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The Use of Fish Protein Preparations in Meat Sausages

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Introduction

Generally substitution of meat proteins by vegetable or animal protein concentrates or preparations higher than 10% brings about marked decrease in the product quality, especially colour and texture. The quality deterioration depends of course upon the properties and concentration of the substitute but also on the technological parameters of manufacturing of the sausages.

Utilization of completely deodorized fish protein concentrates, produced by the standard boiling isopropanol extraction technique /1/ as protein supplement in foods has not found broad application because of lack of functional properties of such concentrates /2/. However, it might be expected that these concentrates, or at least isolates prepared under mild extraction parameters, can be used as structure-forming substitutes in comminuted meat sausages, if suitable procedure of homogenization of the sausage formulation will provide for interactions of the partially denatured and aggregated fish proteins with various meat constituents.

Experimental

Manufacturing of fish protein concentrate and isolate. The fish protein products /Table I/ were prepared from a mince obtained from cod frames in a commercial bone separator. The concentrate was made by 3-or 5 fold extraction with boiling isopropanol, according to the procedure developed in Bureau of Commercial Fisheries Technological Laboratory /3/, and the

Table I
The composition of raw materials used in the sausage formulation

Ingredient	Fish protein content /% of N x 6.25/										
	0	5		10		15		20		30	
		A	B	A	B	A	B	A	B	A	B
Pork	51.0	-	48.4	45.6	45.6	42.9	42.9	40.1	40.1	34.6	-
Beef	21.3	-	26.3	19.2	19.2	18.2	18.2	17.1	17.1	15.0	-
Fish proteins	-	-	2.6	5.6	5.3	6.6	7.9	8.8	10.6	16.9	-
Skinned pork jowls	12.8	-	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	-
Lard	-	-	0.6	0.7	1.2	1.7	1.7	2.3	2.3	2.0	-
Added water	14.9	-	15.3	16.1	15.9	17.8	16.6	18.9	17.1	18.7	-

A - fish protein concentrate B - fish protein isolate

isolate by washing the mince with 0.1 M NaCl, followed by 5-fold extraction with isopropanol at 32-36°C. In both cases the solvent residues were removed by exhaustive washing with water and the hydrated product was stored at about -25°C.

Manufacturing of sausages. The sausage formulation was prepared in a laboratory silent cutter with a pair of knives revolving with a speed of 1400 rpm. In the first stage a binder was made from cured beef meat, fish protein, salt, and water. Later other constituents were added, i.e. cured pork, skinned pork jowls, and ice. The temperature of the formulation in the cutter did not exceed 16°C and the time of cutting and mixing was not longer than 35 min. The meat proteins were substituted by fish proteins in 0-30% /Table II/. In all samples the proportion of water /W/ to protein /P/ i.e. $\frac{W}{P}$, and fat/F/ to protein $\frac{F}{P}$ was 4.7 and 2.7,

Table II
The physicochemical characteristic of the fish mince and protein preparations

Factors	Fish mince	Fish protein concentrate	Fish protein isolate
Crude protein /Nx6.25/ /%/	18.0	34.3	28.8
Dry weight /%/	19.7	36.3	30.9
Lipids /%/	0.8	0.26	0.4
Ash /%/	0.8	0.86	0.63
pH	7.1	7.65	7.8
Protein solubility in 5% NaCl / % Nx6.25 /	20.8	3.0	3.7
Hydration ability / g H_2O/g dry weight /	7.8	7.8	7.7
Odour threshold value	1:250	1:400	1:500

respectively. Immediately after mixing of the formulation its viscosity, pH, and water holding capacity /WHC/ were determined. The sausaged in collagen casings, 35 mm in diameter, were cooked in water at 85°C and rapidly cooled at 10°C. Their properties were determined by the yield limit /yield value/, instantaneous and retarded elastic and plastic strains, free and expressible drip, and the contents of dry matter.

Methods of analysis

The composition of the raw materials, i.e. crude protein /Nx6.25/, dry matter, and minerals was determined using standard procedures. The fat content was calculated as the difference between the dry matter and the sum of proteins + minerals. The pH was measured in a mince : distilled water slurry /1:5/. WHC was assayed by the Grau-Hamm method, using 0.3 g samples. Free drip of the cooked product was measured in graduated test tubes. The hydration ability of fish protein concentrates and isolates was determined by measuring the quantity of 3% NaCl solution absorbed during 1 hr at 10°C and held after 15 min. of centrifuging at 2700 x g. Protein solubility was assayed by homogenizing 2g of the concentrate with 40 cm^3 of 5% NaCl 30 sec. at 12000 rpm, centrifuging 30 min. at 2700 x g, and determining the protein content in the supernatant. Viscosity of the emulsion was measured in a Rheotest 2 viscometer having instead of the cylinder S a slowly rotating blade /1.35 rpm/. In the formula for calculating viscosity a constant factor of the rotor, K = 93.4 Nm^{-2} was introduced.

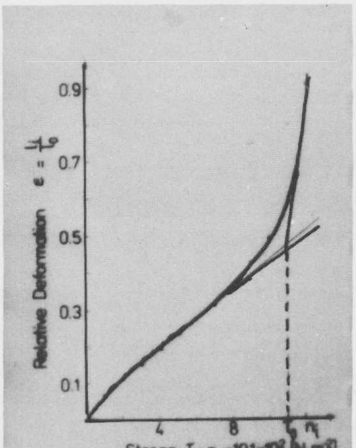

Fig.1 Rheogram of sausage

The rheological properties of the sausages after 24 hr at 4°C were determined using a Holde penetrometer with a flat punch of a cross section area of 49.6 mm^2. On a slice of sausage, 15 mm thick /l_o/ increasing stress was applied, using loads of $n_i \cdot 50$g, where $n_i = 1, 2, \dots i$, which corresponded to $n_i \cdot 10^4$ Nm^{-2}. The depth of penetration of the punch /l_i/ after 30 sec. of stress was measured and the yield limit was calculated as presented in fig. No. 1. For determining the instantaneous /ε_o/ and retarded elastic /ε_{el}/ strain and plastic strain /ε_{pl}/ a flat punch was used of a cross section area of 30.8 mm^2 and a constant load of 380g. The depth of penetration was measured with load on and load off after 0, 5, 10, 15, 20, 25, 30, 60, 120, 180, 270, 360, 480, and 600 sec. The creep curve and different deformations are presented in fig. No. 2. The error of penetrometric determinations did not exceed 15%.

Sensory analysis. Quality differences between the products were detected using triangle and ranking tests. For interpreting the results of ranking method the procedure described by Kramer was used /4/.

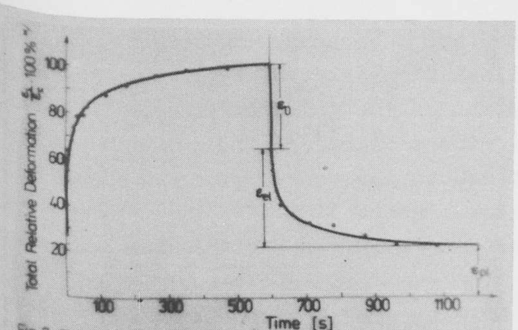

Fig.2 The deformation-time curve of sausage at constant stress
$\varepsilon_1 = \varepsilon_0, \varepsilon_{el}$ or ε_{pl} $\varepsilon_c = \varepsilon_0 + \varepsilon_{el} + \varepsilon_{pl}$

Results of experiments

15% substitution of meat proteins by fish protein concentrate or isolate increased the pH of the sausage formulation by 0.25 and 0.4 units, respectively.

All emulsions heated 20 min. at 80°C lost some drip, which consisted of a watery and a fatty phase. The largest quantity of drip exuded from unsubstituted formulations /Table III/. On the other hand, addition of fish proteins did not influence WHC of the sausage emulsions and the final products. Heating of the systems reduced WHC by about 70%.

The influence of fish proteins on the viscosity of sausage emulsions depends on the properties of the other constituents of the formulations, especially the meats. Substitution of 15% of good quality meats by fish protein isolate and concentrate increased the viscosity of the sausage emulsions by 13 and 40%, respectively.

The yield limit and the share of instantaneous, retarded, and plastic deformation in the total deformation of the slices of sausages do not depend upon the amount of fish proteins in the formulation but are significantly influenced by the quality of meats. Depending on the quality of the raw materials the variability of instantaneous elastic deformation was 25-30%, that of retarded elastic deformation 15-18%, of plastic deformation 52-59%, and of the yield limit $9 \cdot 10^4$ to $13 \cdot 10^4$ Nm^{-2}.

Substitution of 15% of meat proteins in the formulation by fish proteins slightly increased the yield of the product. Sensory differences were detectable by the panel, using the triangle test, between the controls and sausages containing up to 10% of fish protein from the isolate and 20% from the concentrate.

Table III
The range of changes in physicochemical properties of sausage formulations and sausages induced by 15% substitution of meat proteins by fish proteins

Factors	Variability of the raw material A	Relative changes $\frac{B-A}{A} \cdot 100\%$	
		isolate B	concentrate B
WHC / cm^3/g /:			
sausage formulations	0	0	0
sausage	0	0	0
Free drip /%/:			
water	23 - 33	-58.4	-25.5
fat	0 - 8	completely binds	-30.7
Viscosity /Nsm^{-2}/	37 - 49	39.4	13.5
Yield limit /10^4 Nm^{-2}/	9 - 13	0	0
Strain /%/:			
instantaneous elastic	26 - 30.5	0	0
retarded elastic	15 - 18	0	0
plastic	52 - 59	0	0
Yield of product /%/	90 -100	94 - 102	92 - 103
ΔpH	0.4	0.8	0.5
Least concentration of fish proteins causing detectable sensory differences /%/		10	20

Discussion of results

Results of the experiments show that fish proteins used in sausage emulsions in quantities up to 20% of total proteins do not spoil the rheological properties of the products, i.e. they apparently participate actively in the formation of the texture. This effect can be partially attributed to the increase of pH, due to the presence of the concentrate or isolate, and also to the fact, that in substituted products the concentration of myofibrillar proteins is higher than in the controls. The positive interaction of fish proteins with meat proteins in the formulation is more pronounced in emulsions and sausages containing meats of better binding properties.
The influence of the variability of the raw materials on the physicochemical characteristics of the sausage emulsions and sausages is significantly higher than that of the protein substitutes. Therefore a very strict control of the quality standard of meats used in sausage formulations must be applied if fish protein substitutes are to be introduced successfully in the meat industry.

Conclusion

Fish protein concentrate and isolate can be used in comminuted sausage formulations, as they enhance the binding of water and fat and increase the yield of the product. In quantities up to 15% of total proteins they do not induce any significant undesirable rheological or sensory properties of the sausages.

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