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Effect of Varieties and Processing Methods on Phytic Acid and Protein Digestibility of Groundnut (*Arachis hypogaea* L.)

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Processed groundnuts (cultivar 'Florunner', 'US No. 1)' by boiling, water- and steam- blanching and roasting, and other varieties (viz, 'TP 171-2', 'TP 172-2', 'TP 175-3', 'TP 175-6', 'TP 178-1', 'TP 18-3', 'TX AG-3', and 'RMP-12') were analyzed for protein, phytic acid, total phosphorous, nitrogen solubility and *in vitro* protein digestibility (IVPD). Phytic acid of nine varieties varied from 2.89 to 3.96 mg/g indicating significant differences among varieties. The IVPD values of these varieties ranged from 66.8 to 77.5% with mean being 70.9%. There was a significant negative correlation between phytic acid and IVPD of these varieties. Removal of seed coat in the present study did not reveal noticeable differences in phytic acid, whereas it considerably influenced nitrogen solubility and IVPD values. Processing methods reduced the phytic acid of groundnut and effect was more pronounced in boiling process (wet-heating) followed by blanching processes. Dry-heating (roasting) considerably reduced IVPD of groundnut, whereas it did not show any noticeable effect on phytic acid.

Over the past years, major attention has been directed to the uses of oilseeds as cheaper yet adequate protein foods. In addition to being a good source of oil, peanut also called groundnut (*Arachis hypogaea* L.) is used as human food in various forms. Boiling, blanching and roasting processes are commonly employed for converting raw groundnut into consumable form. Nutritional quality of groundnut proteins has been the subject of several studies in the past and this subject has been periodically reviewed[1-3]. Raw and heat processed groundnut flours were found to have higher trypsin inhibitors and lectins than similarly processed soy flour[4].

When consumed in excess, phytic acid can function as an anti-nutrient. Major concern is over the bioavailability of minerals such as zinc, calcium, and iron which are not readily absorbed when insolubilised as calcium phytate[5]. Phytic acid has also been linked to the inhibition of digestive exzymes such as protease[6], lipase[7], and alpha-amylases[8]. Complexing between phytate and proteins has been reported for several proteins of cereals and legumes including groundnut and this might affect the protein digestibility and bioavailability[9-11]. Information on the phytic acid content of groundnut is scanty. Therefore, the objectives of this study were : 1) to examine the variability in phytic acid content of groundnut varieties, 2) to study the effect of processing methods on removal of phytic acid, and 3) to study the relationship between phytic acid, nitrogen solubility and *in vitro* protein digestibility (IVPD) of groundnut.

Materials and Methods

Seed samples of nine varieties ('TP 171-2', 'TP 172-2', TP 175-3', 'TP 175-6', 'TP 178-1', 'TP 178-3', 'TXAG-3', 'RMP-12' and 'Florunner', 'US No 1') were obtained from Yoakum Experimental Research Station, Texas, USA. These varieties were grown in 1988 and the 'Florunner' ('US No. 1') was used as a control. Seed lots were cleaned and stored in a cold room at 4°C until used. To study the effect of processing methods, the variety 'Florunner' was used. For boiling process, about 50 g seed material was boiled in 200 ml distilled water for 30 min. Water was brought to a boiling point and then seed material was transferred to the boiling water and boiling continued for 30 min. After boiling, excess water was discarded and seeds were dried in the oven at 50°C overnight. For water-blanching, seeds were dipped in hot distilled water at 90°C for 2 min according to Ukuku *et al.*[12]. Excess water was discarded and material was dried as above. The steam-blanching was carried out at 100°C for 2 min[12]. The water- and steam-blanched samples were dried at 50°C overnight. The roasting was carried out at 165°C for 8 min in a cabinet drier (Proctor and Schwartz Inc. Horsham, PA). All processed samples were decorticated by removing the seed coat manually. Raw, processed and decorticated samples were ground using a Wiley Mill (Arthur H. Thomas Company, Philadelphia).

Moisture, protein, fat, and ash contents in the ground samples were determined using standard AOAC methods[13].

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Protein content was calculated by using the nitrogen to protein conversion factor of 5.46. Phytic acid was determined according to the method described by Wheeler and Ferrel[14]. Phytate content was calculated from the iron concentration by assuming a constant Fe: P molecular ratio of 4:6 in the precipitate. A colorimetric method using ammonium molybdate and amino naphthol-sulphuric acid reagent was used for the determination of phosphorus[15].

The nitrogen solubility was determined by employing AACC method[16] with minor modifications.

For determination of *in vitro* protein digestibility (IVPD)[17], an amount of defatted sample containing 5.0±0.1 mg N was used.

Results and Discussion

Protein content of these varieties ranged from 23.2 to 29.5 per cent showing a large variation (Table 1). There was also a large variation in 100-seed weight which ranged from 50.4 to 65.0 g. Fat content did not show much variation, as it ranged from 42.4 and 48.9 per cent with a mean of 46.1 per cent.

Phytic acid content ranged from 2.89 ('T P 178-3') to 3.96 mg/g ('T P 172-2'). Phytic acid constituted from 61.2 to 76.0 per cent of the total phosphorus (Table 1). Nitrogen solubility of these varieties ranged between 49.7 and 60.5 per cent and *in vitro* protein digestibility (IVPD) between 66.8 and 77.5 per cent, with mean being 70.9 per cent. The IVPD values are considerably lower than those reported by Anurag and Geervani[18]. The highest protein digestibility was observed in 'T P 178-3', which contained the lowest amount of phytic acid. There was a negative and significant correlation (r=-0.353**), although the magnitude of correlation was low, between phytic acid and IVPD values (Table 2). Phytic acid is reported to form a complex with proteins rendering them less soluble[10]. The results of the present study do not appear to lend support to this observation. The ability of phytic acid to complex with proteins and inhibit enzyme activity has been reported by earlier workers[6]. It appeared that phytic acid reduced the protein digestibility by interfering with protease enzymes. The formation of a complex with protein did not appear to be a strong factor in the present study as there was no noticeable negative correlation between nitrogen solubility (as an index of protein solubility) and phytic acid (Table 2). However, the present results suggest that phytic acid possibly inhibits the enzyme activity.

TABLE 2. CORRELATION COEFFICIENT BETWEEN PHYTIC ACID, NITROGEN SOLUBILITY AND *IN VITRO* PROTEIN DIGESTIBILITY (IVPD).

	Phytic acid	PA/P	N solubility	IVPD
Phosphorus (P)	0.116	−0.027	−0.192	−0.175
Phytic acid (PA)	—	0.251*	−0.071	−0.353**
PA/P	—	—	0.041	−0.235*
N Solubility	—	—	—	0.589**

*Significant at 5% level.
**Significant at 1% level.

The processing methods studied reduced the protein content to variable extents, maximum reduction being noticed in case of boiling process. This might have been due to the solubility of proteins in boiling water (Table 3). Removal of seed coat in the present study did not reveal noticeable differences in phytic acid, whereas it considerably influenced nitrogen solubility and IVPD values (Table 3). This contradicts the previously reported results on phytic acid which was significantly increased due to dehulling in dry beans[19]. Boiling resulted in a considerable (15 per cent) reduction in phytic acid. Phytic acid reduction due to roasting was less (1.2 per cent). It has been reported that 30-min autoclaving reduced the phytate content of cereals by less than 10 per cent [20]. The boiling of groundnut did not change the nitrogen

TABLE 1. MOISTURE, 100-SEED WEIGHT, FAT, PROTEIN CONTENTS, PHOSPHORUS, PHYTIC ACID, NITROGEN SOLUBILITY, *IN VITRO* PROTEIN DIGESTIBILITY (IVPD) OF GROUNDNUT

Cultivar	Moisture (%)	100-seed wt (g)	Fat (%)	Protein (%)	Phosphorus (mg/g)	Phytic acid (mg/g)	Phytic acid as % of P	N solubility (%)	IVPD (%)
TP 171-2	4.9	60.5	44.6	24.9	4.8	3.3	68.1	60.5	73.0
TP 172-2	4.8	62.3	46.3	23.2	5.4	4.0	73.9	50.0	68.5
TP 175-3	5.2	59.9	48.9	24.1	4.8	3.1	65.0	58.3	72.5
TP 175-6	5.1	59.5	46.3	24.2	4.5	3.2	71.1	52.6	72.7
TP 178-1	5.3	53.0	46.2	25.0	5.0	3.4	67.9	55.4	70.4
TP 178-3	4.8	50.4	45.3	24.7	4.6	2.9	63.4	51.5	77.5
TX AG-3	4.9	65.0	47.7	28.7	4.9	3.5	72.0	49.7	69.6
RMP-12	4.9	56.0	47.6	29.3	4.9	3.3	66.7	51.4	67.0
Florunner	4.9	50.9	42.4	29.5	5.1	3.9	76.0	50.6	66.8
Mean	5.0	57.5	46.1	26.0	4.9	3.4	69.3	53.3	70.9
SD±	0.38	1.32	0.98	0.81	0.32	0.27	1.52	1.26	2.04

1. Means of two independent determinations.

TABLE 3. EFFECT OF PROCESSING METHODS ON PROTEIN, PHYTIC ACID, NITROGEN SOLUBILITY, AND *IN VITRO* PROTEIN DIGESTIBILITY (IVPD) OF GROUNDNUT[1]

Processing	Protein (%)		Phytic acid (mg/g)		Nitrogen solubility (%)		IVPD (%)	
	a	b	a	b	a	b	a	b
Raw	29.5	30.6	3.4	3.5	50.6	53.7	66.8	70.1
Boiling	25.4	26.0	2.9	2.9	50.8	58.5	70.0	74.7
Water-blanching	27.9	28.5	3.1	3.1	50.4	52.3	69.4	77.5
Steam-blanching	29.0	29.5	3.2	3.2	49.6	50.5	68.4	72.0
Roasting	28.5	29.3	3.4	3.4	45.5	48.0	60.7	65.8
Mean	28.1	28.8	3.2	3.2	49.4	52.6	67.1	72.1
SD±	0.35	0.32	0.18	0.19	1.34	1.08	1.32	1.45

1. Means of two independent determinations.
a. With testa (seed coat)
b. Without testa

solubility, whereas it improved *in vitro* protein digestibility. McWatters and Cherry[3] reported that heat processing of groundnut flour reduced protein solubility. But in the present study, roasting decreased both nitrogen solubility and protein digestibility whereas boiling increased the protein digestibility. The observation partly disagrees with those of Anurag and Geervani[18] who reported that roasting, boiling, and frying improved the *in vitro* protein digestibility of groundnut.

To conclude, it may be mentioned that large variability existed in IVPD and phytic acid of groundnut varieties. Nitrogen solubility also showed noticeable variation among varieties. There was a significant and negative correlation between phytic acid and IVPD of groundnut implying that phytic acid would adversely influence the protein quality of groundnut. The boiling process considerably decreased the phytic acid and this might have improved the *in vitro* digestibility of groundnut.

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