MILK CO-PRECIPITATES IN SAUSAGE MANUFACTURE

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Calcium co-precipitates are prepared by adding calcium salts to milk and heating. They contain both casein and whey proteins and represent a recovery of 95 to 97% of the proteins of skim milk. Variations in manufacture give co-precipitates with different calcium contents which have different functional properties.

Three spray dried types which are commercially available: Low Calcium co-precipitate, High Calcium co-precipitate No 2 and High Calcium co-precipitate No 6, were studied in comparison with sodium caseinate, and two types of soya (concentrate and isolate) as protein additives in sausage manufacture.

The study was carried out in two separate experiments. An initial study on the emulsifying capacity (EC), emulsion stability (ES) and water binding capacity (WBC) in a model system was carried out. All proteins tested were compared with mutton L. dorsi muscle at varying pH levels; the meat and protein content of the mixtures were adjusted to give protein additive/meat ratios of 0/10 (meat control) 2/8, 4/6, 6/4, 8/2 and 10/0 (protein additive).

The three-factor interaction, pH x type of protein additive x replacement level was significant at the 5% level of probability indicating that the effect of level of replacement tends to be different between proteins of the same pH, and also different for the same protein at different pH levels. All proteins improved the EC and ES of the emuslion when the pH was low. However, at 20% replacement all proteins tested improved the WBC of the emulsion even when the pH of the meat was high.

Overall, the co-precipitate proteins performed equally as well as the more conventional additives used in sausage manufacture. A subsequent study, with actual manufacture of both fresh sausage and cooked luncheon sausage, evaluated the effect of the protein additives on the physical properties of the sausage emulsions and on their sensory qualities. Two milk co-precipitates at 40% substitution give sausages that were not significantly different from the control in general acceptability. It was found, however, that only 20% of the meat protein is necessary to give the sausage cohesion and binding properties, when the remainder of the meat protein is replaced by the low calcium co-precipitate. Other proteins did not seem to possess such a quality.

There is a potential for use of calcium co-precipitates in sausage manufacture, particularly when additional work has been carried out to determine the most appropriate combinations of co-precipitates for particular functions in commercial sausage emulsions.

CO-PRECIPITATS DU LAIT DANS LA MANUFACTURE DES SAUCISSES

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Les co-precipitats de Calcium sont prepares par l'addition des sels de Calcium au lait suivi par chauffage.

Ils contient casein aussi que de proteines du petit-lait et represent ent une recouvrement entre 95 jusqu'a 97% des proteines du lait ecreme.

Variations de manufacture donnent des co-precipitats avec niveaus differentes de Calcium avec proprietes fonctionnels differentes.

Trois types desseche par pulverinage son disponible dans le commerce:

Un co-precipitat de Calcium un bas niveau de Calcium, un co-precipitat No 2 contenant un niveau eleve de Calcium et un co-precipitat No 6 contenant un niveau eleve de Calcium.

Ils sont comparees avec Natrium caseinate et deux types de soya (concentrat et isolat) comme additives proteiques dans la manufavture des saucisses.

L'investigation ete reparti en deux experiences. La premiere experience ete sur la capacite emulsificatif (EC) la stabilite de l'emulsion (ES) et la capacite pour lier l'eau (WBC) dans une systeme modele.

Tous les proteines essayees etaient comparees avec le muscle L. dorsi, du mouton au niveaux differentes de pH; le contenu de mixtures ete ajuste a donner les proportions suivantes des additives proteiques/viande: 0/10 (controle au viande) 2/8, 4/6, 6/4, 8/2 et 10/0 (additive proteique).

L'interaction entre les trois facteurs: pH vers le type du additive proteique vers le niveau de remplacement ete significatif au niveau 5% de probabilite. Cela indique que l'effet du niveau de remplacement est different entre proteines du meme pH aussi bien que entre differents niveaux de pH pour le meme proteine.

Tous les proteines ameliorent le EC et le ES du emulsion quand le pH est bas. Cependant, au niveau 20% de remplacement tous les proteines mixe au preuve ameliorent le WBC du emulsion meme quand le pH du viande est eleve.

En general les proteines co-precipitees s'quittent si bien comme les additives plus conventionnels qui sont employees dans la manufacture des saucisses.

Dans la deuxieme experience, l'effet des additives proteiques sur les proprietes physiques des emulsions du saucisses meme que sur leurs qualitees sensorielles ete investique dans la manufacture actuelle des saucisses frais et des saucisses type 'Luncheon' cuit.

Deux co-precipitats de lait un niveau substitutif 40% ont donnees saucisses qui ne sont different en substance du control en acceptabilite generale. Cependant on a trouve que seulement 20% du proteine du viande est necessaire pour donner du saucisses les proprietes de cohesion et retention quand le rests due proteine du viande est remplace par le co-precipitat au niveau bas du Calcium.

Aunre proteines ne possedent pas tel qualitees.

Il y a un potential pour l'usage de co-precipitat du Calcium dans le manufacture des saucisses, en particuliere quand encore plus de travail sera fait pour determiner les combinations les plus convenables des co-precipitats pour certains fonctions particulieres dans les emulsions commerciales des saucisses.

MILCH CO-PRAZIPITATEN IN DIE WURSTVERFERTIGUNG

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Calcium Co-prazipitaten verfertigt sind aus Milch und Calcium salzen Hinzusetzung und Hitzung.

Biede Casein und Molkeproteinen enthalten sind und von 95 bis 97% zuruckgewonnen in diejenigen co-prazipitaten auf magermilch.

Verfertigungs variationen, Co-prazipitaten mit verschiedenen Calcium und verschiedenen funktionellen Eigenarten geben.

Es gibt drei Typen spruhgetrocknet die kaufbar sind: Co-prazipitat mit neidrig Calcium, Co-prazipitat nit hoch Calcium No 2 und Co- prazipitat mit hoch Calcium No 6.

Die obenerwahnt Co-prazipitaten mit zwei Typen von Zoya (Conzentrat und Isolat) und Natrium Caseinate vergleichen waren wei Proteinzusatze in die Wurstverfertingung.

Die Untersuchung war in zwei Versuche getrennt. Der ersten Versuch uber Emulsionscapazitat (EC), Emulsionsstabilitat (ES) und Wasserbindung scapazitat (WBC) war in ein model System studiert.

Alle gepruften Proteinen mit der Muskel L. dorsi, aus Hammel in verschiedenen pH Stufen Vergleichen waren.

Das fleisch und Protein inhalt der Mischungen zwischen folgenden verhaltnissen geordnet war:

Proteinzusatz/fleisch verhaltnissen von 0/10 (Fleisch controlle) 2/8, 4/6, 6/4, 8/2 und 10/0 (Proteinzusatz).

Ein dreifaktor Wechselwirkung, pH gegen Art von Proteinzusatz gegen Ersetzungsgrad am 5% wahrscheinlichkeitsgrad wichtig war. Das eindeutet dass der Ersetzungsgradseinfluss verscheiden ist zwischen Proteinen selben pH und auch verscheiden fur den selben Protein in verschiedenen pH Stufen.

Alle Proteinen der Ec und ES von den Emulsion verbessern wann der pH niedrig ist, doch an 20% Ersatzunsgrad alle Proteinen haben den WBC den Emulsion verbessert auch wann den pH hoch war.

Uberall die Co-prazipitaten verrichten sich so gut wie die mehr convenzionellen zusatzen die in den Wurstverfertigung venutzt sind.

In zweiter Versuch der Einfluss von Proteinzustzen auf die physikalischen Eigenheiten von Wurstemulsionen und auf die Sinneseigenheiten verechnet waren in die aktvelle Verfertigung von beide Frischwurst und gekocht 'Luncheon' wurst. Zwei Milch Co-prazipitaten am 40% Ersetzungsgrad heben wursten gegeben die nicht deutlich Underscheidbar waren von Controllen im Genehmigung.

Jedoch, nur 20% Fleischprotein notwendig ist das wurst Kohasions und Befestigungesigenheiten zu ergeben wann der Rest beim Co-prazipitat mit niedriges Grad von Calcium ersetzt wird.

Andere proteinen haben solche Eigenheit nicht. Es gibt Moglichkeit, fur derge Brauch von Calcium Co-prazipitaten im Wurstverfertigung, insbesonders wann weitere arbeit gemacht wird uber die meist Zweckmassig Zusammensetzungen von Co-prazipitaten fur bestimmten Funktionen in Commerziellen Wurstemulsionen.

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Молочные Ко-присипитаты в приготовлении сосисок.

Кальцевые Ко-присипитаты приготавляются путём добавления солей кальция в молоко при подогревании. Ко-присипитаты содержат казеиновые и сывороточные протеины и позволяют получить от 95 до 97% протеинов снятого молока. Изменения в процессе дают Ко-присипитаты с разными содержаниями кальция, имеющие различные действующие свойства.

Проведено сравнение между казеином натрия, двух разновидностей сои (концентрированой и очищеной) и тремя видами Ко-присипитатов: Низко-кальцевым, Высоко-кальцевым №2, Высоко-кальцевым №6, получаемых при помощи распыленого высушивания, как добавленых протеинов в приготовлении сосисок.

Начальное изучение,1 ёмкости имульсификации (EC)*, 2 устойчивости имульсии (Es)*, 3 водосвязывающей ёмкости (WBC)* было проведено в лабораторных условиях. Протеины были сравнены с L.dorsi мускулом барана в различных pH уровнях. Проценты мяса и протеина в смесях были уровнены для получения следующих пропорций мяса к добавленным протеинам: 0/10 (контрольное мясо), 2/8, 4/6, 6/4, 8/2, 10/0 (добавленые протеины).

Взаимное отношение трёх данных: pH x Вид добавленого протеина x Процент заменения, было замечено на уровне 5% статистической возможности. Это указывало на то что влияние процента заменения изменялось между протеинами одного pH, как и между однотипными протеинам в разных pH уровнях. Все протеины улудьшали EC и ES имульсии в низких pH. На 20% заменения, протеины улудьшали WBC имульсии, даже при высоком pH мяса.

В обьщей сложности, Ко-присипитат протеина давал результаты сравнимые с добавлениями протеинов употребляемых в приготовлении сосисок. Последовательная работа по получению как свежых, так и приготовленых сосисок заключалась в иследовании действия добавленых протеино на физические свойства имульсии. Сосиски полученые из двух молочных Ко-присипитатов при 40% заменения, мало отличались от контрольных по обьщим качествам. Но, было установлено, что только 20% мясных протеинов необходимо на получение нужной вязкости, при условии что остальные мясные протеины были заменены Низко- кальцевым Ко-присипитатом. Эти качества небыли замечены в других протеинах.

Наблюдается потенциальная возможность в употреблении Ко-присипитатов кальция в приготовлении сосисок, особенно когда дальнейшие опыты установят наиболие подходящие комбинации Ко-присипитатов для специальных функций в имульсии сосисок.

* EC – is defined as the volume of oil that can be emulsified by the meat or protein additive homogenates before inversion or collapse of the emulsion.

* ES – is a measure of the ability of the meat or protein additives to produce an emulsion that remains unchanged for a serviceable lifetime.

* WBC – is a measure of the water bound by the meat or protein additive homogenates after applying pressure. The method used here is the centrifugal method.

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INTRODUCTION

The manufacture of sausages of various types as an effective means of making meat "go further" has long been recognised and as population pressures add to the demand for meat protein it seems certain that there will be an increasingly intensive search for a means of extending the limited supplies of red meat. This increased demand will call for high quality protein from other sources.

Of the many which have been tried or considered, milk proteins, in the form of calcium co-precipitates are among the most attractive, both nutritionally and functionally.

In addition to the obvious contribution of proteins to the flavour, nutritive value, texture and appearance of sausages, their role in emulsifying and stabilising fat and in binding water is highly important.

Any protein added must contribute to one or more of these functional properties. Ideally it will correct defects which might result from meat of low pH, frozen meat, which decreases the effectiveness of muscle proteins in providing the functional requirement for a good quality product.

Calcium co-precipitates are prepared by heating skim milk to which calcium chloride has been added (Buchanan, et al, 1965). Their functional properties can be altered by varying the calcium content and manufacturing procedures (Smith and Snow, 1968).

The work described in this paper compares the functional properties of some co-precipitates with other protein preparations in sausage manufacture.

EXPERIMENTAL

1. Functional Properties

Materials used

The six protein preparations tested: a soy protein concentrate "Promosoy" (65.3%); isolated soy protein "Promine D" (91.8%) - both of which are manufactured by Central Soya Co. Inc., Chicago, Ill. - "Sod. Cas." (91.0%), a sodium caseinate obtained from Halcyon Proteins Pty.Ltd., Melbourne; "Low Cal" (91%), a low calcium co-precipitate; "High Cal 2" a high calcium co-precipitate (83%) (obtained from South Eastern Milk Products Ltd., Yarram, Victoria); "High Cal 6" (82.0%), a high calcium co-precipitate obtained from C.S.I.R.O., Division of Food Research, Highett, Victoria; were compared with each other and with *Longissimus dorsi* muscle from sheep obtained from abattoirs and local butchers.

Mixtures of each material and meat protein were prepared to give protein additive/meat protein ratios of 0/10 (meat control)2/8; 4/6; 6/4; 8/2 and 10/0 (additive alone).

These experiments were repeated using meat at different levels of pH.

Methods

The emulsifying capacity (EC), emulsion stability (ES) and water binding capacity (WBC) and statistical analyses were as reported by Thomas et al (1974).

2. Sausage Manufacture

A standard breakfast type sausage mix was prepared to the following formulation; 48.2% frozen mutton (18.5% protein, 17.3% fat, 63.2% moisture) 21.7% pork fat, 20.5% ice and water, 7% wheaten binder, 2% salt, 0.2% polyphosphates, 0.4% preservative and seasoning.

Trial samples were then made by replacing 20, 40, and 60% of the meat protein in this formulation by each of the protein preparations being tested. This was done by reducing the amount of mutton in the mix and adding the appropriate quantities of protein preparations, pork fat and water to give similar levels of protein and fat to that of the control.

Statistical Procedure

The data from the sensory tests were analysed by standard statistical techniques. If an analysis indicated a significant difference between the sausage varieties the means were subjected to the Student-Newman-Keuls multiple comparison test as described by Steele & Torrie (1960). Varieties not significantly different by this test were linked together by a common letter (a, b, c, ..) placed after their means in the tables. The estimated standard error (S.E.) with its degrees of freedom (n) was also tabulated.

RESULTS

Emulsifying Capacity EC)

The three-factor interaction; pH level x type of protein additive x replacement level was significant at the 5% level of probability, indicating that the effect of level of replacement tends to be different between proteins at the same pH, and also different for the same protein at different pH levels.

The higher EC of the meat at pH 6.15 was expected (Table 1), being due to the fact that salt soluble protein which is the major emulsifier in a sausage-type emulsion (Swift and Sulzbacher, 1963) is greatly influenced by pH. Increasing the pH results in an increase in the salt soluble protein extracted (Saffle and Galbreath, 1964).

Replacement of the meat with protein additives gave two different results depending on the pH of the original meat sample. Use of the high ph 6.15 meat resulted in a continuous decrease in EC with increasing replacements of the meat protein with other protein additives. The meat showed the highest EC.

Use of the lower pH sample, pH 6.65 (Table 2) resulted in an increase in EC at 20% replacement of all protein additives, and all but High Cal. 6 at 40% replacement. Thereafter, the EC decreased with further replacements, with the exception of Sod. Cas. and Low Cal, as the EC of these two proteins is higher than the original meat sample when used by themselves.

There was no significant differences ($P <\cdot 0.05$) in EC between High Cal 2, High Cal 6, Promosoy and Promine D at 20% replacement. All, however, were significantly higher than Sod Cas and Low Cal at this same level of replacement.

Emulsion Stability (ES)

The two-factor interactions: protein x replacement, and pH x replacement, are significant at the 5% level of probability indicating that the effect of replacement level of ES varies for different proteins, averaged over pH levels, and also varies for pH levels areraged over proteins.

The meat with higher pH value of 6.10 produced a more stable emulsion (0.5 ml phase separation) when compared to the meat sample with a pH of 5.66, (4 ml phase separation). The meat (control) of higher pH was significan tly more stable than all the protein additives at 20% replacement with the exception of High Cal 6 which showed results very similar to the control. Stability thereafter decreased sharply with increasing replacement of the meat with protein additive, especially with High Cal 2, High Cal 6, Promosoy and Promine D. All these proteins had a value of 32 ml phase separation at 100% replacement of the meat, as they did not form an emulsion initially. One result of interest is the low stability of Sod Cas and Low Cal at 100% replacement despite the fact that they have a fairly high EC.

With low pH meat and at 20% replacement, the meat (control) was significantly more stable than Sod Cas and Promine D, with High Cal 6 showing the highest stability. Higher replacement showed a sharp decrease in stability.

Water Binding Capacity (WBC)

Meat (control) with higher pH tended to have a higher WBC than meat with lower pH (Tables 3 & 4). These results are in agreement with Bouton *et al* (1971) and Hamm (1959), who showed that the WBC of the meat homogenates is closely related to pH. At 20% replacement of the meat of pH 6.0, (Table 3) all protein additives showed an increase in WBC. Increasing the level of meat replacement caused a decrease in the WBC.

When the pH of the meat was 5.6 (Table 4) all protein additives showed higher values than the control (meat) at 20 and 40% replacements. Higher levels of protein replacement caused a decrease in WBC in all proteins except Promosoy, which had a value higher than the control at both 60 and 80% replacement.

Sensory Tests on Fresh Sausages

The six samples of fresh sausages with 20% substituted protein (Table 5) were not significantly different from each other in general acceptability, but they were less acceptable than the control sausages. However, the scores for general acceptability of the samples with 40% substituted protein, with the exception of Promosoy sample, were within 0.4 units of the score for the control. This unexpected result may be a consequence of the tasters having assessed the 20% samples first, then the 60% samples and lastly these with 40% substituted protein. The tasters clearly detected differences between the 20% substituted samples and the controls in the early sittings and consequently recorded lower scores for the samples with nonmeat proteins. As the taste tests continued the tasters apparently began to accept the sausages with substituted protein although these samples often differed in particular characteristics from the control sausages. If this training effect resulted in the generally high scores for general acceptability for the samples with 40% substituted protein it seems likely that higher scores would also have been obtained for the 20% samples if they had been assessed later in the series of taste tests.

Discussion

The results presented show that the original meat and its pH influence greatly the type of emulsion formed when some of the meat is replaced by other non-meat proteins and that the greatest effect seems to be at 20% level of replacement. Conventional non-meat protein additives are added at the rate ranging from 1 to 3 percent of the total sausage products (Meester 1969).

Considering that sausages, e.g. fresh-frying sausage or luncheon-type sausage, contain 10 to 12% protein, these protein additives in actual fact are contributing approximately 20% of the total sausage protein.

The experiment showed that at the 20% level of replacement, protein additive improve the EC of the meat emulsion when the pH is low. We used pH alone to study the meat performance. Other factors such as freezing and aging as practised by sausage manufacturers are known to decrease the amount of salt soluble protein (Saffle and Galbreath, 1964) which make the use of protein additives in sausage manufacture more critical. The improvements in the (EC) amount of fat which can be incorporated into a sausage product without causing it to collapse, is of great practical significance to the sausage manufacturer (Franzen and May, 1968). There was an improvement in the EC when protein additives were used at 20% replacement. Both High Cal 2 and High Cal 6 performed equally well to Promosoy and Promine D, both of which are used currently in the sausage manufacture. Although proteins used with a high muscle pH did not improve the EC one cannot be sure that the meat has the right EC for reasons mentioned earlier.

The greatest contribution of the protein additives seems to be in their contribution to the WBC especially at the 20% level of replacements. This was noticed with all the three meat samples. Again the three types of milk co-precipitates performed equally well to the conventional non-meat protein additives. The WBC of raw and cooked meat has been related to such important organoleptic properties as juiciness and tenderness (Hamm, 1960).

In this experiment, all of the protein additives tested showed that when combining protein additives with meat, different values were obtained than when using meat alone or protein additive alone. With the exception of EC for Sod Cas and Low Cal when using low pH meat, all values for protein additives when used with meat were higher than when used by themselves.

The work showed that Promine D, Promosoy, High Cal 2 and High Cal 6 are poor emulsifiers when used by themselves. However, they increased the EC of the meat when used at 20% replacement. They also improved the WBC of the meat, the WBC being greater at 20% replacement than the original meat and protein additives themselves.

FUTURE DEVELOPMENT

The study presented demonstrates that calcium co-precipitates have one or more of the functional properties important in sausage and other comminuted meat products. All proteins tested showed some synergestic effects with meat protein noticeably at 20% replacement. It is postulated that a combination of co-precipitates with each other or other protein additives will provide a more satisfying protein additive. Such a study is projected or required.

In the consumers evaluation of sausage they gave a better flavour and general acceptability to sausage with co-precipitates particularly at the higher level of replacements.

In other experiments we have shown that only 20% of the meat protein and the rest in the form of milk co-precipitates is necessary to produce a satisfactory emulsion. The product though different from an all-meat sausage, was quite acceptable to a taste panel.

In a separate study we have developed experimental simulated meat products using calcium co-precipitates as the protein source. The product is similar and, in some cases, superior to the product developed using texturized vegetable proteins.

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Table (1) The effect of replacement of the meat with non-meat proteins on EC when the pH of the meat was 6.15. Expressed as ml of oil emulsified by 0.2g of protein.

% Replacement	Meat	Type of non-meat protein preparations					
		Sod. Cas.	Low Cal	High Cal 6	High Cal 2	Promine D	Promosoy
0	49.38						
20		44.87	47.47	42.67	41.67	43.40	46.60
40		42.56	45.10	34.13	38.80	39.20	41.17
60		42.53	39.93	31.13	28.50	35.03	32.47
80		42.50	38.93	17.53	10.37	22.87	13.00
100		42.48	38.88	0.00	0.00	0.00	0.00

Differences necessary for significance ($P<0.05$) between replacement rates for each protein level = 2.8

Table (2) The effect of replacement of the meat with non-meat protein on EC when the pH of the meat was 5.65. Expressed as ml of oil emulsified by 0.2g of protein.

% Replacement	Meat	Type of non-meat protein preparations					
		Sod. Cas.	Low Cal	High C Cal 6	High Cal 2	Promine D	Promosoy
0	31.86						
20		34.17	32.17	41.13	41.20	38.90	39.80
40		36.33	35.97	31.27	38.50	35.20	38.10
60		38.87	36.46	30.43	28.03	31.47	30.37
80		39.77	36.96	14.30	9.73	17.13	10.13
100		42.48	38.88	0.00	0.00	0.00	0.00

Differences necessary for significance ($P\leq0.05$) between replacement rates for each protein level = 2.8

Table (3) The effect of replacement of the meat with non-meat proteins on WBC when the pH of the meat was 6.0. Expressed as grams of water bound by 1.52g of protein.

% Replacement	Meat	Type of non-meat protein preparations					
		Sod. Cas.	Low Cal	High Cal 6	High Cal 2	Promine D	Promosoy
0	19.60						
20		20.60	22.29	20.78	21.96	24.29	23.17
40		15.78	18.43	16.28	17.04	18.77	17.39
60		10.78	9.55	10.59	13.96	15.08	14.07
80		6.17	8.18	6.33	9.79	9.22	9.15
100		0.34	1.96	4.91	5.21	3.98	7.01

Table (4) The effect of replacement of the meat with non-meat proteins on WBC when the pH of the meat was 5.60. Expressed as grams of water bound by 1.52g of protein.

% Replacement	Meat	Type of non-meat protein preparations					
		Sod. Cas.	Low Cal	High Cal 6	High Cal 2	Promine D	Promosoy
0	7.93						
20		10.02	10.12	10.87	12.41	12.22	11.10
40		9.71	9.58	9.20	10.14	11.37	10.46
60		5.50	5.10	7.77	7.82	7.30	9.33
80		3.20	3.71	6.37	7.07	4.58	8.04
100		0.34	1.96	4.91	5.21	3.98	7.01

Table 5 Results of sensory tests on fresh sausages; overall comparison of treatments

	Colour	Juiciness	Texture	Flavour	General acceptability
20% Substitution	**	N.S.	*	*	**
Control	4.6a	4.8	4.8a	6.4a	6.4a
Low Cal	3.4bc	4.2	4.0ab	4.9b	5.0b
High Cal 6	3.7bc	4.1	4.1ab	5.5b	5.5b
High Cal 2	3.6bc	4.7	4.4ab	5.2b	5.3b
Promosoy	3.6bc	4.7	4.4ab	4.9b	5.0b
Promine D	3.8b	4.2	4.0ab	5.1b	5.1b
Sodium caseinate	3.8b	3.7	3.7b	5.4b	5.2b
S.E.for differences between means (n=8)	0.25	0.34	0.21	0.30	0.24
40% Substitution	***	***	***	***	***
Control	5.7a	5.2b	5.5a	5.9a	5.8a
Low Cal	4.5bc	4.3b	4.1b	5.4b	5.4b
High Cal 6	4.9b	4.6b	4.4b	5.8a	5.9a
High Cal 2	4.3c	4.7b	4.3b	5.8a	5.8a
Promosoy	3.4d	6.6a	5.2a	4.4c	4.5c
Promine D	4.0c	4.2b	4.1b	5.3b	5.4b
Sodium caseinate	4.4c	4.7b	3.9b	5.6ab	5.5b
S.E.for differences between means (n=8)	0.19	0.29	0.16	0.11	0.11
60% Substitution ø	***	**	***	***	***
Control A	5.7a	5.1b	5.1a	6.0a	5.9a
Control B	5.4a	4.6b	5.0a	5.9a	5.8a
Low Cal	4.2b	3.8b	3.3c	5.0b	4.7bc
High Cal 6	4.1b	4.6b	3.4c	4.6bc	4.7bc
High Cal 2	3.8b	4.4b	3.3c	5.1b	4.9b
Promosoy	3.2b	6.3a	4.4b	4.0d	3.9d
Promine D	3.6b	4.7b	3.6c	4.2cd	4.3cd
S.E.for differences between means (n=8)	0.32	0.36	0.17	0.20	0.17

N.S. Treatments not significantly different and Student-Newman-Keuls Test omitted.
*** Treatments significantly different ($P < 0.001$).
** Treatments significantly different ($P < 0.01$).
* Treatments significantly different ($P < 0.05$).
Any pair of treatments in a set without a letter in common are significantly different ($P < 0.05$) according to the Student-Newman-Keuls method for multiple comparisons
ø The 60% replacement of the meat with Sod Cas produced a very viscous product that was difficult to extrude into the animal casing. So two controls were used instead of one to replace the Sod Cas.