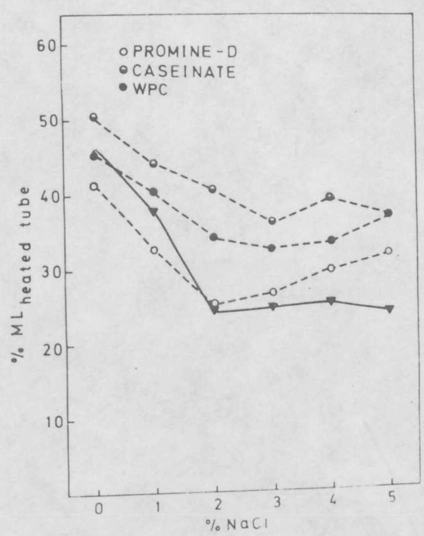

Fig. 6. Moisture loss of pork shoulder systems with and without 50% exchanged protein as a function of NaCl concentration (heated to 80°C). (From J. Food Sci. 40, 603, 1975).