Klavons, J. A.; Bennett, R. D. "Nature of the Pectin Constituent of Commercial Lemon Juice Cloud". *J. Agric. Food Chem.* **1987**, *35*, 159–161.
Krop, J. J. P.; Pilnik, W. "Effect of Pectin Acid and Bivalent Cations on Cloud Loss of Citrus Juice". *Lebensm. Wiss. Technol.* **1974**, *7*, 62–63.
Lee, H. S.; Nagy, S. "Quality Changes and Nonenzymic Browning Intermediates in Grapefruit Juice During Storage". *J. Food Sci.* **1988**, *53*, 168–172.
Marshall, M.; Nagy, S.; Rouseff, R. L. "Factors Impacting on the Quality of Stored Citrus Fruit Beverages". In *The Shelf Life of Foods and Beverages*; Charalambous, G., Ed.; Elsevier: New York, 1986.
Meydav, S.; Saguy, I.; Kopelman, I. "Browning Determination in Citrus Products". *J. Agric. Food Chem.* **1977**, *25*, 602–604.
Nomura, D. "The Manufacture of Natsudaidai Juice. The Mechanism of Browning". *J. Ferment. Technol.* **1955**, *33*, 494–498.
Nordby, H. E.; Nagy, S. "Processing of Oranges and Tangerines". In *Fruit and Vegetable Juice Processing Technology*, 3rd ed.; Nelson, P. E., Tressler, D. K., Eds.; Avi: Westport, CT, 1980.
Petrus, D. R.; Nagy, S. "Spectrophotometric and Spectrofluorometric Characterization of Orange Juices and Related Products". In *Instrumental Analysis of Foods and Beverages*; Charalambous, G., Inglett, G., Eds.; Academic: New York, 1984; Vol. 2.
Rouseff, R. L.; Fisher, J. F.; Nagy, S. "HPLC Separation and Spectral Characterization of Browning Pigments in Canned and Glass-Packed Grapefruit Juices". 38th Annual Citrus Processors Meeting, Lake Alfred, FL, Oct 1987a; Abstract.
Rouseff, R. L.; Fisher, J. F.; Nagy, S. "HPLC Separation and Spectral Characterization of Browning Pigments in Canned and Glass-Packed Grapefruit Juices". 194th National Meeting of the American Chemical Society, New Orleans, LA, Sept 1987; American Chemical Society: Washington, DC, 1987.
Scott, W. C.; Kew, T. J.; Veldhuis, M. K. "Composition of Orange Juice Cloud". *J. Food Sci.* **1965**, *30*, 833–837.
Varsel, C. "Citrus Juice Processing as Related to Quality and Nutrition". In *Citrus Nutrition and Quality*; Nagy, S., Attaway, J. A., Eds.; ACS Symosium Series 143; American Chemical Society: Washington, DC, 1980.
Wolfrom, M. L.; Naoki, K.; Derek, H. "Factors Affecting the Maillard Browning Reaction between Sugars and Amino Acids. Studies on the Nonenzymic Browning of Dehydrated Orange Juice". *J. Agric. Food Chem.* **1974**, *22*, 796–800.

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Effect of Processing on the Phytic Acid Content of Bengal Grams (*Cicer arietinum*) Products

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The effect of processing on the phytic acid content of brown and white varieties of Bengal grams (*Cicer arietinum*) has been studied. Soaking, boiling, roasting, and frying invariably result in the loss of phytic acid. Loss of phytic acid in presoaked grams increases with resting time. The loss during the soaking and resting period of presoaked grams may be attributed to enzymic activity. Immature brown grams contain much less phytic acid than dried mature brown grams, but the loss of phytic acid on boiling and roasting is greater in the former than in the latter. Soaking of white grams in sodium bicarbonate solution reduces the loss of phytic acid on soaking and heat treatments.

Legumes contain a significant amount of phytic acid (Makower, 1970; Thompson and Erdman, 1982; Chen and Pan, 1977; Chang and Schimmer, 1977). These are used as traditional supplements to staple cereals in Pakistan as a source of good-quality proteins. A wide variety of legumes known as pulses are grown in Pakistan. Bengal gram (*Cicer arietinum*) is the most commonly used legume. It is consumed as a curry or in snack foods.

Phytic acid has antinutritional properties because of its ability to chelate several metals and thereby reduce their bioavailability, resulting in mineral deficiencies and various diseases (Harrison and Mellanby, 1939; Reinhold et al., (1973). It is decreased significantly during the processing of cereals and legumes (Beal and Mehta, 1982; Harland and Harland, 1980).

Previously the effect of processing on the phytic acid content of wheat products has been reported (Khan et al., 1986). This paper deals with the effect of processing on the phytic acid content of Bengal grams (both brown and white varieties) for the preparation of various traditional food products.

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EXPERIMENTAL SECTION

Materials and Methods. *Description of Products. Brown Grams. Boiled Grams.* The grams were cleaned and soaked overnight in water. The water was drained off, and the grams were boiled in fresh water until they become soft enough to be eaten. These are consumed as such or mixed with boiled, peeled, and sliced potatoes after spicing with salt, chillies, lemon, etc. These are also used in the preparation of curry with or without meat and fried rice.

Roasted Grams. The grams were cleaned and roasted in a sand bath until the outer skin (hulls) split. These are consumed both with or without hulls as a snack food.

Presoaked and Roasted Grams. The grams were soaked in water overnight. The water was removed, and the grams were covered with moist muslin cloth. The grams were roasted in sand/salt bath after an interval of 2–6 h. These are consumed after the sand and salt particles are rubbed off.

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Table I. Phytic Acid Content (% mfb)[a] of Brown and White Varieties of Bengal Gram

sample description	moisture, %	phytic acid, %
whole brown gram	9.56	1.22
hulls	0.80	0.20
dehulled brown gram (Dal chana)	10.20	1.32
whole white gram	12.25	0.80
hulls	1.10	0.07
dehulled white gram	12.40	0.97

[a] mfb = moisture-free basis.

Table II. Changes in Phytic Acid Content (% mfb)[a] of Brown Grams (Whole) during Processing for the Preparation of Various Products

type of processing	moisture, %	phytic acid, %	diff in phytic acid	% loss on processing
	9.56	1.22		
boiling in water	38.44	0.92	0.30	24.59
roasting	8.15	0.78	0.44	36.07

[a] mfb = moisture-free basis.

Immature Grams (Cholia). The grams were consumed as raw fresh immature grams after being removed from the pods.

Roasted Immature Grams. The immature grams in pods and after removal from the pods were roasted in salt/sand bath for about 2–3 min. The pods were split, and the grams were removed and consumed as such.

Cooked Immature Brown Grams. The immature grams are removed from pods and cooked as a vegetable alone or in combination with meat. In the present studies, these were fried alone without spices in edible oil for 2 min, water was added, and the mixture was boiled until they became soft enough to be eaten. Boiling time usually varies from 15 to 20 min.

Boiled Immature Brown Grams. The immature grams were removed from the pods and boiled for about 15–20 min in water until they became enough to be eaten.

White Grams. Boiled White Grams. The grams were soaked in water and 2% sodium bicarbonate solution for 4 h. The water and bicarbonate solution were drained off. The grams were washed to remove bicarbonate and were boiled in fresh water until they became soft enough to be eaten. These are consumed just like boiled brown grams.

Fried White Grams. The boiled white grams were fried alone in edible oil for 2 min, water was added, and the mixture was boiled for 5 min.

All the reagents used were of analytical grade. A Hitachi spectrophotometer, Model No. 2205, was used for spectrophotometric readings. Bengal grams were purchased from the local market.

Phytate phosphorus was determined by the method of Wheeler and Ferrel (1971), as described earlier (Khan et al., 1986). The phytic acid values as shown in Tables II–V are based on single determinations.

RESULTS AND DISCUSSION

Table I shows that the phytic acid content of brown bengal gram is more than that of white variety.

Table II indicates that phytic acid losses during boiling and roasting of brown grams were 24.59% and 36.0%, respectively.

Table III shows the effect of soaking, resting period of presoaked grams, and roasting on the phytic acid content of brown grams. The same quantity (100 g) of the presoaked grams was roasted in sand/salt bath after an interval of 2 h for the same time (6 min). It is evident that during soaking phytic acid is reduced by 18.18%, which is in contrast with the results reported by Sutardi and Buckle (1985) on soaking soybeans during preparation of tempeh. Phytic acid is further reduced during resting period and roasting. The loss during soaking and the resting period may be attributed to the activity of phytase enzyme. The presence of this enzyme has been reported in legumes (Chang, 1967; Singh and Sedeh, 1979). It has also been reported that during germination of legumes the phytase activity is increased with the concomitant decrease in phytate (Eskin and Wiebe, 1983; Beal and Mehta, 1985).

Table IV shows the changes in phytic acid content during processing of white Bengal grams. Soaking white grams in water for 4 h resulted in reduction of phytic acid by 12.5%, and boiling the presoaked grams increased the loss of phytic acid to 25.0%. Frying of the presoaked and boiled grams further increased the loss to 37.5%.

The grams are usually soaked in sodium bicarbonate solution and/or boiled in the presence of sodium bicarbonate, which reduces the cooking time. The grams were therefore soaked for 4 h in sodium bicarbonate solution (2.0%). The bicarbonate solution was drained off, and the grams were washed and boiled in fresh water. The loss of phytic acid has been significantly reduced due to soaking in bicarbonate solution. Reduction in loss of phytic acid during Nan making and preparation of Iranian flat bread in the presence of sodium bicarbonate has been reported (Khan et al., 1986; Faridi et al., 1983).

The immature brown Bengal grams are cooked like vegetables alone or with meat. The immature grams are also consumed as such or after roasting in pods in sand/salt bath.

Table V includes the changes in phytic acid content of immature brown grams during processing. The phytic acid content of immature grams is much less than that of dried brown grams and is significantly reduced on boiling, frying, and roasting.

Comparison of Tables II and V shows that the loss of phytic acid on boiling and roasting is greater in immature grams than in dried brown grams.

Table III. Changes in Phytic Acid Content (% mfb)[a] after Soaking and Roasting Presoaked Brown Bengal Grams after Different Intervals

			before roasting			after roasting		
sample description	resting time, h	moisture, %	phytic acid, %	diff in phytic acid	% loss	phytic acid, %	diff in phytic acid	% loss
whole		9.60	1.10					
soaked	0	32.15	0.97	0.13	11.82	0.90	0.20	18.18
	2	32.15	0.91	0.19	17.27	0.80	0.30	27.27
	4	32.15	0.87	0.23	20.91	0.78	0.32	29.09
	6	32.15	0.85	0.25	22.73	0.75	0.35	31.82

[a] mfb = moisture-free basis.

Table IV. Changes in Phytic Acid Contents (% mfb)[a] during Processing of White Bengal Gram

sample description	moisture, %	phytic acid, %	diff in phytic acid	% loss of phytic acid on processing
whole white grams	12.25	0.80		
soaked white grams in water	29.60	0.70	0.10	12.50
soaked, boiled	35.12	0.60	0.20	25.00
soaked, boiled, fried	22.05	0.50	0.30	37.50
soaked in $NaHCO_3$	28.50	0.40	0.06	7.50
soaked in $NaHCO_3$, boiled	36.00	0.70	0.10	12.50

[a] mfb = moisture free-basis.

Table V. Changes in Phytic Acid Content (% mfb)[a] of Immature Brown Bengal Grams during Preparation of Various Products

sample description	moisture, %	phytic acid, %	diff in phytic acid	% loss on processing
immature grams	24.14	0.15		
immature boiled grams	32.82	0.06	0.09	60.00
fried	21.78	0.07	0.08	53.33
roasted on sand/salt bath	19.14	0.08	0.07	46.66
roasted in pods in sand/salt bath	20.32	0.09	0.06	40.00

[a] mfb = moisture-free basis.

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Registry No. $NaHCO_3$, 144-55-8; phytic acid, 83-86-3.

LITERATURE CITED

Association of Official Agricultural Chemists. *Official Methods of Analysis*, 10th ed.; AOAC: Washington, DC, 1965.
Beal, L.; Mehta, T. O. *J. Food. Sci.* **1985**, *50*, 96.
Chang, C. W. *Cereal Chem.* **1967**, *44*, 129.
Chang, R. *J. Food Sci.* **1977**, *42*(4), 1098.
Chang, R.; Schimmer, S. *J. Food Biochem.* **1977**, *1*, 45.
Chen, L. H.; Pan, S. H. *Nutr. Rep. Int.* **1977**, *16*, 125.
Eskin, N. A. M.; Wiebe, S. *J. Food Sci.* **1983**, *48*(1), 270.
Faridi, H. A.; Finney, P. L.; Rubenthaler, G. L. *J. Food Sci.* **1983**, *48*(6), 1654.
Harland, B. F.; Harland, J. *Cereal Chem.* **1980**, *57*(3), 226.
Harrison, D. C.; Mellanby, E. *Biochem. J.* **1939**, *33*, 1660.
Khan, N.; Zaman, R.; Elahi, M. *J. Agric. Food Chem.* **1986**, *34*, 1010.
Lolas, G.; Markakis, P. *J. Food Sci.* **1977**, *42*(4), 1094.
Makower, R. W. *Cereal Chem.* **1970**, *47*, 288.
Reinhold, J. G.; Lahmigarzadeh, A.; Nasr, K. J.; Hedayat, H. *Lancet* **1973**, *1*, 283.
Singh, B.; Sedeh, H. G. *Cereal Chem.* **1979**, *56*, 26.
Sutardi; Buckle, K. A. *J. Food Sci.* **1985**, *50*, 260.
Thompson, D. B.; Erdman, D. B., Jr. *J. Food Sci.* **1982**, *47*, 513.
Wheeler, E. L.; Ferrel, R. E. *Cereal Chem.* **1971**, *48*, 312.

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Quantitative Structure–Activity Relationships of Photosystem II Inhibitory Anilides and Triazines. Topological Aspects of Their Binding to the Active Site

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We analyzed the quantitative structure–activity relationship for inhibition by meta- and para-substituted anilides and 2-chloro-4,6-diamino-*s*-triazines with sterically different substituents of photosystem II. The results showed that the acyl moiety of anilide compounds and the smaller of the two amine substituents of triazines have features in common in their interaction with the receptor. The steric demands for the meta substituent of anilides and another amine substituent of the triazines were also common. On the basis of these findings and the knowledge that their binding to chloroplasts is competitive, we drew a receptor map that makes visible the structural correspondence between the two series of compounds when bound at the common active site.

Functional binding to spinach chloroplasts of structurally congeneric inhibitors of photosystem (PS) II, anilides, ureas, and carbamates, and chemically different triazines is competitive at a common site (Mitsutake et al., 1986). Studies of the quantitative structure–activity relationship (QSAR) have given a single common equation for the anilide type of compounds, indicating that their modes of action are identical or almost so. In this study, we extended the QSAR study to explore the steric mode of interaction of anilides and structurally different triazines in detail with compounds having various steric dimensions. The analyses were done for the PS II inhibitory activity examined by virtue of DCIP (2,6-dichlorophenolindophenol) reduction, and the results revealed the structural correspondence of the two structures when bound at the common active site. Figure 1 shows the generic formulas of the compounds studied.

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MATERIALS AND METHODS

Chemicals. The syntheses or sources of **A1–A5, A8, A9, A12, A14, A16–A20, A22–A26, A33, A34, A36–A38, T1–T6, T10–T15, T17–T23, T25, T26, T28, T29, T37,** and **T38** were reported before (Mitsutake et al., 1986). The rest of the anilides were prepared for this study, mostly by the addition of an acid chloride in dry benzene to a DMF solution of an appropriately substituted aniline and

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