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Protein enrichment of bread: I. Chemical and sensoric evaluation

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Bread was probably the first ever man produced processed food, and still remains the most universally accepted. Though it is not a perfectly nutritional source of protein, it is nonetheless a principal source of both calories and protein in most countries. Some 70 % of the world's protein supply comes from vegetable sources, 30 % from animal sources (1). Because of the unique structural properties of hydrated wheat protein, bread can be fortified with a wide variety of protein, vitamin, and mineral supplements. Bread is also a suitable vehicle for uniformal distribution of a nutritional supplement among family.

Several animal and vegetable protein sources have been considered for bread enrichment. Milk and its products are considered important sources of bread protein fortification in a number of countries. Fish protein concentrate and egg protein are also used. Grain legumes and oilseed protein furnish good sources of bread fortification. Soybean, cottonseed, sunflower, peanut, lupine, and rice bran are reported as protein supplements for bread (2–4).

The aim of the present investigation is to report on the effect of enrichment of wheat flour with protein sources on the chemical composition and organoleptic properties of bread.

Materials and methods

The wheat flour (WF) used was a local quality soft wheat of 85 % extraction, usually used by bakeries for bread making. Sunflower seed protein concentrate (SNC), free of chlorogenic acid and phytates, was prepared according to Taha and El-Nockrashy procedure (5). Soy protein concentrate (SC) and fish protein concentrate (FC) were commercial products suitable for human consumption. Rice bran flour (RBF) was supplied by Salt and Soda Company. Lupine flour (LF) was prepared from locally grown *Lupinus termis* according to Darwish and El-Nockrashy (6) procedure.

Analytical procedures

The moisture, oil, ash and crude fibre percentages were determined according to A.O.A.C. methods (7). The nitrogen percentage was determined by semimicro Kjeldahl procedure (8), and the percentage protein was calculated as N × 6.25.

Bread flour recipes and baking

Preliminary work on the preparation of the dough and the baking of the bread was carried out to establish a standard recipe. The bread was prepared from the following eleven wheat flour and protein source combinations:

Recipe No.	Protein source	WF : Protein ratio
I	None	100 : 00
IIA	SNC	95 : 5
IIB	SNC	90 : 10
IIIA	SC	95 : 5
IIIB	SC	90 : 10
IVA	LF	95 : 5
IVB	LF	90 : 10
VA	RBF	95 : 5
VB	RBF	90 : 10
VIA	FC	95 : 5
VIB	FC	90 : 10

WF: wheat flour, 85 % extraction; SNC: sunflower seed protein concentrate; SC: soy protein concentrate; LF: lupine flour; RBF: rice bran flour; and FC: fish protein concentrate.

Flour from the above five recipes, in 300 g lots, was mixed in a mixing bowl together with 3 g of table salt. The yeast starter was prepared in a separate container by dissolving 1.5 g fresg baker's yeast in 42 ml of lukewarm water, followed by the addition of 60 g wheat flour and mixing. The container was covered with a towel and left overnight at room temperature (27 °C). 30 g of the prepared yeast starter were dissolved in 40 g water and then added to the flour mixture. Water (150 g) was then added gradually to the flour while mixing it with the starter to make a water-flour of 70 %. Each sample was then kneaded for 10 minutes, and the dough was fermented for about 2 hours. The resulting dough was divided into three equal loaves that were flattened a little by patting with fingers over small amount of wheat flour to prevent sticking.

Loaves were covered with a towel and left for 2 hours at room temperature. They were flattened to a diameter of about 25 cm, baked on the bottom of an oven at 260 °C till they rised, and then placed in the upper shelf for another 2 minutes.

Samples of the different bread treatments were evaluated by a taste panel. The rest was cut into slices and spread out into single layers on trays and allowed to dry at room temperature for 72 hours. The dry bread was ground using a Wiley mill, and then sieved to pass 80-mesh screen. The bread flour was analysed for its chemical composition.

Table 1. Experimental Design for Baking of Bread.

Block	% Protein source in bread		
	A	B	Duplicate
1	0	5	0
2	0	10	10
3	10	5	5
4	5	0	0
5	10	0	10
6	5	10	5

Experimental design for sensoric evaluation of different kinds of bread

The experiment was run as a balanced incomplete block design designated type V by Cochran and Cox (9), with k = 2, t = 3 and b = 6 as shown in table 1. Thus three loaves of bread, made from each of two different wheat flour-protein combinations, were baked on each of six days. In addition, a second three loaves of bread were made from just one of the combinations. The judges did not know that there was a duplicate among the three samples presented to them. The duplicate was always presented as the last sample.

Two loaves from each flour combination were cut into pieces for the judges, and the third loaf was kept as a whole to judge the crust colour. The samples were presented to the judges in the order shown in the experimental design. The bread was scored for aroma, crumb colour, crust colour, texture, flavour, and overall acceptability by a panel of six persons from the staff and students of the Home Economics Department, Ain Shams University. The grading scores were given numerical values from 1–7 for: very poor, poor, fair, fairly good, good, very good, and excellent, respectively.

Table 2. Chemical Composition of Bread Ingredients[1]).

Ingredients	Protein %	Oil %	Fibre %	Ash %	NFE[2]) %
Wheat flour	12.96	0.63	0.37	0.09	85.95
Sunflower concentrate	83.04	0.34	7.08	2.34	7.20
Soy concentrate	67.23	4.35	4.47	3.04	20.91
Lupine flour	41.40	6.79	16.51	1.03	34.27
Rice bran flour	16.71	0.56	9.47	10.39	62.87
Fish concentrate	84.46	0.23	0.76	14.07	0.48

[1]) Values are given on moisture-free basis
[2]) Nitrogen-free extract

Table 3. Chemical Composition of Bread Prepared from Protein-enriched Wheat[1]).

Recipe No.			Protein %	Oil %	Fibre %	Ash %	NEF %	Protein[2]) enrich-ment %
I	Whole wheat		11.83	0.43	0.41	0.30	87.03	
IIA	Wheat-SNC	(95:5)	14.38	0.36	0.76	1.02	83.48	21.55
IIB		(90:10)	18.56	0.42	1.45	1.24	78.33	56.88
IIIA	Wheat-SC	(95: 5)	13.77	0.40	0.63	1.58	83.62	16.39
IIIB		(90:10)	16.40	0.44	0.78	1.86	80.52	38.63
IVA	Wheat-LF	(95: 5)	13.70	1.32	1.10	0.15	83.73	15.80
IVB		(90:10)	14.61	1.63	1.53	1.19	81.04	23.49
VA	Wheat-RBF	(95: 5)	12.86	0.14	0.44	0.63	85.93	8.70
VB		(90:10)	13.01	0.24	0.85	0.96	84.94	9.97
VIA	Wheat-FC	(95: 5)	14.50	0.32	0.24	0.73	84.21	22.56
VIB		(90:10)	19.19	0.33	0.53	2.20	77.75	62.21

[1]) Values are given on moisture-free basis
[2]) Percentage increase in protein content over whole wheat bread

Table 4. Average Scores for Different Protein-enriched Wheat Bread.

Wheat Flour: Protein source	Sunflower conc.						Soy conc.						Lupine flour						Rice bran flour						Fish conc.					
	Aroma	Crumb	Crust	Texture	Flavour	Overall	Aroma	Crumb	Crust	Texture	Flavour	Overall	Aroma	Crumb	Crust	Texture	Flavour	Overall	Aroma	Crumb	Crust	Texture	Flavour	Overall	Aroma	Crumb	Crust	Texture	Flavour	Overall
100:0	6.6	6.4	6.4	6.3	6.3	6.2	6.6	6.5	6.6	6.6	6.5	6.6	6.6	6.7	6.7	6.8	6.7	6.6	6.6	6.7	6.6	6.6	6.6	6.7	6.6	6.6	6.5	6.5	6.5	6.5
95:5	6.2	5.4	5.5	5.4	5.4	5.4	6.1	6.0	6.1	6.1	6.2	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.2	6.0	6.0	6.1	6.0	6.1	6.0	5.9	6.0	5.9	6.0	6.1
90:10	5.4	5.0	5.2	5.1	5.2	5.2	5.9	5.9	5.9	5.9	6.0	6.2	6.0	5.9	6.0	6.0	6.0	6.1	5.9	6.0	6.0	5.9	5.9	5.8	5.1	5.1	5.1	5.0	5.0	5.1
L.S.D. (1%)	0.6	0.5	0.5	0.6	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.4

Table 5. Degrees of freedom, mean square and F. Value in the analysis of variance for scores of Aroma, Crumb Colour, Crust Colour, Texture, Flavour and Overall Acceptability as Affected by different protein-enriched wheat bread.

Source of Variance	D.F.	Aroma		Crumb		Crust		Texture		Flavour		Overall	
		MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
WF:SNC													
Treatments	2	12.704	15.796	21.528	30.603	14.370	22.009	14.565	16.370	11.194	12.601	10.333	14.355
Error	105	0.804		0.703		0.653		0.900		0.888		0.720	
WF:SC													
Treatments	2	4.593	9.977	3.731	8.360	4.454	9.868	3.954	8.022	2.787	6.075	2.009	4.580
Error	105	0.460		0.446		0.451		0.493		0.459		0.439	
WF:LF													
Treatments	2	3.444	9.510	5.593	11.718	5.120	11.452	5.454	11.861	4.454	9.041	3.065	6.635
Error	105	0.362		0.477		0.447		0.460		0.493		0.462	
WF:RBF													
Treatments	2	5.120	14.337	6.028	14.853	4.481	11.057	5.898	13.916	3.954	9.074	8.361	19.004
Error	105	0.357		0.406		0.405		0.424		0.436		0.440	
WF:FC													
Treatments	2	20.028	47.138	18.120	28.852	19.370	37.186	20.583	36.121	20.176	33.115	17.509	29.626
Error	105	0.425		0.628		0.521		0.570		0.609		0.591	

* WF: Wheat flour, SNC: sunflower protein concentrate, sc: soybean protein concentrate, LF: lupine flour, RBF: rice bran flour, FC: fish protein concentrate.

Results and discussion

The ingredients used in bread recipes include: wheat flour, sunflower seed protein concentrate, soy protein concentrate, lupine flour, rice bran flour, and fish protein concentrate. Table 2 gives the chemical composition of these ingredients.

The protein content of wheat flour is 12.9 %. Four out of five sources used for the enrichment of wheat flour are considered rich sources of protein. Rice bran flour contains 16.7 % protein, and, similar to wheat flour, carbohydrates constitute the greatest percentage.

Table 3 gives the analysis of the bread samples prepared from whole wheat and protein-enriched wheat. Values are given on dry basis. Enrichment of wheat flour with 5 % of the protein-rich sources increased the protein content of the bread by values ranging from 15.8 to 22.5 %. Breads fortified with 10 % protein source contain substantial amount of protein.

Acceptability of protein-enriched bread

Table 4 shows the average scores for aroma, crumb colour, crust colour, texture, flavour and overall acceptability of the three different treatments (0 %, 5 % and 10 %) for each of the five types of protein-enriched bread. The table also gives the least significant difference (L.S.D.) for each of the above characters.

It is clear from table 4 that the L.S.D. values in most of the characters in all combinations were less than the difference between treatment means, which were significant at 1 % level.

In table 5 the analysis of variance was then applied to each of the characteristics of all wheat flour-protein source combinations. It is clear that the computed F value for each of the above six characteristics in all combinations was greater than 1 %, which means that the difference is significant for each of them.

When wheat flour was fortified with 5 % of any of the five protein sources, the mean scores for the six characteristics in all combinations fall in the range 6–5, which is considered very good – good. The very good – good mean scores for the different characteristics show that these protein sources are favourable supplements.

It is therefore concluded that fortification of wheat flour with 5 % to 10 % of the protein-rich sources, namely, sunflower seed protein concentrate, soy protein concentrate, lupine flour, and fish protein concentrate, results in substantial increase in the protein content of the bread. Sensoric characteristics favour the addition of these sources.

Summary

Five protein sources, namely, sunflower seed protein concentrate, soy protein concentrate, lupine flour, rice bran flour, and fish protein concentrate, were used to enrich wheat bread. The protein sources were added at 5 % and 10 % levels. Chemical analysis of the enriched bread revealed increase in the protein content by values ranging from 16 to 62 %. Sensoric evaluation included: aroma, crumb colour, crust colour, texture, flavour, and overall acceptability. The mean scores for these characteristics show that the protein sources are favourable supplements especially at 5 % level.

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