Sweet Lupine-Fortified Bread: Nutritional Value and Amino Acid Content

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ABSTRACT

Full-fat sweet lupine flour (SLF), which is rich in protein (39.7%) and has a fairly high concentration of the indispensable amino acids lysine, leucine, and threonine, was used to fortify bread at 7 and 10% levels (on flour basis). The protein efficiency ration (PER) of bread fortified with 7% SLF was 0.90, slightly higher than that of the control (0.81); however, the PER of bread fortified with 10% SLF showed an increase of 58% over that of the control. Fermentation resulted in an increase in lysine. During baking of the fermented dough, a reduction in the dibasic amino acids lysine and arginine occurred. The concentrations of lysine, arginine, aspartic acid, isoleucine, and tyrosine were higher in the fortified bread than in the control, but those of proline and phenylalanine were lower.

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Sweet lupine (*Lupinus albus*) is gaining momentum as a high protein food supplement. It can be planted in soil unsuitable for most other crops and yet yield well (Gladstones 1970). The seeds are low in alkaloids and rich in protein and have a relatively good balance of amino acids (Campos and El-Dash 1978, Gladstones 1970). Sweet lupine flour (SLF) can be milled easily and can replace up to 10% of medium-strength flour with no change in bread quality (Campos and El-Dash 1978). The present study was conducted to determine the nutritional value of bread made with 7 and 10% full-fat SLF and to determine changes in amino acid content during fermentation and baking.

MATERIALS AND METHODS

Sweet lupine (*Lupinus albus*, ssp. multolupa) was obtained from the Instituto de Pesquisas e Experimentações Agropecuarias de Centro-Oeste in Minas Gerais, Brazil. The sample was cleaned and dehulled in a disk mill (Lilla), and the hull (about 15%) was separated pneumatically. The dehulled kernels were then ground in a hammer mill equipped with a 300-μ sifter. The wheat flour used was an untreated straight-grade flour from Brazilian-grown wheat milled on a commercial roller mill. It contained 0.54% ash and 10.51% protein (N × 5.7) on 14% mb.

The protein, oil, ash, and moisture contents were determined according to the AACC approved methods. Amino acids of acid hydrolysates were analyzed with a Beckman 120C automatic analyzer as descsribed elsewhere (Robbins et al 1971). Alkaloids were extracted and fractionated by thin-layer chromatography according to Barnes and Gilbert (1960). Trypsin inhibitor was determined according to Kakade et al (1969). All experiments were repeated at least twice.

The protein efficiency ratio (PER) of bread and of bread baked from composite flours containing 7 and 10% full-fat SLF were determined, using groups of six weanling rats of the Wistar strain. The animals, weighing an average of 40 g, were caged individually and fed diets containing 60% starch, 15% sucrose, 10% protein, 8% oil, 5% salt mixture, and 2% vitamin mixture. Unrestricted quantities of the diets and water were allowed. A control group of six rats was maintained on a similar diet with 10% casein.

Bread for chemical analysis was baked from composite flour containing 10% full-fat SLF according to the procedure of El-Dash (1978), using the following formula, with percentage of ingredients based on flour weight: flour, 100; salt, 1.75; sucrose, 5; fresh compressed yeast, 3; hydrogenated shortening, 3; and L-ascorbic acid, 90 ppm.

Bread for PER determination was prepared by the Chorleywood process; 20-kg of flour and other ingredients according to the formula were mixed in a Tweedy high-speed mixer for 4 min, divided and rounded immediately, rested 10 min, molded, and panned. The proof time, baking time, and temperature, as well as water absorption, were as previously reported (El-Dash 1978).

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TABLE I

Chemical Composition[a] and Protein Efficiency Ratio (PER) Value of Full-Fat Sweet Lupine Flour (SLF) and Bread Made from Composite Flour Containing SLF

	SLF	Bread		
		Control	7% SLF	10% SLF
Protein	39.70	11.07	13.24	13.92
Lipids	12.20	3.72	4.26	4.63
Ash	3.41	1.97	2.14	2.21
Carbohydrates	44.70	83.24	80.36	79.26
PER	...	0.81	0.90	1.28

[a]Percentage on dry basis.

TABLE II

Amino Acid Composition of Full-Fat SLF Flour, Bread, and Bread Made from Composite Flour Containing 10% Full-Fat SLF[a]

	Full-Fat Sweet Lupine Flour	Sweet Lupine Flour	
		0%	10%
Protein (%)[b]	39.70	11.07	13.92
Lysine	3.85	1.41	1.93
Histidine	1.65	1.26	1.24
NH_3	3.31	6.44	6.43
Arginine	8.10	1.97	2.59
Aspartic acid	10.31	3.71	5.55
Threonine	3.31	2.30	2.47
Serine	5.84	4.72	5.00
Glutamic acid	28.81	42.80	40.14
Proline	3.76	9.83	8.26
Glycine	4.00	3.01	3.24
Alanine	3.17	2.72	2.88
Cystine	1.50	1.04	1.14
Valine	3.07	3.34	3.55
Methionine	0.65	0.97	0.89
Isoleucine	3.59	2.55	2.89
Leucine	7.66	6.07	6.45
Tyrosine	4.10	1.72	2.02
Phenylalanine	3.31	4.14	3.33

[a]Expressed as grams of amino acid per 100 g of amino acid recovered.
[b]On dry basis.

TABLE III

Amino Acid Content of Unfermented and Fermented Dough and of Bread Made from Composite Flour Containing 10% Full-Fat SLF[a]

	Dough		Bread
	Unfermented	Fermented	
Protein (%)[b]	12.94	12.94	13.92
Lysine	2.23	2.66	1.93
Histidine	1.40	1.50	1.24
NH_3	5.75	6.74	6.43
Arginine	3.03	3.03	2.59
Aspartic acid	5.88	5.55	5.55
Threonine	2.55	2.53	2.47
Serine	4.86	4.86	5.00
Glutamic acid	39.84	38.78	40.14
Proline	8.26	8.29	8.26
Glycine	3.15	3.24	3.24
Alanine	2.85	2.81	2.88
Cystine	1.13	1.13	1.14
Valine	3.64	3.67	3.55
Methionine	0.81	0.79	0.89
Isoleucine	3.03	3.01	2.89
Leucine	6.38	6.38	6.45
Tyrosine	1.88	1.76	2.02
Phenylalanine	3.40	3.46	3.33

[a]Expressed as grams of amino acid per 100 g of amino acid recovered.
[b]On dry basis.

RESULTS

Chemical Composition and PER Value

As shown in Table I, SLF is characterized by high protein, lipid, and ash contents. This flour was also free of antitrypsin factors and contained a very low concentration of alkaloid (0.013%). Although addition of 7% SLF to the bread increased the PER only slightly, addition of 10% increased it approximately 58% (Table I).

The nutritional value of bread supplemented with SLF probably improved because of better balance in the amino acid content. The improvement of nutritional value of bread supplemented with various high-protein flours reported by various workers (Guggenhein and Friedman 1960, Horan 1973, Hutchinson et al 1959, Jansen and Ehle 1965, Wilding et al 1968) has been attributed to the increase in the basic amino acid lysine (Bender 1958, Hutchinson et al 1959, King et al 1963, Rosenberg and Rhodenburg 1952). Wilding et al (1968) found that fortification of bread with 10% defatted soya flour increased the PER value from 1.0 (control) to 1.95.

Amino Acid Composition

Table II presents a comparison of the amino acid contents of bread supplemented with 10% full-fat SLF, of unsupplemented bread, and of full-fat SLF in isolation. The percent change in the amino acid content of bread with 10% SLF from that of the control is shown in Fig. 1. The concentrations of lysine, isoleucine, aspartic acid, arginine, and tyrosine increased with addition of SLF, but those of proline and phenylalanine decreased. The concentrations of other amino acids showed only minor changes or remained essentially constant. Campos and El-Dash (1978) previously reported that full-fat SLF is characterized by a high content of the indispensable amino acids lysine, leucine, and threonine; the other amino acids such as aspartic acid, arginine, and tyrosine are also more abundant than in wheat flour. SLF however, is deficient in the sulfur-containing amino acids and low in glutamic acid, proline, and phenylalanine.

Changes in Amino Acid Content During Baking

Table III presents the amino acid contents of unfermented and of fermented dough supplemented with 10% full-fat SLF and of bread baked from such dough. The effect of the overall baking process on the content of amino acids was evaluated by calculating the percent change in amino acid content of bread from that of unfermented dough. The dibasic amino acids lysine, histidine, and arginine were the most affected by baking, with reductions of 13.5, 11.4, and 14.5%, respectively. The other amino acids showed only minor changes.

Effect of fermentation. The only change in amino acids in fermented and unfermented doughs was the increase in lysine (19.3%) during fermentation. This increase could be due to the resistance of lysine to deamination (Mohles 1953); the utilization of amino acids by yeast during fermentation depends on the ease of

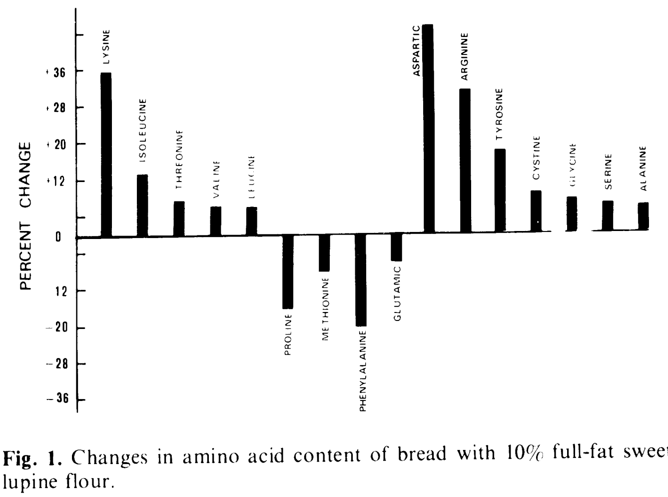

Fig. 1. Changes in amino acid content of bread with 10% full-fat sweet lupine flour.

their deamination to the corresponding keto acids. Similar findings have been reported by others (El-Dash and Johnson 1970, Ponomareva et al 1964).

Effect of Baking. The effect of baking on amino acid content was evaluated by calculating the percent change of amino acid content of bread from that of its fermented dough immediately before baking. This change in concentration can be considered an index of reactivity during baking; greater negative values indicate more reactive amino acids. The dibasic amino acids lysine, histidine, and arginine were reactive and were sharply reduced by baking (−27.8, −17.7, and −14.5%, respectively) (Table III). El-Dash and Johnson (1970) previously reported that the dibasic amino acids are among the most reactive in the formation of bread crust.

The high reactivity of this group of amino acids can be explained by the fact that one of the two amine groups of a dibasic amino acid can be involved in peptide chain formation and the other is free to react with reducing sugars to form glycosylamine. The latter undergoes Amadori-type rearrangements, followed by dehydration, polymerization, and other complex reactions, leading to the formation of the bread flavor compounds (El-Dash 1971, Hodge 1953).

The aromatic amino acid tyrosine increased by 14.7% during baking, as reported elsewhere. Previous comparison of the free amino acid contents of bread crumb and of fermented dough showed a significant increase in the crumb content of methionine and tyrosine and a comparatively slight increase in serine, glycine, alanine, and glutamic acid (El-Dash and Johnson 1970). The increase was attributed to an increase in protein synthesis by yeast during the first few minutes of baking before the dough reached the temperature of deactivation of the yeast enzymes.

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