EFFECT OF ADDITION OF FULL FAT SWEET LUPINE FLOUR ON RHEOLOGICAL PROPERTIES OF DOUGH AND BAKING QUALITY OF BREAD[1]

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ABSTRACT

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The grain of sweet or low alkaloid lupine (*Lupinus albus*), which grows under semiarid conditions, was dehulled and milled into flour (0.013% alkaloid). The full fat flour, which has 39.7% protein (on a dry basis) and a fairly well-balanced amino acid composition (lysine content 3.96 g/16 g N), showed no inhibitory effect on trypsin. Addition of sweet lupine flour to wheat flour increased the water absorption, arrival time, and tolerance index while reducing the dough stability. Dough extensibility and maximum resistance to extension also showed a proportional reduction as the level of sweet lupine flour increased. When bread was produced using an experimental baking test, 5% lupine flour produced bread with a quality similar to the control. Use of 10% lupine flour, however, resulted in a slight reduction in volume and quality. Calcium stearyl-2-lactylate at the 0.25% level, however, improved both volume and quality.

Lupines are members of the family *Leguminose,* subfamily papilionaceae. Cultivation of lupines was practiced in Egypt as early as 2000 BC, where they are known as "termis." Lupines were also well known to Latin American Indians as "tarhui." Lupine seeds are highly rich in protein (38–50%), but the species generally grown around the Mediterranean and in many parts of Latin America are characterized by a high alkaloid content (1–2%). Selective breeding of new varieties, however, has led to development of sweet lupine (1), which has a low alkaloid content (0.090% maximum) as well as a high yield (1–2.5 tons/acre). Studies on the toxicity of sweet lupine (2,3) indicated that rats, rabbits, dogs, and hogs fed the crushed raw seeds showed neither growth retardation nor physiologic damage. Thus, the prospect of using sweet lupine as a protein-rich food or supplement seems bright, especially since lupine offers a variety of other advantages. Lupines can be grown in sandy and acid soils that are unsuitable for most other crops. Moreover, lupines have a high capacity for absorption of phosphates that other plants do not use (1,2), and they can be harvested easily with a combine.

Since lupine seems to be a potentially valuable crop, a series of studies were conducted to evaluate the properties of lupine flours and their role in the baking industry. This article is concerned with the use of full-fat lupine flour.

MATERIALS AND METHODS

Sweet lupine (*Lupinus albus,* var. *multolupa*) was obtained from the Instituto de Pesquisas e Experimentacoes Agropecuarias de Centro-Oeste in Minas Gerais, Brazil. The sample was cleaned and dehulled in a disc mill (Lilla), and the hull (about 15%) was separated pneumatically. The dehulled kernels were

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ground in a hammer mill equipped with a 1,500-μ sifter. The ground lupine flour was graded over a 300-μ sieve; particles larger than 300 μ were reground in a hammer mill equipped with a 300-μ sieve. The wheat flour used was an untreated, straight-grade flour from Brazilian-grown wheat milled on a commercial roller mill (ash 0.54%, protein 10.51% [N × 5.7] on 14% mb).

Chemical Analysis

The protein, oil, ash, fiber, and moisture contents were determined according to AACC approved methods (4). Amino acid analysis was performed on a Beckman amino acid analyzer model 120 C (5). Alkaloids were extracted and fractionated by thin-layer chromatography according to Barnes and Gilbert (6). The trypsin inhibitor was determined according to Kakade *et al.* (7).

Physical Dough Testing

Properties of a flour-water dough were evaluated by the farinograph and extensigraph using AACC approved methods (4).

Baking Test

The baking quality of wheat flour and wheat flour mixed with 5, 10, 15, and 20% sweet lupine flour was determined according to El-Dash (8) as follows:

Bread formula	%	*Weight*
Flour (14% mb)	100	300 g
Salt	1.75	5.25 g
Sucrose	5	15 g
Fresh compressed yeast	3	9 g
Hydrogenated shortening	3	9 g
L-ascorbic acid	90 ppm	27 mg

Procedure. The water absorption was determined with the farinograph to be the amount of distilled water at 30° C required to give a bread dough containing all the above-listed ingredients with a consistency of 500 farinograph units (FU). The mixing temperature was 30° C, and the mixer speed 63 rpm. The dough was mixed to the test optimum time, which was the time required to mix the dough (formed by the addition of all ingredients within a 30-sec period) until a 10 FU drop was observed after reaching maximum development. Two 150-g dough pieces were immediately scaled off, rounded, molded, and placed in the baking pans for fermentation of 105 min at 30° C. The loaves were baked for 20 min at 220° C. The baking test was repeated three times to give a total of six loaves for each flour mixture.

Bread Quality Evaluation

Bread quality was evaluated by a panel of five trained personnel who were asked to score the bread according to the following scale: crust color and characteristics, 15 points; break and shred, 5 points; symmetry, 5 points; crumb color, grain, and texture, 10 points each; and aroma and taste, 25 points. A loaf volume score was also determined by multiplying the specific volume by 3.33 to allot the maximum of 20 points for a loaf of bread with a specific volume of 6, which was considered optimum.

RESULTS AND DISCUSSION

Chemical Characteristics of Lupine Flour

The chemical composition of lupine flour is presented in Table I. It is characterized by a high protein content, which should be of value in the supplementation of wheat flour for the production of high-protein bread. Not only is sweet lupine flour low in alkaloids (0.013%) but also it is free of trypsin inhibitors; this eliminates the necessity for heat treatment, which is required for soya flour.

The amino acid content of full-fat sweet lupine flour on the basis of 16 g N is presented in Table II. Sweet lupine flour is characterized by a high content of the indispensable amino acids lysine, leucine, isoleucine, and threonine. The high content of lysine is particularly important nutritionally, because wheat flour is deficient in this particular amino acid. Other amino acids such as aspartic, arginine, serine, glycine, tyrosine, and alanine are also more abundant in sweet lupine flour than they are in wheat flour. Sweet lupine flour, however, is deficient in the sulfur-containing acids methionine and cystine, which are present in significant quantities in wheat flour. This indicates that a beneficial complementary nutritional effect of the amino acids of lupine and wheat flour is

TABLE I
Chemical Composition of Sweet Lupine Flour

Components	Dry Basis[a] (%)
Protein	39.70
Lipids	12.20
Carbohydrates	42.60
Fiber	2.10
Ash	3.41
Alkaloids	0.013
Antitrypsin activity	Absent

[a]Moisture content 6.1%.

TABLE II
Amino Acid Content of Full Fat Sweet Lupine Flour[a]

Amino Acid	g/16 g N	Amino Acid	g/16 g N
Glycine	4.12	Arginine	8.24
Alanine	3.27	Histidine	1.70
Valine	3.17	Tyrosine	4.22
Leucine	7.87	Phenylalanine	3.40
Isoleucine	3.70	Cystine	1.55
Aspartic	10.58	Methionine	0.67
Glutamic	29.53	Serine	6.00
Proline	3.87	Threonine	3.41
Lysine	3.96		

[a]Protein content 39.7% (dry basis).

probable and that a mixture of wheat and sweet lupine flour should have nutritional value superior to either flour alone.

Effect of Lupine Flour on Physical Properties of Dough

Water absorption and mixing properties. Increasing concentrations of sweet lupine flour increased the water absorption steadily as shown in Fig. 1. The specific water absorption was 0.56 ml/g for wheat flour and 1.12 ml/g for sweet lupine flour.

The effect of the addition of sweet lupine flour on the mixing properties of a flour-water dough is presented in Fig. 2. The stability of the dough was reduced in proportion to the amount of sweet lupine added. The dough development time increased sharply at the 5% level, and the arrival time showed a slight increase as the concentration of sweet lupine flour increased.

These results lead to the conclusion that mixing sweet lupine flour with wheat flour results in a dough that requires significantly greater mixing time. Care must be taken, however, as the tolerance of the dough to mechanical mixing has decreased sharply.

Effect of baking ingredients on water absorption and mixing requirements. The water absorption and mixing requirements of a bread dough, including all baking ingredients prepared from wheat flour and wheat-sweet lupine flour mixtures, are presented in Table III. The presence of sweet lupine flour required addition of more water to maintain a dough of 500-FU consistency. When the specific water absorption was calculated (0.51 ml/g for flour and 0.86 ml/g for

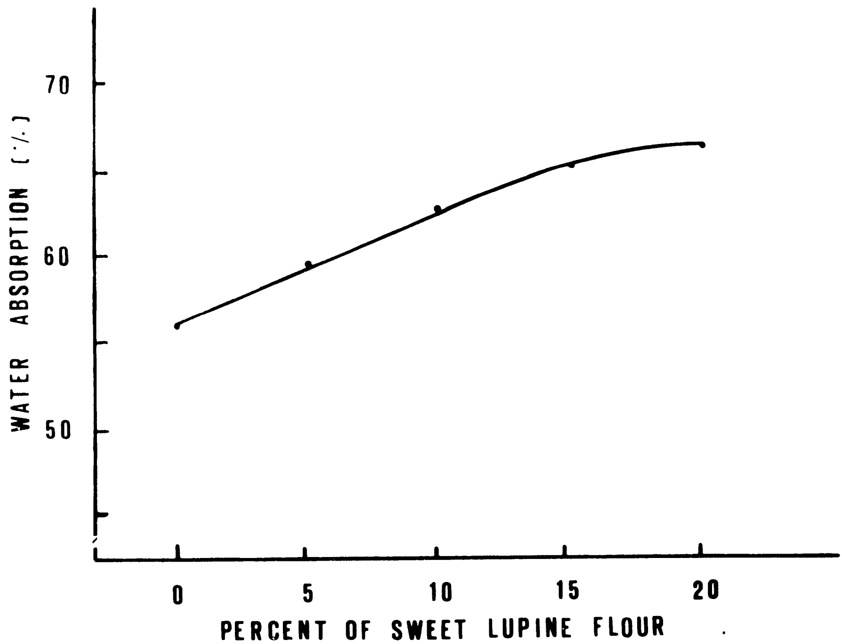

Fig. 1. Effect of sweet lupine flour on water absorption.

sweet lupine), it was found to be lower than that obtained above for a flour-water dough. This reduction was apparently due to the effect of the baking ingredients on the water absorption capacity of the flour.

The mixing energy required to develop the dough was increased by the presence of sweet lupine flour, as indicated by the increase in test optimum mixing time. The increase in mixing requirements for bread dough was much

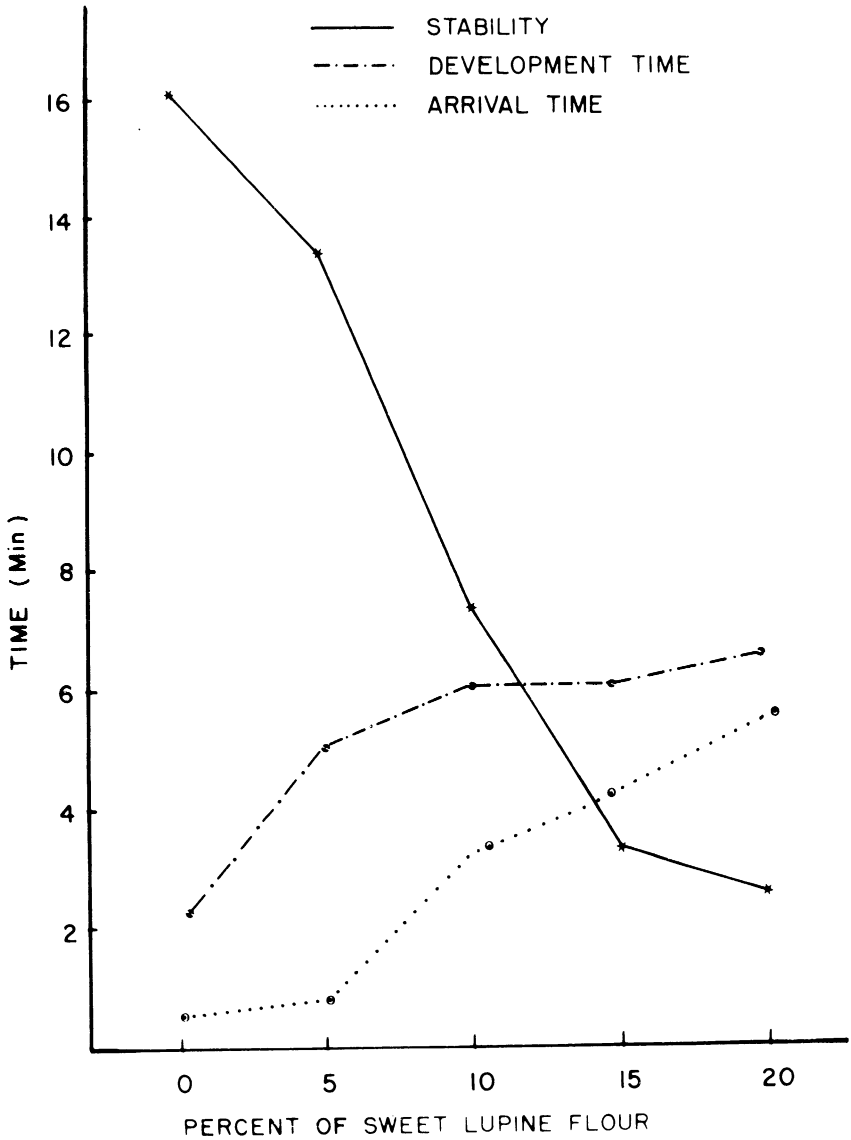

Fig. 2. Effect of sweet lupine flour on mixing properties of dough.

higher than that suggested by the farinograph results (flour-water dough), indicating that the presence of the bread ingredients increases the mixing requirement significantly.

Load extension properties. The effect of sweet lupine flour on extensigram properties is presented in Table IV. Dough extensibility showed a rather pronounced decrease as the amount of sweet lupine flour and time of resting increased; the maximum resistance to extension also showed a proportional reduction as the level of sweet lupine flour increased. The total area of the extensigram declined sharply on addition of sweet lupine flour, especially after more than 90 min of dough resting. The proportional number, however, showed a steady increase as the resting time and level of sweet lupine increased, indicating a strengthening of the gluten network capable of retaining gas during the fermentation process.

TABLE III
Effect of Sweet Lupine Flour on Water Absorption and Test Optimum Mixing Time of Bread Dough[a]

Sweet Lupine (%)	Water Absorption (%)	Test Optimum Mixing Time (min)
0	51.0	10.5
5	53.5	13.0
10	54.5	14.5
15	57.0	16.0
20	58.1	18.0

[a]Measured at 500-FU consistency.

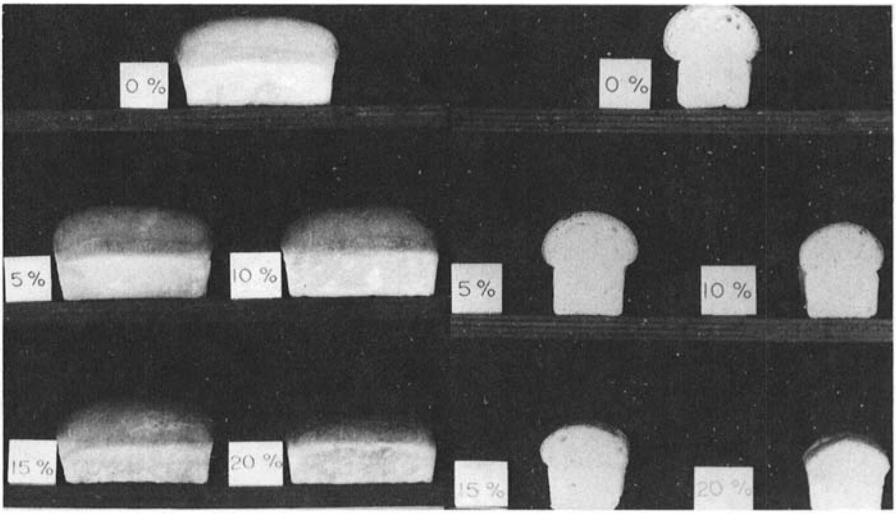

Fig. 3. Internal and external characteristics of bread with various levels of sweet lupine flour.

TABLE IV
Effect of Sweet Lupine Flour on Load Extension Properties of Dough

	Full Fat Sweet Lupine Flour (%)														
	0			5			10			15			20		
	Rest Time (min)														
	45	90	135	45	90	135	45	90	135	45	90	135	45	90	135
Extensibility (E) (min)	175	140	130	150	122	120	145	120	110	130	117	105	130	115	102
Maximum resistance (R_m) (EU)[a]	820	1000	1000	580	890	960	550	860	940	460	800	910	430	700	820
Area (cm^2)	162	178	167	115	126	118	97	117	109	77	112	107	75	108	103
Proportional number (D) (D = R/E)	2.63	4.92	5.76	2.66	4.95	5.66	2.83	5.58	6.63	2.85	5.64	7.61	2.46	5.04	7.35

[a]EU = extensigraph units.

Bread quality. Bread made with 0, 5, 10, 15, and 20% sweet lupine flour is shown in Fig. 3. The specific volume was 4.61, 4.63, 4.02, 3.81, and 3.27, respectively. The crust color was intensified as the concentration of sweet lupine flour increased. This was attributed to the increased protein concentration, therefore intensifying the Maillard nonenzymatic browning reaction (9).

As indicated in Fig. 4, addition of 5% sweet lupine flour did not affect the bread quality; use of higher levels, however, had an exceedingly deleterious effect on quality. Although the bread volume dropped at the 10% level, the aroma and taste were not affected. At 15%, a slight change in taste was detected, and the

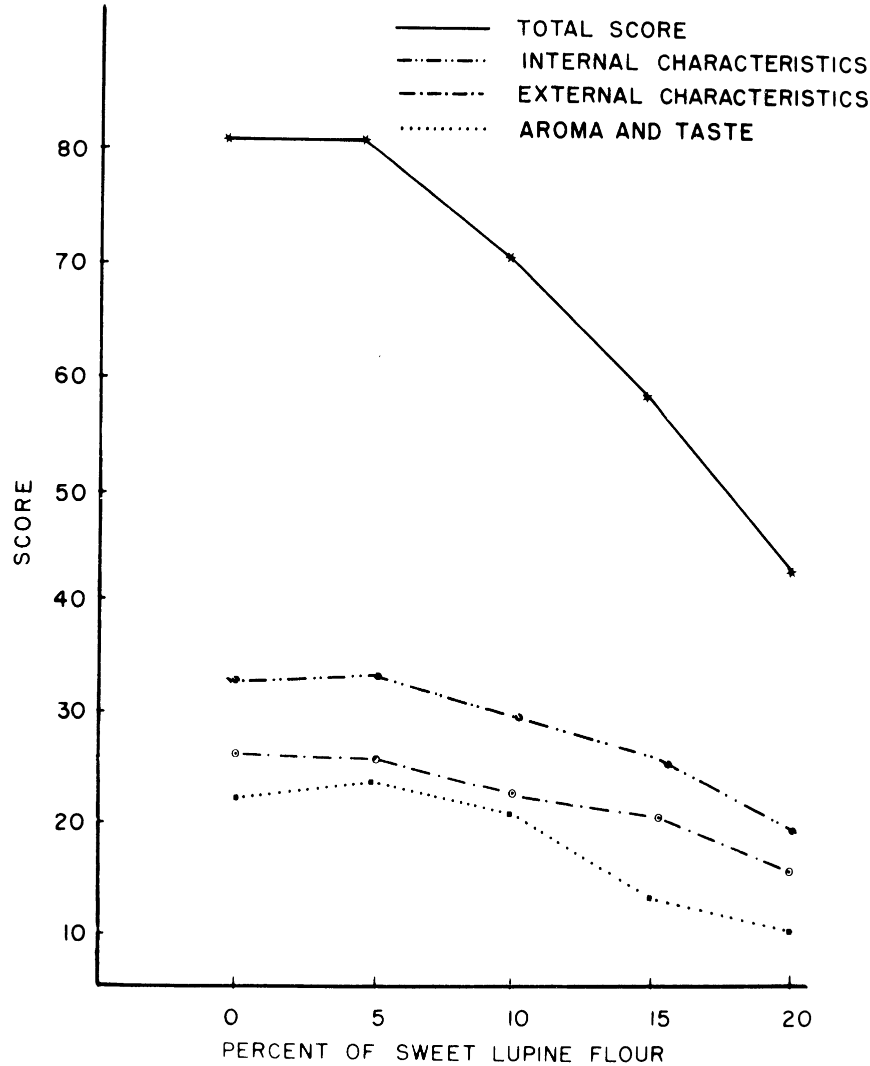

Fig. 4. Effect of sweet lupine flour on bread quality.

crumb color was slightly yellowish due to the yellow color of the lupine flour; this suggests the need for color bleaching of sweet lupine flour.

Calcium stearyl-2-lactylate used at the 0.25% level was effective in improving the bread volume; its use with 10% sweet lupine flour resulted in a bread volume equivalent to that of the control (sp vol 4.63).

CONCLUSIONS

Use of sweet lupine flour in bread is feasible, and the functional tolerance of wheat flour to sweet lupine flour is good. Although the wheat flour used in this study was only of medium baking strength, it tolerated up to 10% sweet lupine flour; with stronger flours, toleration of even higher levels of sweet lupine flour could be expected.

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