Effects of Germination on Bread-Baking Properties of Mung Bean (*Phaseolus aureus*) and Garbanzo Bean (*Cicer arietinum*)[1]

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Cereal Chem. 59(6):520–524

ABSTRACT

Flours from whole mung bean were unsuitable in straight-dough breads because of an undesirable "beany" off-flavor even at the 5% replacement level. Decoated mung produced excellent breads when substituted for 5% of bakers' flour and acceptable breads when substituted for 10–15% of bakers' flour. Three days of germination produced noticeable deleterious affects to both bread flavor and structure at the 5–10% replacement level. Flour from whole garbanzo bean produced outstanding breads when replacing 10% of bakers' flour and acceptable breads when replacing 15–20% of bakers' flour. Germination imparted a slightly sweet taste at the 15–20% level and preserved desirable bread properties. Unlike mung and all other legumes previously tested, 48 hr of germination reduced yeast gas production of whole garbanzo flour slurries and approximately doubled that of mung. Germination did not materially alter amino acids of either mung or garbanzo, which have similar amino acid patterns.

For hundreds of millions of people, wheat breads are a staple food and provide a high percentage of the essential nutrients. For the many people whose diets are based on a nonwheat staple, breads may nevertheless be an important source of B vitamins, many minerals, carbohydrates, proteins, and dietary fiber. Maximizing nutrient availability and minimizing costs is always important, particularly to destitute individuals who must rely on a staple foodstuff like legume-supplemented white flour from wheat.

Most legume flours improve the nutritive value of wheat breads and other foods by balancing some of the deficient essential and nonessential amino acids. Most common legume protein, with the exception of peanut, is high in lysine but low in sulfur-containing amino acids. In a summary that included five to ten references for most amino acids assayed (Kuppuswamy et al 1958), amino acid levels in most mung and garbanzo beans were similar. Average values for lysine and methionine were 6.1 and 7.1, respectively, and 1.6 and 1.7% for total protein, for the two legumes.

Using a chemical method, Heller (1927) reported that mung protein contained 0.4% cystine, a determination that was confirmed microbiologically by Betton and Hoover (1948). Vijayaraghavan and Srinivasan (1953) and Bagchi et al (1955) found that mung bean protein contained about 0.2% cystine, using microbiological and chemical methods, respectively. Vijayaraghavan and Srinivasan (1953) microbiologically determined that garbanzo protein contained 0.2% cystine.

Soy flours and concentrates in breads and as supplements in wheat and other cereal foods have been extensively studied (Bean et al 1976, 1977; Fellers et al 1976; Finney and Shogren 1971; Finney et al 1950; Mecham et al 1976; Pomeranz et al 1969; Tsen et al 1971). Other legumes used in breads, including mung, lentil, pea, cowpea, and navy, pinto, and faba bean, have also been evaluated (D'Appolonia 1977, Jeffers et al 1978, Kim and DeRuiter 1968, McConnell et al 1974, Thompson 1977, Thompson et al 1976).

Defatted germinated soybean flour (10%) was judged slightly superior to a commercial defatted, ungerminated soybean flour (Ardex 550) in bread-making studies (Pomeranz et al 1977). Replacement of 7% wheat flour in sponge and dough breads with fresh, whole germinated, and mashed soybeans had no adverse effects on important bread properties (Finney 1979). Germination adversely affected bread-making properties of peas and lentils, but not faba beans (Hsu et al 1980). In fact, germination improved organoleptic properties of faba beans without impairing their bread-baking properties (Finney et al 1980). Kumar and Venkataraman (1978) found 80–90% of the garbanzo bean cotyledon protein to be salt-soluble globulins. Decoating made the ungerminated mung bean suitable for supplementation in quantities up to 15% in bread; however, mung breads had inferior grain quality and reduced loaf volume (Thompson 1976).

The objective of this study was to discover which legume flours produce the most nutritious and delicious breads and other foods with the legume replacing relatively high levels (15–25%) of white wheat flour. We evaluated germinated and ungerminated legume flours because of the implied nutritive benefits of carefully controlled seed germination. In addition to a sugar formula, a bread formula that contained more malt and no sugar was used to evaluate the legume supplementary values because it generally produces less crust browning, thereby preserving availability of more of the important vitamins, amino acids, and other nutrients.

MATERIALS AND METHODS

Samples

A commercial, straight-grade bakers' flour with good loaf volume potential, medium mixing time, and medium oxidation requirement was used. Mung and garbanzo beans were obtained locally (Moscow Food Co-op, ID).

Germination

Mung and garbanzo beans were steeped for 12 hr at 25°C in excess water, which was changed after 4 and 8 hr. After steeping, the legumes were germinated for 60 additional hr (three days total) in a control cabinet (23°C, 100% rh) that provided automatic rinsing and draining every 2 hr, as described by Hsu et al (1980).

Milling

Whole garbanzo beans were air-dehydrated from about 15 to 11% moisture (45°C, 3 hr) before being ground into flour using a Hobart grinder, whereas whole mung beans were milled on a Buhler experimental mill to a straight-grade flour of 87% extraction. Germinated whole garbanzo and germinated and hand-decoated mung beans were frozen and freeze-dried to a moisture content of about 3.5%, pulverized into flour with a Hobart grinder, and then stored (−20° C) until analyzed or formulated into breads.

Analytical Procedures

Moisture and protein contents of the wheat (N × 5.7) and legume (N × 6.25) flours were determined by AACC methods (1962). Yeast-gas production from slurries of wheat, germinated or ungerminated legume, and wheat-legume flour (15% substitution) was determined on the Gasograph (Rubenthaler et al 1980). Mixograms (10 g) were prepared as described by Finney and

[1]Scientific Paper No. 6198, College of Agriculture Research Center, Washington State University, Pullman, WA 99164.

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Shogren (1972) on wheat flour and wheat-legume flour combinations. Amino acid levels were determined on hydrolysates with a Beckman automatic amino acid analyzer by the method of Hubbard et al (1982) and were expressed in grams per 100 g of amino acids recovered.

Breadmaking

Breads were produced from 100 g of flour with legume flours formulated by replacing 5, 10, 15, or 20% of the wheat flour (14% mb). The straight-dough formula included 7.6% fresh baker's yeast, 1.5% NaCl, 0.6% of the water-solubles from a commercial malted barley (50 dextrinizing units [DU]/g, 20° C) or 6% sucrose and 0.3% malt water extract, 3% shortening (Crisco) and 75 ppm ascorbic acid and variable amounts (optimum) of $KBrO_3$ as oxidizing agents. Baking data reported are the mean of two to ten individual bakes. Bread-making procedures are described in detail elsewhere (Finney et al 1976, Magoffin et al 1977).

RESULTS AND DISCUSSION

Germination

After three days of germination (including 12 hr of steeping), garbanzo beans lost 6.7% dry weight because of respiration. Mung bean dry weight loss during germination was not calculated.

Milling

An 86.8%-extraction mung cotyledon flour was produced by a Buhler experimental mill. Third-reduction flours from the milling and remilling of the "bran" after Hobart grinding were discarded because they contained significant amounts of mung seed coat. Whole garbanzo flour was produced without difficulty by Hobart grinding (open 10 units) and regrinding (closed setting).

Protein and Amino Acids

The protein content of ungerminated and germinated mung cotyledon was 30.74 and 32.89, respectively, and that of whole garbanzo flours was 21.87 and 22.86 (dry basis). Increases in protein are attributable primarily to the reduction in the carbohydrate fraction resulting from three days of germination.

No dramatic changes in amino acid composition of whole garbanzo- or mung cotyledon-flour occurred after three days of germination (Table I). Although legumes are generally low in sulfur-containing amino acids, mung and garbanzo are particularly low in cystine (0.25 and 0.84%, respectively) but somewhat higher in methionine (1.69 and 1.72%, respectively) as compared to yellow pea, lentil, and faba bean, which all have about 1.75% cystine and 1.15% methionine (Hsu et al 1980).

Mixograph

The mixograms of the legume-wheat flour blends are shown in Figs. 1 and 2. Blends of up to 15% mung cotyledon- and 20% whole garbanzo-flour had similar mixograph development times and about the same apparent dough strength (width and height of line at mixograph peak) as the 100% control baker's flour. Numbers below mixograms denote quantity of water. Increasing levels of ungerminated and germinated mung and garbanzo flours decreased mixograph hydration by 1.3 and 1.5%, and 3 and 1.5%, respectively (Figs. 1 and 2).

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

	Control (Bakers' Flour)	Whole Garbanzo[b] Ungermi-nated	Whole Garbanzo[b] Germi-nated	Decoated Mung[c] Ungermi-nated	Decoated Mung[c] Germi-nated
Protein (db)	11.67	21.87	22.86	30.74	32.89
Lysine	2.03	7.35	7.14	7.64	7.13
Histidine	1.99	3.80	3.76	4.41	4.47
Ammonia	5.42	2.70	2.82	3.23	3.52
Arginine	3.05	11.21	10.98	10.01	9.71
Aspartic acid	3.58	11.13	10.79	11.27	11.54
Threonine	2.43	3.66	3.54	3.43	3.20
Serine	4.75	5.37	5.14	5.51	5.20
Glutamic acid	32.46	16.09	15.91	17.77	16.97
Proline	13.75	4.24	4.12	7.17	6.83
Cystine	2.90	0.84	0.74	0.25	0.20
Glycine	3.20	4.00	3.85	3.70	3.34
Alanine	2.65	4.11	4.26	4.19	3.92
Valine	3.85	4.82	5.07	5.49	5.74
Methionine	1.54	1.72	1.62	1.69	1.62
Isoleucine	3.01	4.36	4.35	4.38	4.46
Leucine	6.39	7.36	7.22	8.04	7.64
Tyrosine	2.39	2.97	3.09	3.31	3.20
Phenylalanine	4.53	5.87	5.71	6.03	5.95

[a] Expressed in grams per 100 g of amino acids recovered.
[b] Whole ground on Hobart coffee grinder.
[c] Milled to 86.8% on the Buhler experimental mill.

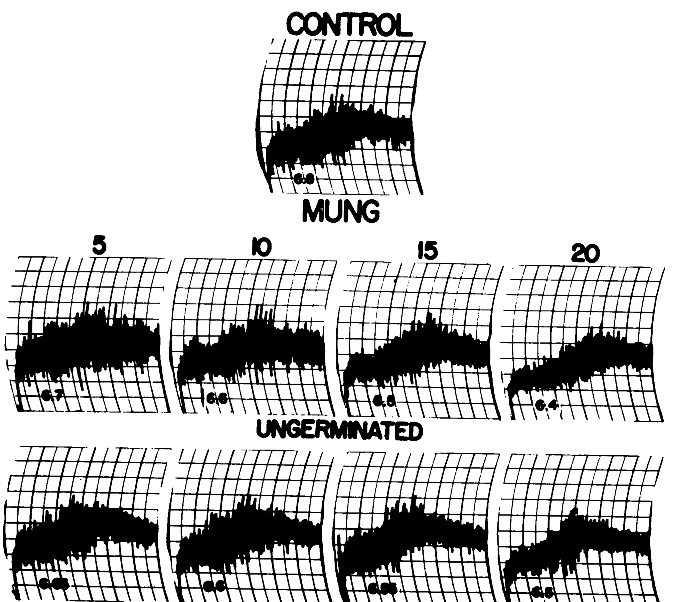

Fig. 1. Mixograms (10 g) of commercial control flour with 5,10,15, or 20% germinated or ungerminated decoated mung cotyledon flour added on replacement basis. Water absorption values appear under the mixograms.

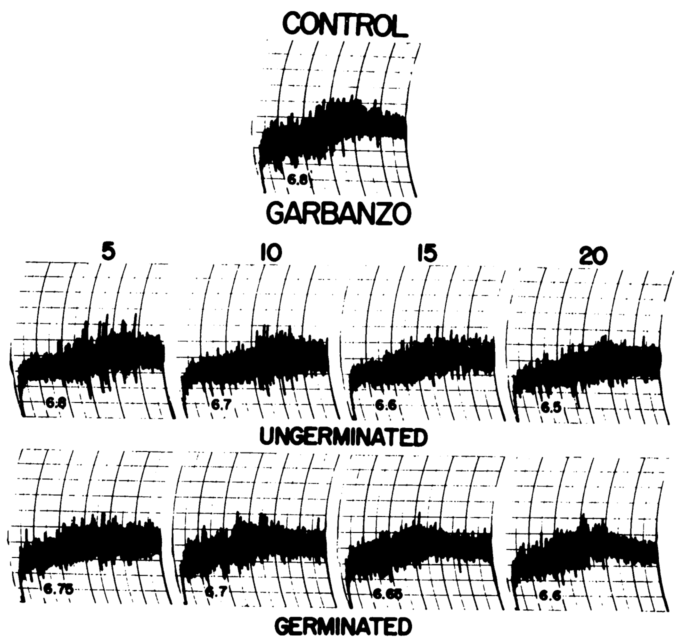

Fig. 2. Mixograms (10 g) of commercial control flour with 5, 10, 15, or 20% germinated or ungerminated whole garbanzo bean flour added on replacement basis. Water absorption values appear under the mixograms.

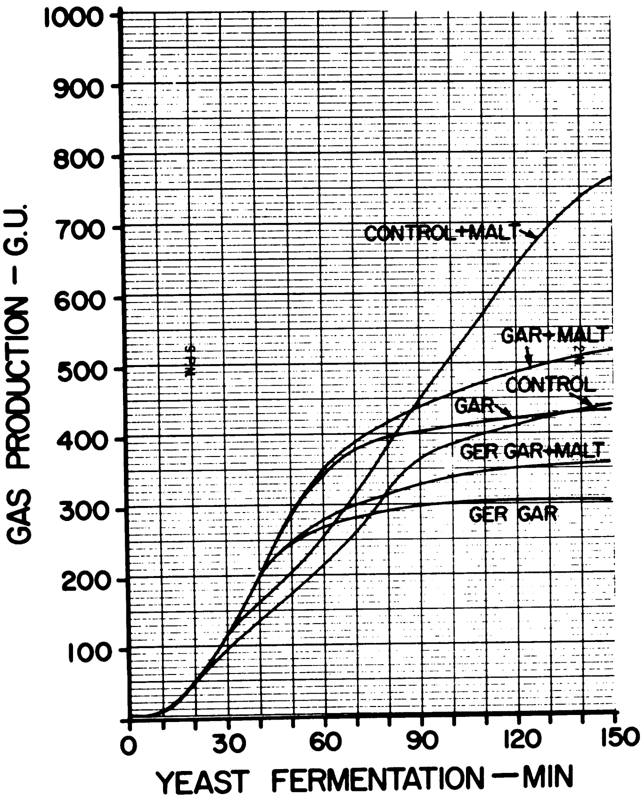

Fig. 3. Gas production (gasograph units, G.U.) by yeast (7.6%) in slurries of control flour and germinated or ungerminated whole garbanzo bean flour, all with 150% water, with or without 0.6% diastatic malted barley (50 dextrinizing units/g, 20° C), fermented at 30° C.

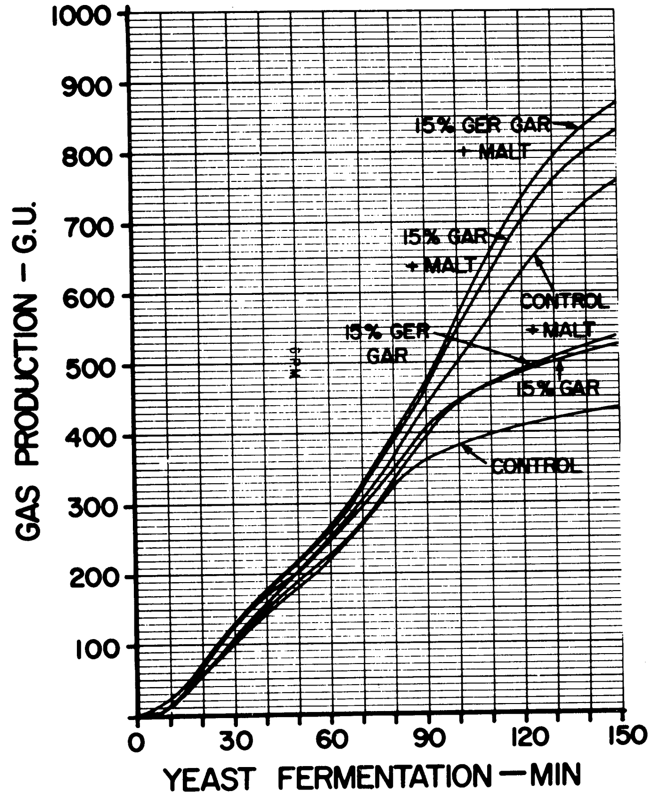

Fig. 5. Gas production (gasograph units, G.U.) by yeast (7.6%) in slurries of control flour with and without 0.6% 50 dextrinizing units of malt and control flour with 15% replacement of germinated or ungerminated garbanzo bean flour, all with 150% water and fermented at 30° C.

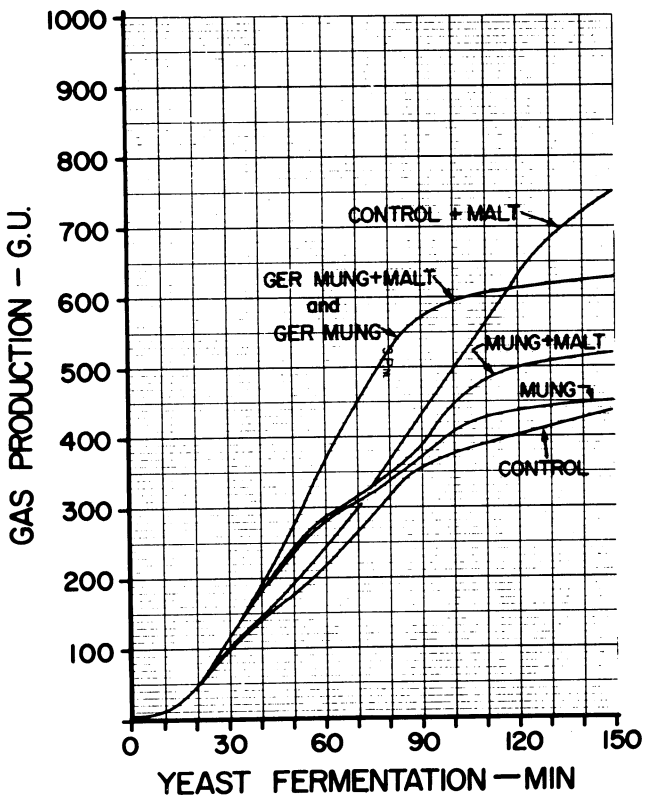

Fig. 4. Gas production (gasograph units, G.U.) by yeast (7.6%) in slurries of control flour and germinated or ungerminated, decoated mung bean flour all with 150% water, with or without 0.6% diastatic malted barley (50 dextrinizing units/g, 20° C), fermented at 30° C.

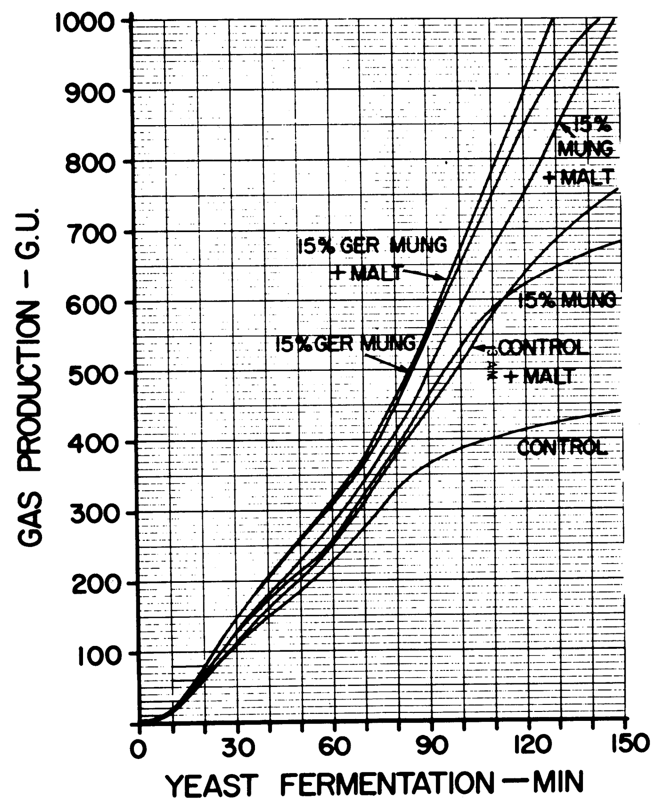

Fig. 6. Gas production (gasograph units, G.U.) by yeast (7.6%) in slurries of control flour with and without 0.6%, 50 dextrinizing units of malt and control flour with 15% replacement of germinated or ungerminated, decoated mung bean flour, all with 150% water and fermented at 30° C.

Yeast Gas Production

Whole garbanzo, mung, and the control flour produced approximately 450 gasograph units (GU) of gas after 150 min of fermentation. Addition of malt (0.6 g or 50 DU/g, 20°C) moderately increased gas production of both legume flours and approximately doubled the control flour (Figs. 3 and 4). Germination increased mung-gas and decreased garbanzo-gas production. In studies by Rodriguez-Bujan et al (1974), garbanzo beans germinated for 72 hr lost 15% dry weight, which was attributed to the reduction in carbohydrates from 69 to 53%. Garbanzos retained most of their 6.5% lipid content whereas soluble sugars were essentially depleted after 18 hr of germination and then rose steadily thereafter.

Others reported large increases in garbanzo amylase activity by 48 hr of germination, which reached maximum at 120 hr. Soluble sugars increased beginning 16 hr after water imbibition began, whereas starch content dropped rapidly after 72 hr of germination (Fernandez-Tarrago et al 1978). Because garbanzo beans in our study germinated far less (6.7% rather than 15%) than those in the Rodriguez-Bujan study, the reduction in garbanzo flour gas production after germination is understandable.

When 15% of the wheat flour was replaced by the germinated or ungerminated legume flour, mung was a significantly more effective yeast-gas producer than garbanzo (Figs. 5 and 6).

Breadbaking

Preliminary breads were baked with whole mung bean flour replacing 5, 10, 15, and 20% wheat flour. Even the 5% level was judged unsuitable because of distinct "bitter-beany" flavors. Germination heightened off-flavors and further impaired loaf volume and crumb grain (data not reported). For that reason, and because of the color imparted to the breads from the seed coat, a mung cotyledon flour was prepared as described.

Increasing levels of decoated mung flour to more than 5% decreased loaf volume directly and relatively gradually. No sugar formula depressed loaf volume for all mung flours and for levels tested with a 20% level, reducing volume about 20%. Germination materially reduced loaf volume; 20% depressed it about 45% when formulated with no sugar (Fig. 7).

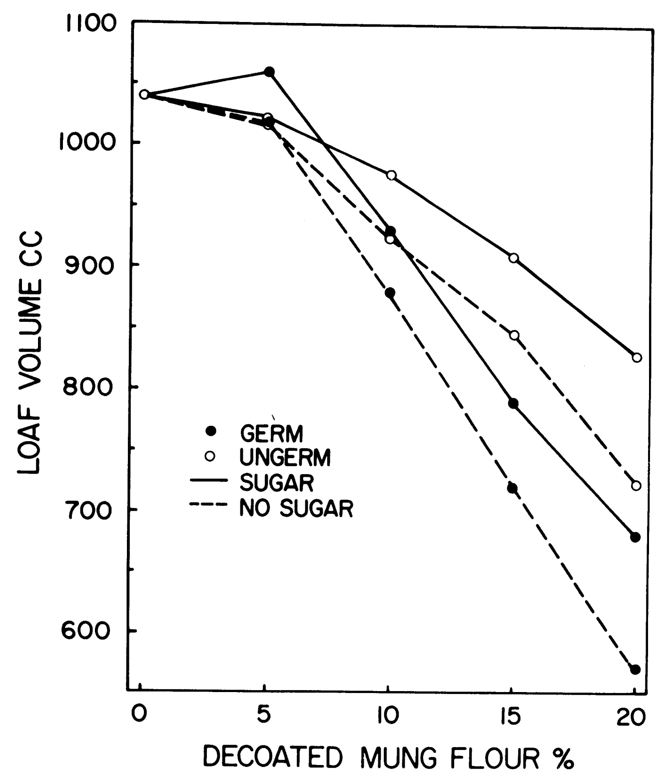

Fig. 7. Loaf volume of sugar and no-sugar breads using a straight grade commercial bakers' (control) flour replaced with 5, 10, 15, or 20% germinated or ungerminated, decoated mung flour.

The whole garbanzo flour reduced loaf volume and other bread properties above 5% replacement level more gradually than dehulled mung; 20% reduced loaf volume about 16% (Fig. 8). Germination preserved garbanzo bread properties but imparted a slightly sweet taste at the 20% replacement level. Garbanzo breads were equal to or better than mung bean breads when formulated with no sugar. Crumb grain for both legume flours and all levels tested are presented in Table II; $KBrO_3$ requirements are shown in Table III.

Bread crusts generally darkened with increasing levels of legume replacement. Breads formulated with germinated legume flours were invariably slightly darker than with ungerminated. In addition, breads formulated with 6% sugar were darker at all replacement levels than when formulated with no sugar (data not presented). The darkest breads were sugar-formulated with 20% of either germinated legume flour.

Thus, whole garbanzo flour performed better than mung and perhaps all previously studied legumes by producing as much or more loaf volume as yellow pea and faba bean, performing as satisfactorily as the faba bean after germination, and producing a bread as tasty as or slightly tastier and sweeter than other legumes tested. In addition, the garbanzo bean does not require decoating,

TABLE II
Effect of Legume Replacement Level and $KBrO_3$ (ppm) on Crumb Grain of Breads[a]

Supplement		Replacement Level (%) 5	10	15	20
Garbanzo	G[a] Su	S	S	S	Q-S
	G~Su	VS	S	S	Q-S
	UG Su	···	S	S	Q-S
	UG~Su	S	S	S	Q-S
Mung	G Su	S	Q-S	U	U^3
	G~Su	S	Q-U	U^3	U^6
	UG Su	S	VS	Q-S	Q-U
	UG~	S	Q-S	Q-U	U

[a]All treatments received 75 ppm ascorbic acid.
[b]G = germinated, UG = ungerminated, Su = sugar, ~Su = no sugar, S = satisfactory, VS = very satisfactory, Q = questionable, U = unsatisfactory.

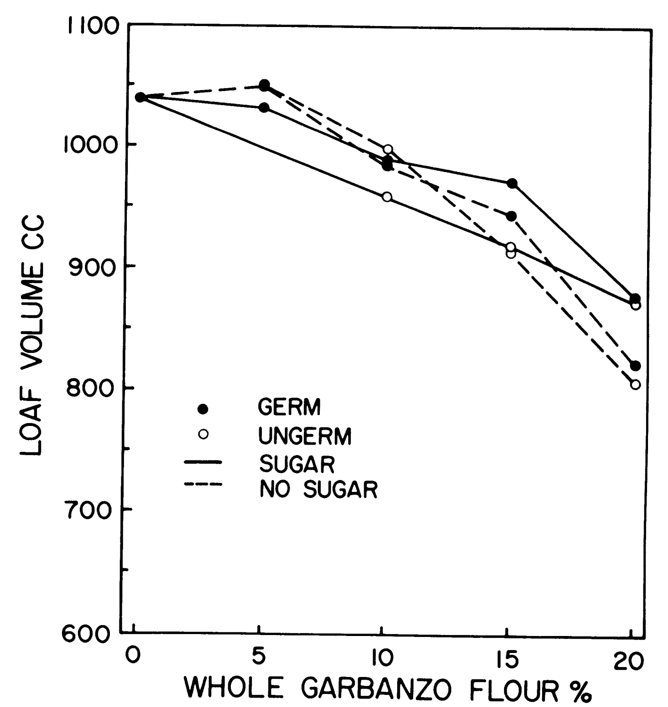

Fig. 8. Loaf volume of sugar and no-sugar breads using a straight grade, commercial bakers' (control) flour replaced with 5, 10, 15, or 20% germinated or ungerminated whole garbanzo bean flour.

TABLE III
Effect of Legume Replacement Level on $KBrO_3$[a] Requirement[b]

Supplement		Replacement Level (%) 5	10	15	20
Garbanzo	G[c] Su	2.5	5	10	30
	G~Su	2.5	5	10	30
	UG Su	···	10	10	20
	UG~Su	5	10	15	20
Mung	G Su	10	15	20	30
	G~Su	10	15	20	30
	UG Su	10	20	25	30
	UG~Su	5	15	30	25

[a] Ppm, flour basis.
[b] All treatments received 75 ppm ascorbic acid.
[c] G = germinated, UG = ungerminated, Su = sugar, ~Su = no sugar, S = satisfactory, VS = very satisfactory, Q = questionable, U = unsatisfactory.

as do faba bean, mung bean, and lentil.

Other studies have shown that germinated mung and garbanzo caused less flatus in animals than the ungerminated ones (Jaya et al 1979). Numerous vitamins increased during germination of pulses, including mung and garbanzo beans. Chattopadhyay and Banerjee (1953) found that the rat feeding value of mung bean increased from 1.72 to 2.05 (casein 1.95) after two days of germination. Both germinated and ungerminated garbanzo-rice or garbanzo-wheat blends improved protein efficiency ratio, but clear differences attributable to germination were not found by Jaya and Venkataraman (1979a). Mathur et al (1964, 1965, 1968) found that garbanzo reduced serum cholesterol in man and rat. They believed that isoflavones and *p*-coumaric acid possess the hypocholesterolemic activity. Others found that garbanzo and mung were effective in lowering cholesterol levels in rats; germinated beans were still more effective (Jaya and Venkataraman 1979b). In a summary comparing more than 25 edible legumes, garbanzo flours had the highest average protein efficiency ratio and ranked among the best in percent biological value and percent coefficient of true digestibility (Kuppuswamy et al 1958).

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[Received March 2, 1981. Accepted April 27, 1982]