Germinated and Ungerminated Faba Bean in Conventional U.S. Breads Made With and Without Sugar and in Egyptian Balady Breads

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ABSTRACT

Eighteen hours of steeping followed by four days of germination only moderately changed the amino acid spectrum of faba beans (*Vicia faba*). Aspartic acid, ammonia, and serine increased 17.2, 10.8, and 7.2%, respectively, whereas isoleucine, tyrosine, glycine, and arginine decreased 11.8, 9.5, 7.2, and 7.0%, respectively. Flour from ungerminated and germinated decoated faba beans replaced (15%) straight grade baker's flour and produced straight dough, yeast-leavened loaf breads that were equally acceptable with and without sugar. Twenty percent replacement with ungerminated faba flour was suitable in Egyptian balady bread. Slurries containing 15% faba bean flour yielded slightly more gas when yeast fermented than did the control wheat flour slurries containing 0.60% malt (50 DU/g, 20°C).

Interest in legume supplementation of cereal-based food continues to increase. Some highly nutritious, low-cost legumes, particularly defatted soy flours or isolates, have been well studied in breads and other foods. In comparison, many other legumes such as the faba bean have received little attention.

The faba bean (*Vicia faba*) is often fed to animals but is more often eaten by humans. Where they are a significant part of the diet, faba beans are eaten fresh or are prepared in a variety of ways, including steeping and boiling, baking, roasting, or frying. They are also germinated and then boiled or baked. The bean is often included in soups or other hot dishes, but rarely in bread. Nevertheless, some work has been published on faba bean flour and protein isolates and concentrates in yeast-leavened wheat breads (D'Appolonia 1977; McConnell et al 1974; Patel and Johnson 1974, 1975, 1977).

Beans of different varieties vary in size and shape, from a sphere with a 5-mm diameter to an ellipsoid over 1.5 cm long and similar in shape to a lima bean. Cotyledons are creamy to yellow and are relatively low in fat and sugar, moderately high in carbohydrate, and high in protein and ash. Although generally higher than soybeans in lysine, faba beans are usually lower in sulfur-containing amino acids. The seed coat color varies within and among varieties and includes white, green, brown, and black variations. The coat is high in fiber and tannin but low in protein content (Marquardt et al 1978). A thermolabile growth inhibitor has been isolated from the faba bean seed coat (Marquardt et al 1977, Ward et al 1977). Seed coats are included in some food preparations and excluded in others and are usually processed at relatively high heats before they are eaten.

Although faba beans are grown and consumed as an inexpensive and popular staple throughout the world, a hemolytic disease, termed favism, is associated with faba bean consumption. The disease occurs in specific geographic areas. However, in many places where nearly entire populations consume the bean, no cases of favism are reported. Thus, in their review Mager et al (1969) concluded that the unidentified toxic constituents in faba beans probably differ among the many international varieties and that variations in preparation and eating habits are probably as important as the genetic makeup of persons susceptible to the disease.

For example, no cases of favism have been reported in Egypt, where the faba bean is a staple (Abdalla et al 1976, El-Wakeil 1955). In Egypt the bean is usually steeped overnight or germinated 3–5 days before being cooked.

For centuries seeds have been germinated for food or feed uses. For many seeds, appropriate germination conditions can: 1) increase several vitamins (Banerjee et al 1955, Burkholder 1943, Burkholder and McVeigh 1942, Chattopadhyay and Banerjee 1954, Fordham et al 1975, Hsu et al 1980, Klatzkin et al 1946, Lee and Reed 1936, Miller and Hair 1928, Rudra 1938); 2) increase relative nutritive value, protein efficiency ratio, or lysine, methionine, or tryptophan (Cook 1962, Dalby and Tsai 1976, Everson et al 1944, Hamad and Fields 1979, Hasim and Fields 1979, Wang and Field 1978); and 3) reduce some seed antinutritional factors or decrease the cooking time or temperature required to inactivate antinutritional factors (Disikachar and De 1950, Mattingly and Bird 1945, Liener,[4] Subbulakshmi et al 1976). Germination sometimes increases phytase activity, reduces phytate content and thereby probably increases mineral availability (Chen and Pan 1977, Mandal et al 1972).

In this investigation, we compared the amino acid levels and yeast-gas production of flours from germinated and ungerminated faba beans and the dough-making and bread-making properties of wheat flours containing from 5 to 20% faba bean flour when formulated in yeast-fermented U.S. breads made with and without sugar and in yeast-fermented Egyptian breads.

MATERIALS AND METHODS

Flours from Wheat and Faba Beans

A commercial, straight grade baker's flour with a good loaf volume potential, medium mixing time, and medium oxidation requirement was used in this study. Samples of three varieties of faba beans—Ackerperle, Herz Freya, and Diana—were donated by the Department of Plant Science of the University of Manitoba, Winnipeg.

Equal portions of each variety were composited, ground in a Hobart mill, and sifted as described by Morad and Finney (1980).

Faba Bean Germination

Faba beans were steeped for 18 hr at 21–22°C in excess water, which was changed every few hours. After steeping, they were germinated for four days in a cabinet with controlled temperature and humidity that provided automatic rinsing and draining every 2 hr, as designed and built by Y. S. Hsu and described by D. Hsu et al (1980).

The coats of germinated faba beans were easily removed because nearly all the seed coats had split open from the swelling of the cotyledon. The decoated beans were frozen and freeze-dried to a moisture content of 7.5%, ground into flour with a Hobart mill, and then frozen until analyzed and formulated into breads.

Analytical Procedures

Moisture and protein of the wheat (N × 5.7) and faba bean (N × 6.25) flours were determined by AACC methods (1962).

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Yeast gas production by slurries containing flour from wheat, germinated and ungerminated faba beans, and wheat-faba combinations (15% substitution) were determined on the gasograph (Rubenthaler et al 1980). The slurries were prepared with 10 g of flour, 15 ml of water, 0.15 g of NaCl, 0.76 g of fresh baker's yeast, and where appropriate, 0.06 g of malt (50 DU/g, 20° C) donated by Ross Industries, Wichita, KS.

Mixograms (10 g) were prepared as described by Shogren and Finney (1972) on wheat flour and wheat-faba combinations.

Amino acid levels were determined on hydrolysates with a Beckman automatic amino acid analyzer by the method of Robbins et al (1971) and were expressed in grams per 100 of amino acids recovered.

The bread-baking procedure of Finney et al (1977) for 100 g of total flour (14% mb) was used for producing conventional U.S. breads. The formula included 7.6% yeast, 1.5% NaCl, 0.6% diastatic malt (50 DU/g, 20° C) or 6.0% sucrose plus 0.3% malt, and 75 ppm ascorbic acid and variable amounts (optimum) of $KBrO_3$ as oxidizing agents. The faba bean breads were produced by replacing 5, 10, 15, or 20% of the wheat flour with flour from decoated germinated or ungerminated faba beans. Data reported are the means of two or three bakes.

TABLE I
Protein and Amino Acid Contents[a] of Wheat and Faba Bean Flours

	Control Wheat Flour	Ungerminated Faba Bean Flour[b]	Germinated Faba Bean Flour[c]	Change After Germination (%)
Protein (14% mb)	11.67	29.10	30.20	...
Amino Acids				
Lysine	2.03	7.00	6.88	− 1.7
Histidine	1.99	2.80	2.92	+ 4.3
Ammonia	5.42	3.14	3.48	+ 10.8
Arginine	3.05	8.82	8.20	− 7.0
Aspartic acid	3.58	11.28	13.22	+ 17.2
Threonine	2.43	3.67	3.56	− 3.0
Serine	4.75	5.45	5.84	+ 7.2
Glutamic acid	32.46	17.17	17.07	− 0.6
Proline	13.75	5.19	5.25	+ 1.1
Half cystine	2.90	3.21	2.99	− 6.9
Glycine	3.20	4.28	3.97	− 7.2
Alanine	2.65	4.46	4.45	0
Valine	3.85	4.04	3.85	− 4.7
Methionine	1.54	1.07	1.07	0
Isoleucine	3.01	3.40	3.00	− 11.8
Leucine	6.39	7.56	7.08	− 6.3
Tyrosine	2.39	3.05	2.76	− 9.5
Phenylalanine	4.53	4.39	4.28	− 2.5

[a] Expressed in grams per 100 g of amino acids recovered.
[b] Mechanically milled and sifted, containing 96% cotyledon.
[c] Germinated (for four days at 23° C after being steeped for 18 hr), hand-decoated, freeze-dried, and mechanically milled; containing 100% cotyledon.

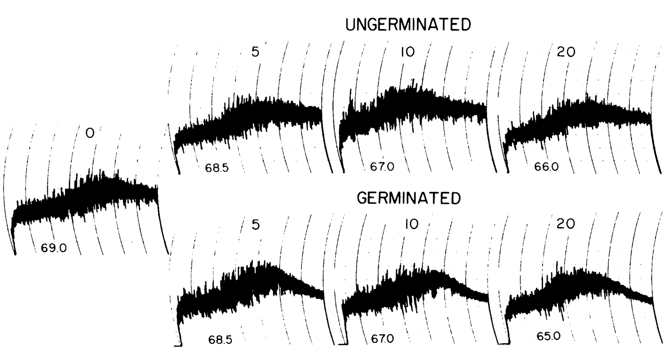

Fig. 1. Mixograms (10 g) of commercial control flour with 5, 10, or 20% germinated or ungerminated faba bean flour added on replacement basis. Water absorption values appear under the mixograms.

Egyptian "balady" bread was produced from 100 g of wheat flour or 80 g plus 20 g of ungerminated faba flour, 75 ml of water, 2 g of NaCl, and 5 g of fresh baker's yeast. Ingredients were mixed to optimum (as measured on the mixograph). Doughs were transferred to bowls and fermented for 60 min (86° F, 90–100% rh), then hand-degassed and fermented for 30 min. Next, 145 g of dough pieces were again degassed, hand-rounded and flattened, and baked for 5 min at 600° F. Balady breads were evaluated by the authors and 10 untrained Egyptian graduate students enrolled at Washington State University. Acceptability depended on taste, color, puffing and layer separation, and high ratio of crust to crumb.

RESULTS

Protein and Amino Acids

The protein and amino acid contents of the control flour and the germinated and ungerminated faba bean flours are reported in Table I. No dramatic changes were found in the amino acid composition of faba beans after 18 hr of steeping followed by four days of germination. Aspartic acid, ammonia, and serine levels increased 17.2, 10.8, and 7.2%, respectively; isoleucine, tyrosine, glycine, and arginine decreased 11.8, 9.5, 7.2, and 7.0%, respectively. Replacement of 10% of the wheat flour with either germinated or ungerminated faba bean flour approximately doubled the lysine content of the bread (data not shown). Although some researchers report that legumes improve in nutritive value after germination (Desikachar and De 1950, Everson et al 1944), no increases in the amounts of the major limiting amino acids of wheat or other cereals, namely lysine, methionine, threonine, or tryptophan have been reported.

Dough Mixing Properties

Mixograms were run with wheat flour alone and with germinated or ungerminated faba bean flours replacing 5, 10, or 20% of the control wheat flour (Fig. 1). Height and width of line at the peak mixing time decreased slightly with increasing levels of both flours, indicating only a slight weakening of dough structure.

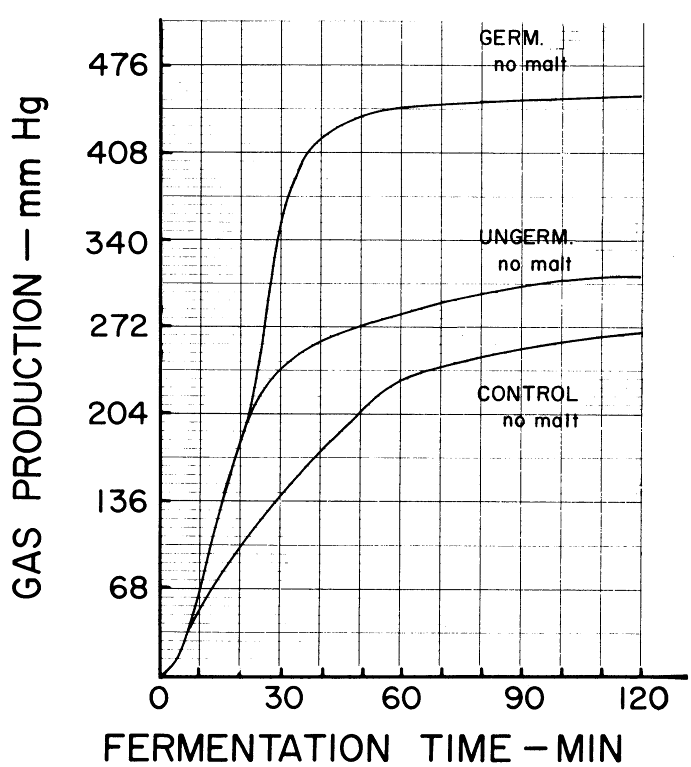

Fig. 2. Gas production (mm Hg) by yeasts (7.6%) in slurries of control flour, and germinated or ungerminated faba bean flour, all with 150% water and no malt, fermented at 30° C.

Germination decreased resistance to over-mixing (mixing beyond peak) with increasing replacement levels (Fig. 1).

Yeast Gas Production

Slightly more yeast fermentables, as indicated by gas production, were in ungerminated faba bean flour than in the control. Germination significantly increased fermentables (Fig. 2). Slurries of wheat flour with 15% faba bean flour yielded slightly more gas than did slurries of control flour with 0.6% malt (Fig. 3). During fermentation in bread-making studies, differences in gas production were estimated by dough height, and results corroborated the direct gas production measurements (data not shown).

Bread Making

Increasing levels of ungerminated and germinated faba bean flour decreased loaf volume and other bread quality characteristics (crumb grain) at approximately the same rate (Fig. 4). As with mixing properties, faba bean flour in breads made with and without sugar compared favorably with yellow pea flour, one of the better legume interactants with wheat flour in bread making (Hsu et al 1980, Jeffers et al 1978). We were particularly interested to find that germinated faba bean breads were equal to ungerminated faba bean breads except that breads formulated with sugar and with faba bean had excessively brown crusts. Breads without sugar with 15% germinated and ungerminated faba bean flour were indistinguishable, and they compared favorably with bread supplemented with yellow pea flour on equal replacement levels and with breads containing about 10% (replacement basis) of the better defatted soybean flours.

Egyptian Balady Bread

Ungerminated faba bean flour was also used to replace up to 30% of control wheat flour in making yeast-leavened Egyptian balady (pocket) bread. Increasing the levels of faba bean flour up to 20% did not change the quality characteristics of the balady bread. The flat, round loaf was puffed up and separated in two layers and was mostly crust, as is normally desired for pocket bread. Color was acceptable at all levels. One or two of the 10 untrained panel members objected to the flavor at 30% replacement. Others in the panel, including M. M. Morad and Egyptian students enrolled at Washington State University, noted a change of flavor with 30% faba bean replacement but found the flavor desirable.

DISCUSSION

Decoated faba bean flour is an excellent fortifier for loaf and flat-breads; in fact, it may be one of the best. Faba flour is a good source of protein, usually 30% or more, and of lysine. Jeffers (1978) successfully substituted more yellow pea flour than defatted soy flour in straight dough breads made with and without sugar. Hsu et al (1980) successfully substituted as much decoated germinated and ungerminated faba bean flour as either yellow pea or lentil flour in similar high yeast (7.6%) bread-making studies. In those studies, four days of germination increased vitamin C content of faba beans from 1.4 to 75.8 mg/100 g, dry weight. Although it increased vitamin C content of yellow peas and lentils from 2.2 and 0.9 to 64.1 and 77.5 mg/100 g, respectively, germination was highly detrimental to both the functional and organoleptic properties of germinated pea or lentil breads.

Because balady bread is a staple food in Egypt, the addition of 10–15% decoated, faba bean flour could improve the nutritive value of a major food while stretching wheat flour resources.

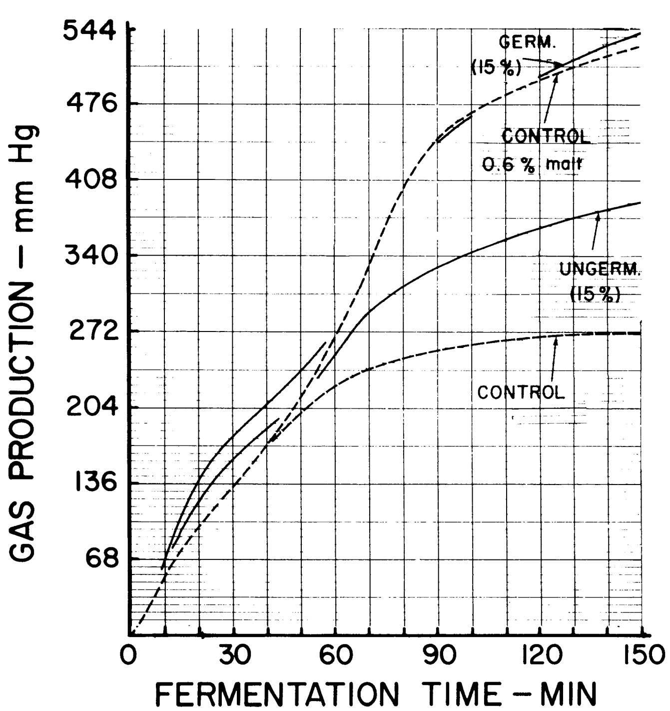

Fig. 3. Gas production (mm Hg) by yeasts (7.6%) in slurries of control flour with and without 0.60% commercial malt and control flour with 15% replacement of germinated or ungerminated faba bean, all with 150% water and fermented at 30°C.

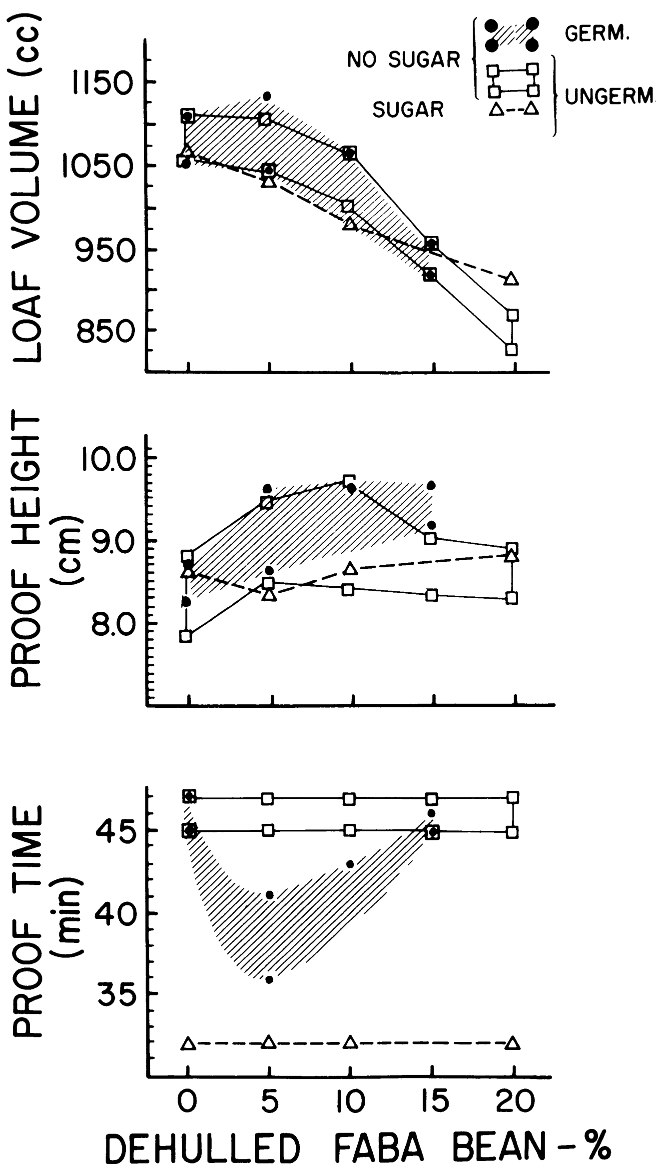

Fig. 4. Bread quality characteristics of straight dough breads with and without sugar formulated with 7.6% yeast and substituted with 0–20% flour from germinated or ungerminated dehulled faba beans.

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