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TECHNOLOGICAL ASPECTS OF OBTAINING STERILISED SOY PUDDINGS*

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Key words: soy protein, sterilised pudding, thaumatin

The aim of this study was to work out a recipe for sterilised soy puddings which, as an analogue of milk pudding, could compose a significant source of the soy protein in the diet.

The investigations were performed to work out recipes for sterilised soy puddings containing similar contents of protein as those of based on milk or containing higher contents of soy protein up to 6.25 g in a 150 g portion of pudding. The quality of products was determined on the basis of the sensory evaluation, chemical composition determination, apparent viscosity, degree of starch gelatinisation, and investigation of sedimentation of high-temperature gelatinising starch. In the puddings additionally enriched in soy proteins, the respective consistency and sensory quality were achieved by adding 2.3% of the high-temperature gelatinising starch and 1.3% of the low-temperature gelatinising starch.

Additive of thaumatin (at the level of 10 ppm in the final product) made the flavour enhancement of the sterilised soy puddings too extensive. As to the overall sensory quality, the sterilised soy puddings were inferior to the milk puddings nevertheless the soy puddings have been evaluated higher than the commercial soy puddings.

INTRODUCTION

The soy protein can compose an important ingredient of many vegetarian products consumed not only from the viewpoint of philosophical, religious and/or economical reasons but also often due to the health benefits of soy proteins. The soy protein preparations have high nutritive value as well as attractive functional properties.

The PDCAAS (Protein Digestability Corrected Amino Acid Score) takes into account the protein true digestibility and its ability to supply essential amino acids in the amounts adequate to the needs of a two- to five-year old child, which represent the most demanding amino acid requirements of any age group. The PDCAAS value for soy protein is 1.00 similarly as for egg white [Henley *et al.*, 1994; Messina, 1995].

Soy consumption influences significantly reduction of the cardiovascular disease risk and decreases some cancers risk [Bakhit *et al.*, 1994; Carroll *et al.*, 1995]. Epidemiological investigations show that in the Western populations the risk of breast, prostate and colon cancers is larger than in the Asian populations applying a typical plant diet with high contents of soy proteins [Messina *et al.*, 1994]. Many studies have supported the health benefits of soy proteins especially when they are together with its native isoflavones like genistein and daidzein [Anthony *et al.*, 1996].

In consequence, in 1999 the U.S. Food and Drug Administration approved to put the health claim, informing on the health benefits of soy proteins in the case of food products containing at least 6.25 g soy protein in the product portion [Massey, 2001].

The functional properties of soy proteins like emulsifying capacity, water and fat binding, foaming properties allow composition of new products being analogues of the traditional milk and meat ones. The aim of this study was to work out a recipe for sterilised soy puddings which, as an analogue of milk pudding, could compose a significant source of the soy protein in the diet. The investigations were performed to work out recipes for sterilised soy puddings containing similar contents of protein as those of based on milk or containing higher contents of soy protein up to 6.25 g in a 150 g portion of pudding.

MATERIAL AND METHODS

The isolated soy protein FP 920 produced by Protein Technologies International, starch Purity M (gelatinised at a high temperature) and Instant Clearjel E (gelatinised at a low temperature) produced by National Starch and Chemical, carrageenan SF 3615 – commercial preparation, soy oil "Bartek" produced by ZPT S.A. in Warsaw, flavours: coffee SD 0672, vanilla SD 0545, cream SD 0654, and milk AR 0641 produced by Pollena-Aroma, sugar, instant coffee produced by Nestle S.A., instant cacao produced by Maspex S.A., thaumatin produced by The Talin Food Company and natural colorant BC-140-WSS produced by Chr. Hansen were used in this study.

In all pudding recipes, the cream and milk flavour additives as well soy oil additive were applied in the same proportions. The natural colorant was used in vanilla pudding, only.

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In order to compare the quality of the obtained puddings, the commercial powdered soy puddings denoted as A and B, and the ready-to-eat milk puddings denoted as C and D were used.

The isolated soy protein hydrated in the proportion 1:8, and next, according to the recipe, the respective ingredients were put in. As a whole it was subjected to a 3-min homogenisation by means of an L4R mixer by Silverson. During the homogenisation, the soy oil was added gradually to obtain a homogenous emulsion. So prepared pudding mixture was poured into 150 g packages by using a dosing--packing machine. The filled packages undergone a 20-min sterilisation at 121°C, and next they were cooled to 20°C. The product was stored at ±4°C.

The apparent viscosity was determined by means of the Rheotest 2/50 HZ type RV2, by using the roll and cylinder type H.

The protein content was determined on the basis of the total nitrogen content using the coefficient 6.38 for milk protein and 6.25 for soy protein. The determination was carried out by the Kjeldahl's method using the Kjeltec 1026 unit produced by Tecator.

The fat content was determined by the Gerber's method, the sucrose contents was determined by the Lane-Eynon's method, and the dry substance content was determined by a technical method.

The sedimentation of high-temperature gelatinising starch was investigated in the crude pudding mixture. After homogenisation, the mixture was left in a cylinder (volume of 100 cm^3). After 30, 60, 90 and 120 min, it was noted, subsequently, whether the white sediment appeared at the bottom of the cylinder.

The degree of the starch gelatinisation in the final puddings was investigated using the optic microscope. A small amount of pudding was distributed in glycerol, and after addition of 1–2 drops of Lugol fluid, it was investigated under microscope with the magnification of 100×.

Using the scaling method the sensory evaluation of pudding samples was carried out by a group of 10 persons [Baryłko-Pikielna, 1995].

The statistical analysis has been done with the use of the computer program *Statgraphics* produced by Statistical Graphics Corp., using the one-variable analysis of variance, with the confidence level of 5%.

RESULTS AND DISCUSSION

While establishing the recipe composition for sterilised soy pudding it was assumed that in the final product the content of protein should account for 3.2%, *i.e.* as large as the protein content in the cow milk. To obtain a suitable and accepted by consumers consistency of sterilised soy puddings, for the assumed isolated soy protein, there were obtained several pudding samples supplemented with different amounts of two starch preparations.

The low-temperature gelatinising starch preparation was used to thicken homogenised crude mixture of puddings before the heating process. It counteracted settling of a high-temperature gelatinising no smelled starch when waiting for sterilisation.

The effect of starch preparation additive on the quality of sterilised soy puddings was tested on the basis of the apparent viscosity measurement, appearance of starch grain under microscope, and on the basis of sensory evaluation of the pudding texture. The pudding samples differed from each other in consistency, structure compactness and the apparent viscosity dependently on the pudding taste, which was induced by different contents of the dry substance in each of flavour groups.

Of the chocolate and coffee flavoured samples, the highest value of viscosity was observed for puddings containing 3% of a high-temperature gelatinising starch and 2% of a low-temperature gelatinising starch, *i.e.* the highest total amount of starch preparations. In the case of the vanilla puddings, no significant difference in the averaged apparent viscosity of the samples containing two starch preparations in different proportions was found (Table 1). Taking into account the additive of a single starch preparation it was concluded that the high-temperature gelatinising starch thickened the puddings less than the low-temperature one did. The additive of the low-temperature gelatinising starch in the amount of 3.5% gave the proper structure compactness and sufficiently high viscosity in the case of chocolate puddings only. Thus, the necessity of using the starch mixture preparation yielded not only from technological reasons but also with respect to the fact that the proper consistency of the product was possible to obtain when both preparations were used simultaneously.

Microscope analysis of the smelled starch showed that in the samples with the high-temperature gelatinising starch with the amount of 3% or higher, the full gelatinising did not appeared. The predicted time of heating chosen in the microbiological investigations appeared to be enough for full gelatinisation of starch with the amount of 2.8% added to puddings. The pudding samples containing 2.8% of a high-temperature gelatinising starch and 1.75% of a low--temperature gelatinising starch achieved high scores for consistency and structure compactness what gave the

TABLE 1. Effect of starch preparation additives on apparent viscosity of sterilised soy puddings.

Contents of protein (%)	Starch gelatinising at a high temperature (%)	Starch gelatinising at a low temperature (%)	Apparent viscosity (Pa·s)		
			vanilla	coffee	chocolate
	3.70	0.00	0.895^{a}	1.115^{bf}	1.170^{bef}
	3.20	1.00	1.185^{be}	1.170^{bef}	1.785^{h}
3.40	3.00	2.00	1.565^{cg}	1.675^{gh}	2.375^{i}
	3.00	1.75	1.450^{cd}	1.450^{cd}	2.120^{j}
	2.80	1.75	1.340^{de}	1.395^{cd}	1.840^{h}
	0.00	3.50	1.005^{af}	1.115^{bf}	1.285^{de}

(a–j) – mean values denoted by the same superscripts do not differ significantly from each other (α=0.05).

TABLE 2. Effect of starch preparation additives on apparent viscosity of sterilised soy puddings enriched with protein.

Contents of protein (%)	Starch gelatinising at a high temperature (%)	Starch gelatinising at a low temperature (%)	Apparent viscosity (Pa·s)		
			vanilla	coffee	chocolate
4.57	2.80	0.00	1.505^{ab}	2.065^{d}	2.400^{e}
	2.50	1.00	1.395^{a}	1.955^{d}	2.110^{d}
	2.30	1.30	1.115^{c}	1.450^{a}	2.010^{d}
	2.00	1.75	0.950^{c}	1.005^{c}	1.675^{b}

(a–d) – mean values denoted by the same superscripts do not differ significantly from each other (α=0.05).

possibility to accept the applied amount of the starch preparations as a sufficiently good.

In the case of the puddings enriched in soy proteins (containing 6.25 g in a 150 g portion), such an additive of starch preparations appeared to be too high, because the higher content of isolated soy protein increased significantly the pudding density and degree of structure gelatinisation. By determining the optimal additive of the starch preparations to puddings with the higher contents of soy protein it was concluded that the samples with the amount of 2.3% starch gelatinising at high-temperature and 1.3% starch gelatinising at low-temperature had a similar or higher apparent viscosity coefficient in the particular taste groups of puddings as those recognised in the first series of the experiments as the best ones (Tables 1 and 2).

Observation of the results of the starch sedimentation in pudding crude mixtures showed that the 1% additive of the low-temperature gelatinising starch was sufficient to hold the high-temperature gelatinising starch in the suspension state in the period of at least 120 min. While in the additive free vanilla pudding mixture the sediment deposited after 60 min.

By means of the apparent viscosity measurement, sensory analysis and investigations mentioned above, the 2.3% additive of high- and 1.3% additive of low-temperature gelatinising starches were found to be the optimal ones among all additives analysed for the puddings enriched with protein.

The effect of the sweeteners (sucrose and thaumatin) and flavour substances (coffee, cacao) on the quality of puddings was evaluated on the basis of the sensory analysis. As an optimal evaluation it was assumed the taste intensity corresponding to 5 units in the scale range from 1 to 10.

The aim of adding the thaumatin solution into pudding (10 ppm in the final product) was to enhance desired aroma (vanilla, chocolate, coffee) and to mask undesired taint tastes, *i.e.* soy and/or metallic [Kolanowski *et al.*, 1998].

In the case of vanilla pudding, the intensity of vanilla flavour and sweet taste were significantly higher for samples with thaumatin (Figure 1). The desired effect of thaumatin additive on the pudding taste was found for 4% and 9% sucrose additive. The amount of the added sucrose influenced the intensity of vanilla flavour. For the 4% sucrose additive, the intensity of vanilla flavour reached 2.55 units, while for 10.5% it reached 4.83 units (Figure 1). With respect to the vanilla flavour, the sample with the 10.5% additive of sucrose and without thaumatin was recognised as the best.

On the basis of sensory evaluation of coffee puddings (Figure 2) it was found that the thaumatin additive excessively enhanced bitter taste (intensity over 8 units) and sweet taste (7.20 units) while the bitter taste intensity for the analogical thaumatin free sample reached 5.21 units only. The effect

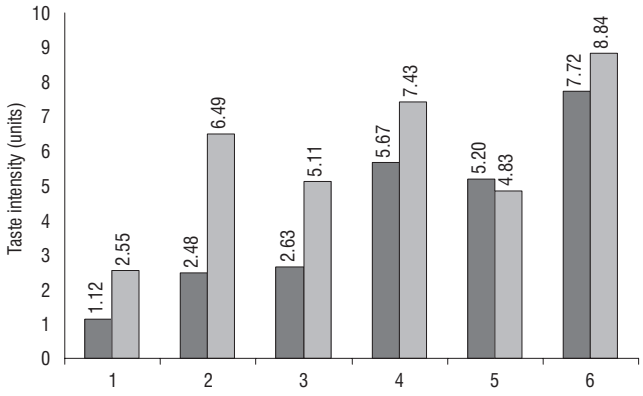

FIGURE 1. Effect of sucrose and thaumatin on the intensity of pudding taste. ■ – sweet taste , ■ – vanilla taste; (1) 4% of sugar; (2) 4% of sugar with thaumatin; (3) 9% of sugar; (4) 9% of sugar with thaumatin; (5) 10.5% of sugar; (6) 10.5% of sugar with thaumatin.

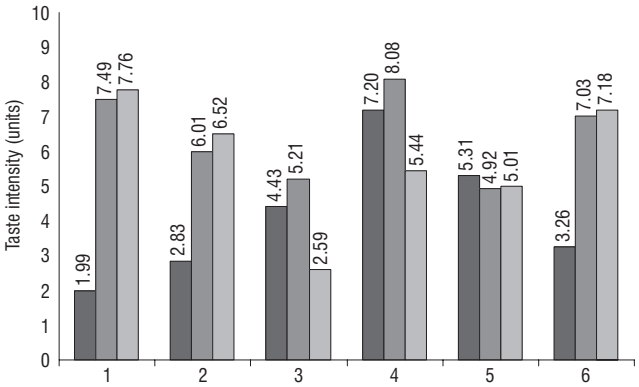

FIGURE 2. Effect of sucrose, coffee and thaumatin on the intensity of pudding taste. ■ – sweet taste, ■ – bitter taste, ■ – coffee taste; (1) 9% of sugar and 2% of coffee; (2) 9% of sugar and 1.5% of coffee; (3) 9% of sugar and 1% of coffee; (4) 9% of sugar and 1% of coffee with thaumatin; (5) 10.5% of sugar and 1% of coffee; (6) 10.5% of sugar and 1.67% of coffee.

of masking the bitter taste in coffee puddings by adding the thaumatin was not achieved, probably because besides of sweetening properties the thaumatin has the ability both to enhance and mask flavour and demonstrates the synergistic effect with other sweeteners or flavour enhancing substances. These properties interact simultaneously and in many cases overlap each other [Kolanowski *et al.*, 1998]. Thus, in some cases the application of the thaumatin does not lead to the desired effect.

The increase from 9.0% to 10.5% of the sucrose additive induced a significant increase of not only the sweet taste intensity but also induced a significant increase of perceptibility of the coffee flavour without changes in the intensity of bitter taste (cf. samples 3 with 5). Thus, it was recognised

that the best taste of pudding samples had been obtained with the additive of the 1% of coffee and 10.5% sucrose, without thaumatin additive. The thaumatin addition to chocolate puddings induced desired improvement of intensity of the sweet taste perceptibility, but simultaneously, the thaumatin additive excessively enhanced the chocolate flavour intensity (Figure 3). As the best tasting pudding it was recognised the sample in which the amount of cacao additive was assumed at the level of 4%, while the sucrose amount was increased up to 10.5%. The application of the thaumatin (10 ppm in the product) improved significantly the vanilla flavour of puddings obtained with the 4% of sugar additive. In the case of the coffee and chocolate puddings, the concentration of thaumatin should be chosen to the assumed amounts of flavour additives. The increase of sucrose additive to 10.5% advantageously intensified the vanilla, coffee and chocolate soy puddings.

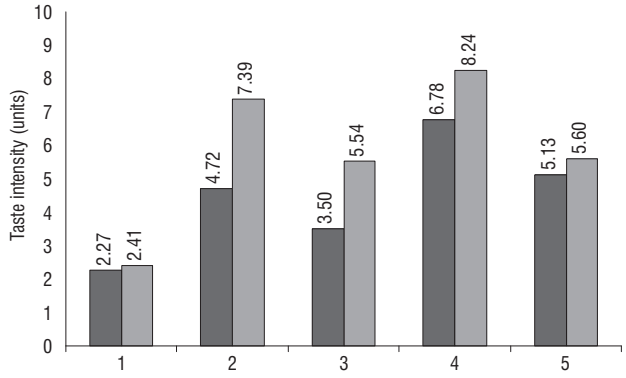

FIGURE 3. Effect of sucrose, cacao and thaumatin on the intensity of pudding taste. ■ – sweet taste, ■ – chocolate taste; (1) 9% of sugar and 3% of cacao; (2) 9% of sugar and 3% of cacao with thaumatin; (3) 9% of sugar and 4% of cacao; (4) 9% of sugar and 4% of cacao with thaumatin; (5) 10.5% of sugar and 4% of cacao.

Comparing the quality of sterilised soy puddings with the quality of commercial soy puddings, it was concluded that they had higher contents of dry matter, protein, fat and also the larger viscosity coefficient (Table 3). In comparison with the commercial milk puddings, they had lower contents of dry matter and in the case of the chocolate pudding, the value of the viscosity coefficient was at the same level as in the case of the milk puddings. The higher protein contents in the sterilised soy puddings made according to own recipes was obtained only in relation to the milk pudding produced by C manufacturer.

On the basis of the overall sensory quality which may be a measure of the degree of consumer's desirability, it was found that among the pudding made according to own recipes the vanilla pudding obtained the lowest note, because of the most perceptible soy off flavour. Nevertheless, all samples of sterilised soy puddings were evaluated higher than the commercial soy puddings. Of soy puddings the best evaluation was given to the chocolate pudding, what could suggest the beneficial effect of cacao additive on the masking of the soy off flavour. The puddings made according to the own recipes were evaluated lower than commercial milk puddings with respect to the consumer's desirability degree (Figure 4).

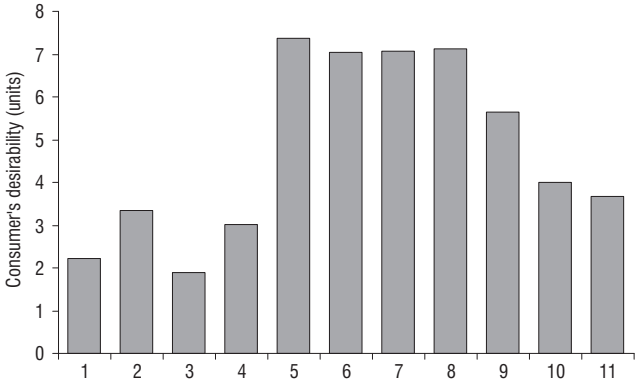

FIGURE 4. Consumer's desirability of commercial and sterilised soy puddings. (1) chocolate A, (2) vanilla A, (3) banana A, (4) fruit B, (5) chocolate C, (6) vanilla C, (7) chocolate D, (8) vanilla D; puddings made according to own recipes: (9) chocolate, (10) coffee, (11) vanilla.

CONCLUSIONS

1. The soy puddings obtained with 2.8% of the high-temperature gelatinising starch and 1.75% of the low-temperature gelatinising starch showed the proper apparent viscosity and respective sensory properties. For the puddings enriched in soy proteins (6.25 g in 150 g portion), the starch additives were 2.3% and 1.3%, respectively.

TABLE 3. The apparent viscosity and chemical composition of commercial puddings (A, B, C, D) and sterilised soy puddings.

Kind of pudding		Pudding flavour	Apparent viscosity (Pa·s)	Contents of components (%)			
				dry matter	fat	sucrose	protein
Made according		Vanilla	1.450[b]	27.31	3.8	9.9	3.4
to own recipes		Coffee	1.450[b]	29.13	3.4	9.4	3.6
		Chocolate	2.120[c]	33.47	3.6	9.8	4.4
Soy	A	Vanilla	0.950[a]	13.10	2.0	2.3	1.4
	A	Chocolate	0.835[a]	12.55	2.0	2.3	1.9
	A	Banana	1.005[a]	13.99	2.2	2.2	1.4
	B	Fruit	1.170[a]	21.98	0.5	12.3	2.9
Milk	C	Vanilla	1.115[a]	27.11	2.0	7.7	1.9
	C	Chocolate	0.895[a]	18.40	2.2	8.5	2.4
	D	Vanilla	2.510[c]	35.00	5.8	4.9	5.5
	D	Chocolate	2.455[c]	34.18	5.4	7.7	4.6

(a–c) – mean values denoted by the same superscripts do not differ significantly from each other (α=0.05).

2. The thaumatin additive in the amount of 10 ppm in sterilised soy puddings excessively intensified their taste. The increasing of sucrose additive in amount up to 10.5% intensified advantageously the flavour of the vanilla, coffee and chocolate soy puddings.

3. In spite of the large content of soy materials, the sterilised soy puddings were evaluated higher with respect to overall sensory quality than the commercial soy puddings, but simultaneously, they were evaluated lower than the commercial milk puddings.

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TECHNOLOGICZNE ASPEKTY OTRZYMYWANIA STERYLIZOWANYCH BUDYNI SOJOWYCH

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Celem pracy było opracowanie receptur sterylizowanych budyni sojowych, które jako analogi budyni mlecznych, stanowiłyby istotne źródło białka sojowego w diecie. Prowadzone badania obejmowały opracowanie receptur sterylizowanych budyni sojowych o zawartości białka zbliżonej do zawartości w mleku oraz o podwyższonej zawartości białka sojowego do 6.25 g w porcji 150 gramowej. Jakość produktów określano na podstawie oceny sensorycznej, oznaczenia podstawowego składu chemicznego, lepkości pozornej, stopnia skleikowania skrobi oraz badania sedymentacji skrobi żelującej na gorąco. W budyniach dodatkowo wzbogaconych w białko sojowe odpowiednią konsystencję i odpowiedni poziom cech sensorycznych osiągnięto przy zastosowaniu dodatku 2.3% skrobi żelującej na gorąco i 1.3% skrobi żelującej na zimno (tab. 2). Dodatek taumatyny (10 ppm w produkcie) nadmiernie intensyfikował smak sterylizowanych budyni sojowych. Sterylizowane budynie sojowe pod względem ogólnej oceny sensorycznej ustępowały budyniom mlecznym, lecz jednocześnie zostały ocenione wyżej niż handlowe budynie sojowe (rys. 4).