Z. Ernährungswiss. **20**, 200–207 (1981)
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ISSN 0044-264 X

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Cooking-quality of broad-bean varieties as influenced by some physicochemical measurements

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(Received February 25, 1981)

Introduction

The role of broad bean (Vicia faba) as a traditional food item in diets of our population is well recognized. It serves as the major source of the protein intake of humans at all ages, and is widely accepted as a common protein source in Egypt especially for the low income groups. The evaluation of the protein quality of broad bean received considerable interest (1, 2).

There is little information available in the literature regarding the methods for predicting the cooking-quality of broad bean varieties grown in Egypt.

It is now recognized that the plant breeder needs simple tests that might help him in his efforts to produce new lines and varieties of broad bean, not only with acceptable field and harvesting characteristics but also with cooking and processing-behaviour that needs specific consumer requirements.

Good correlation has been reported between the cooking-quality of dry peas and their content of phytic acid (3, 4).

On the other hand, starch comprises approximately 45 % of dry broad bean, and viscosity measurements have been used to characterize starch and starch-containing materials.

Therefore the phytic acid content as well as the viscosity and gelatinization characteristics along with measurements of water absorption during the cooking-process have been used to account the differences in cooking-behaviour of the broad bean varieties in this study. Moreover, the protein contents and the amino acid composition of broad bean varieties in relation to their cooking-quality are evaluated in this investigation.

Experimental

Source of samples

Dry broad-bean samples were obtained from 1979 crop of the experimental plots of Legume Research Section, Agricultural Research Centre, Giza (Egypt). Moisture content of the samples was 9–10 % since more than 13 % moisture deteriorated of texture and flavor occurred (5). The varieties tested were Giza 1, Giza 2, Giza 3, Giza 4, Rebaya 40, Family 402, Family 424, and Hybrid 90/1966/72. Part of the samples were hand-cleaned and weighed and their seed coats were removed by hand and the percentage of the seed coat and cotyledon fractions were calculated. Another part of the samples was ground into fine flour and subjected for analysis.

Gelatinization and viscosity measurements

The broad-bean flour was subjected for the gelatinization and viscosity measurements using Barbender amylograph according to the official methods (6). For the complete curve, a 19 % slurry was prepared, and the temperature of the suspension is raised at a constant rate of 1.5 °C/min from temperature 20 °C to 95 °C. Gelatinization temperature was estimated with the range of ± 0.5 °C and peak viscosity in Barbender Units (B.U.), which was reproducible to ± 30 B.U.

Analytical methods

Total Kjeldahl nitrogen was determined (7) from which protein contents were calculated by multiplying using the factor 6.25. Total free amino acids were determined by ninhydrin colorimetric method (8) using Spekol spectrophotometer for the absorbance reading at 570 nm. The phytic acid phosphorus was determined by colorimetric method (9) using the same spectrophotometer for the absorbance reading at 480 nm.

Amino acid content in dry broad bean varieties of variable cooking-quality were determined by hydrolyzing with HCl 6 N (10). The hydrolyzate was evaporated under vacuum till almost dryness, then dissolved in HCl 0.1 N containing 12.5 % sucrose and analyzed for amino acid contents with Technicon amino acid analyzer (11). The Technicon standard mixture of 2.25 U mole each of amino acids was used in calibrating the 75 cm and 0.62 cm diameter column. The average reproducibility of recovery obtained for the 17 amino acids was 100 ± 3 %. Results were expressed as g amino acid per 16 g N, which amounts the same as expressing the results as percent of the protein content.

Cooking-quality

The softness of the cooked seeds was measured after 20 g seeds had been cooked for a standard time (8 h) by immersing in 200 ml boiling water in 500 ml beakers. The softness of the cooked seeds was measured by finger-pressing (12) and the soft seeds were calculated as percentage of the total seeds. The percentage of the water absorption was calculated from the weight of cooked seeds per the weight of raw seeds (13). The color intensity of the liquor after cooking in boiling water was measured by the same spectrophotometer at 620 nm (12). The total solids of this liquor was determined by evaporating an aliquot at 105 °C till constant weight. The cooking-time was taken as the number of minutes required for softness of the seeds (10 g) after they had been immersed in 60 ml water in 200-ml beakers and autoclaving at 120 °C at which the percentage of the water absorption was calculated as before.

Results and discussion

Weight ratio and degree of milling

Broad bean Giza 2 had higher degree of milling than other varieties, whereas Rebaya 40 had the lower degree of milling. This was indicated by the lower yield of seed coat fraction and higher cotyledon fraction of Giza 2 (table 1). It was reported that the decoated seeds of broad bean contained higher protein and amino acid contents than the whole seed (14). This was confirmed by the findings of Marquardt et al. (15), who stated that low protein and high fiber as well as tannin contents were present in the seed

Table 1. Weight ratio of dry broad-bean varieties.

Variety	Seed coat %	Cotyledon %	Variety	Seed coat %	Cotyledon %
Giza 1	14.02	85.98	Rebaya 40	16.69	83.31
Giza 2	12.50	87.50	Family 402	14.59	85.41
Giza 3	14.15	85.85	Family 424	15.10	84.90
Giza 4	14.79	85.21	Hybrid 90/1966/72	14.88	85.12

coat of broad bean. A thermolabile growth inhibitor has been isolated from this fraction (16, 17). Consequently, the nutritional benefits of variety Giza 2 are higher than the other varieties, whereas those of Rebaya 40 variety are the lower. Recently, addition of the cotyledon flour produced acceptable Balady bread and improved its nutritive value (18).

Physicochemical measurements

The gelatinization and viscosity measurement of 8 broad-bean varieties along with some chemical analysis are presented in table 2. In general, these varieties indicated a narrow range of their gelatinization temperatures (67.5–70.5 °C). These values were not correlated with the protein contents of the same samples. These results are in good agreement with other investigators (19, 20), who reported that gelatinization temperatures were not significantly correlated with protein and amylose contents of milled rice flour. Conversely, the peak viscosity indicated a wide range among the tested varieties (160–420 B.U.), which were generally not significantly correlated with protein content. This relationship had been observed also on milled rice flour with different protein contents (20).

Protein contents of broad-bean varieties ranged from 24.42 to 28.61 % (table 2). These protein levels are of the same order of magnitude as levels reported by other investigators (1, 14, 21).

Table 2. Physicochemical measurements of dry broad-bean varieties.

Variety	Protein % (Nx 6.25)	Free amino acids mg/100 g	Phytic acid phosphorus %	Gelatinization temp. (C)	Peak viscosity (B.U.)[a]
Giza 1	25.27	20.0	[b]	67.5	220
Giza 2	24.42	10.0	0.42	67.5	160
Giza 3	24.77	25.0	0.47	67.5	300
Giza 4	28.61	68.7	0.53	69.0	260
Rebaya 40	25.27	16.0	0.89	70.5	420
Family 402	25.64	12.5	[b]	69.0	200
Family 424	28.61	22.5	0.47	70.5	220
Hybrid 90/1966/72	26.96	16.0	[b]	67.5	240

[a]) Brabender unit
[b]) Undetermined

The total free amino acid data indicates a wide range among the tested varieties (from 10 to 68.7 mg/100 g sample).

The phytic acid phosphorus data indicates a wide range among the tested varieties from 0.42 to 0.89 %. Less amounts were found in Giza 2, Giza 3, and Family 424 and more amounts were found in Rebaya 40.

Cooking-quality

Cooking-quality characteristics of eight broad-bean varieties are presented in table 3, 4. Data of table 3 indicated that after cooking in boiling water for 8 h all the seeds of Giza 2 were soft and absorbed more water as well as their liquid after cooking contained more amount of total solids and more color intensity. Less values of all these characteristics were obtained for the other varieties, and low values for Rebaya 40. Similar observations were obtained after cooking by autoclaving (table 4). The cooking-time for Rebaya 40 was longer than that of other varieties (table 4). The total solids and the color intensity of the liquid after cooking increased as the cookability was increased, which might be due to leaching out components from the seeds during cooking process. These results are in good agreement with those of Batcher et al. (22), who reported that variations were recorded in starch and total solids in the residual cooking-liquids of rice, which were apparently due to varietal factors.

It is apparent that maximum cooking-quality is related to phytic acid phosphorus and seed coat contents. Giza 2 variety with the lowest contents of phytic acid phosphorus, and seed coat contents had excellent cooking-quality, whereas other varieties with more contents of these factors had variable cooking-quality. Conversely, Rebaya 40 variety with the highest contents of these factors had less cooking-quality (tables 1, 2, 3, 4). The results are substantiated by other investigators (3, 4), who found a good correlation between the cooking-quality of dry peas and their phytic acid content. Moreover, Finney et al. (18) reported that the seed coats of broad bean are relatively highly heat-processed before eaten. The lignin and alphacellulose contents of seed coats as well as the cotyledon cell walls seem to be important properties for the cooking-quality of pulses (23). The cooking-quality was negatively correlated with the protein content and amino acid composition (tables 2, 3, 4, 6). Similar observations have been reported for the Egyptian rice (20), Indica, and Japonica rice (13). Muller (23) stated that no indications have been found for an influence of cell contents such as protein and starch grains of pulses on their cooking-quality. On the other hand, it is clear that maximum cooking-quality is positively correlated with peak viscosities (tables 2, 3, 4). Giza 2 variety with the lowest level of peak viscosity had excellent cookability, whereas other varieties with more levels of the peak viscosity had variable cookability. Rebaya 40 variety with the highest peak viscosities had less cookability.

Conversely, cooking-quality was not significantly correlated with gelatinization temperatures (tables 2, 3, 4).

The results of cooking-quality were associated by water absorption at room temperature (tables 3, 4, 5). The seeds of Giza 2, which gave excellent cooking-quality, absorbed more quantity of water at room temperature for 4 hours than did the other varieties with exception of Family 402. Rebaya

Table 3. Cooking-characteristics of dry broad-bean varieties after 8 h in boiling water.

Variety	Soft seeds %	Water absorption %	Liquor after cooking		Variety	Soft seeds %	Water absorption %	Liquor after cooking	
			T.S.[1]	C.I.[2]				T.S.[1]	C.I.[2]
Giza 1	86	182.2	7.06	96	Rebaya 40	45	178.4	4.53	84
Giza 2	100	201.7	8.26	98	Family 402	100	200.0	7.43	94
Giza 3	96	196.8	7.75	92	Family 424	96	191.6	7.89	94
Giza 4	92	183.6	7.82	94	Hybrid 90/1966/72	96	184.8	7.84	94

[1]) Total solids
[2]) Color intensity

Table 4. Cooking-characteristics of dry broad-bean varieties after autoclaving at 120 °C.

Variety	Cooking-time (min)	Water absorption %	Total[a]) solids	Variety	Cooking-time (min)	Water absorption %	Total[a]) solids
Giza 1	75	95.9	6.74	Rebaya 40	105	86.7	4.29
Giza 2	75	154.0	9.34	Family 402	75	127.7	7.65
Giza 3	75	101.9	7.42	Family 424	90	110.9	8.01
Giza 4	75	95.9	7.81	Hybrid 90/1966/72	75	110.3	7.42

[a]) of the liquor after cooking

Table 5. Percentage water absorption of dry broad-bean varieties at room temperature for 4 hours.

Variety	Water absorption %	Variety	Water absorption %
Giza 1	55.0	Rebaya 40	41.5
Giza 2	65.5	Family 402	68.0
Giza 3	61.5	Family 424	51.5
Giza 4	44.0	–	–

40, which gave minimum cooking-quality, absorbed the lowest amount of water under the same conditions. Moreover, good correlation was found between the water absorption at room temperature for 4 hours and the water absorption during the cooking-process (tables 3, 4, 5).

Amino acid content

Amino acid data for broad-bean varieties of variable cooking-quality indicated a narrow range with exception of aspartic acid and glutamic acid (table 6). The tested varieties contained at least 17 amino acids, and the

Table 6. Amino acid patterns for dry broad-bean varieties of variable cookability as compared with provisional FAO amino acid patterns (g/16 g N).

Amino acid	Variety and its degree of cookability			FAO (1957) provisional pattern
	Giza 2 (maximum)	Giza 1 (medium)	Rebaya 40 (minimum)	
Aspartic acid	10.34	11.68	12.90	–
Threonine[a])	4.32	4.16	3.84	3.02
Serine	3.62	3.36	3.84	–
Glutamic acid	13.36	14.56	10.37	–
Proline	3.84	3.68	3.30	–
Glycine	3.44	3.28	3.20	–
Alanine	3.62	3.89	3.10	–
Valine[a])	3.94	4.26	3.46	4.54
Cystine	0.50	0.83	0.96	–
Methionine[a])	0.67	0.64	0.82	2.42
Isoleucine[a])	3.02	3.36	2.94	4.54
Leucine[a])	6.50	6.72	6.42	5.15
Tyrosine	3.04	3.20	3.10	–
Phenylalanine[a])	4.10	4.48	3.46	3.02
Lysine[a])	6.42	6.72	6.77	4.54
Tryptophan[a])	[b])	[b])	[b])	1.51
Histidine	2.11	2.24	2.37	–
Arginine	8.67	8.16	7.41	–
Protein %	24.42	25.27	25.27	

[a]) Essential amino acid
[b]) No value available

predominant amino acids were found to be aspartic acid and glutamic acid, whereas the other amino acids were found in variable amounts. Similar observations were stated by other investigators (14, 21). Rebaya 40 contained lower value of glutamic acid than the other tested varieties. From the results shown in tables 2, 3, 4, 6, it could be concluded that the amino acid patterns were negatively correlated, not only with gelatinization temperatures and peak viscosities, but also with cookability.

The nutritional value of the broad-bean protein generally showed that it is deficient in methionine, and isoleucine, compared with the provisional reference of amino acid patterns of the Food and Agricultural Organization of the United Nations (24) (table 6).

Conclusion

There is little information available in literature on methods for predicting the cooking-quality of broad-bean varieties. It is now recognized that the plant breeder needs tests for the factors to guide him in his efforts to produce new lines and varieties of broad bean, not only with acceptable field and harvesting characteristics but only with cooking and processing-behaviour that meets specific consumer requirements. It can be concluded from our study that broad-bean varieties with low content of phytic acid phosphorus and seed coat along with low value of peak viscosity are chemical and physical tests, which are associated with certain preferred cooking and processing-characteristics such as soft seeds, which absorbed more water as well as the liquid after cooking contained more amount of total solids and more color intensity. Moreover, the water absorption of raw seeds was correlated to the water absorption of cooked seeds as well as their cookability.

Summary

Cooking and processing-characteristics of eight Egyptian dry broad-bean varieties were studied along with some of their chemical and physical tests. Good correlation was found between their cooking-quality and their contents of seed coat and phytic acid as well as their amylograms. Seeds of Giza 2 variety contained the lowest contents of seed coat and phytic acid phosphorus and showed the lowest peak viscosity, which were associated with excellent cooking and processing-characteristics. The cooked seeds of this variety were soft and absorbed more water as well as the liquid after cooking contained more color intensity. Other tested varieties contained more of these chemical and physical tests, which were associated with variable cooking and processing-characteristics. Conversely, Rebaya 40 variety contained the highest contents of these chemical and physical tests, which were associated with less cooking and processing-characteristics. Moreover, the water absorption of the raw seeds was correlated to the water absorption of cooked seeds as well as their cookability in the tested varieties. The cooking-quality was not significantly correlated with gelatinization temperatures, protein content and amino acid composition. The amino acids were determined quantitatively by the amino acid analyser, and the predominant amino acids were found to be aspartic acid and glutamic acid, whereas the other acids were found in variable amounts. The nutritional value of broad-bean protein, generally, showed that they are deficient in methionine and isoleucine, compared with the provisional reference of amino acid pattern of the Food and Agricultural Organization of the United Nations.

Key words: broad bean, cookability, physicochemical measurements

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