HARDNESS PHENOMENON IN BEACH PEA (*Lethyrus maritimus* L.)

*Fenomena Kekerasan Biji pada Kacang Pantai (*Lethyrus maritimus *L.)*

U.D. Chavan[a], R. Amarowicz[b], and F. Shahidi[c]

[a]Associate Professor of Department of Food Science and Technology
Mahatma Phule Krishi Vidyapeeth, Rahuri, India - 413722
Phone: +91 02426, Fax: +91 0243253
[b]Institute of Animal Reproductions and Food Research of the Polish Academy of Sciences, Division of Food Science, Olsztyn, Poland
[c]Professor of Biochemistry, Memorial University of Newfoundland, St. John's, Canada
Corresponding author: uttamchavan08@gmail.com

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ABSTRACT

Beach pea is mostly grown on seashores and it contains higher amount of protein than other legumes. However, the pea has several undesirable attributes, such as long cooking time and hard to germinate (imbibitions) that limited its use as food. The present investigation aimed to study the physico-chemical properties, cooking characteristics and hull crude fibre structure of beach pea as compare to other similar legumes. Standard methods of processing pulses were used for present study. Beach pea seeds contained very low grain weight, density, hydration capacity, hydration index, swelling capacity and swelling index than the green pea and field pea. Beach pea had higher amount of crude protein, ash, crude fibre and polyphenols, but lower in starch content than the green pea and field pea. Without any treatment to beach pea seeds the water uptake capacity was very low. Mechanical treatment to beach pea seeds increased the water uptake percentage. The recovery of hull was 3 to 6 times higher in beach pea than that of green pea and field pea. The crude protein content in beach pea hull was 2-5% higher than others. The beach pea hull, dhal and whole seeds were good source of macro- and micro-minerals than that of the other two peas. The electron microscopic structure of beach pea hull crude fibre showed a very close and compact structure than green pea and field pea hull crude fibre structure. Lowering the hardness of beach pea seeds with mechanical or chemical treatments will give more scope for their utilization in the human nutrition.

[***Keywords***: Beach pea, seed hardness, imbibitions, hull structure]

ABSTRAK

Kacang pantai umumnya tumbuh di daerah pantai dan mengandung protein yang lebih tinggi dibanding kacang-kacangan lainnya. Namun, kacang pantai memiliki sifat-sifat yang kurang diinginkan, seperti waktu memasak yang lama dan penyerapan air yang rendah sehingga membatasi pemanfaatan-nya sebagai bahan pangan. Penelitian ini bertujuan untuk mempelajari sifat fisik-kimia, karakteristik masak, dan struktur serat kasar kulit kacang pantai dibandingkan dengan kacang-kacangan lain yang sejenis. Kacang pantai memiliki biji dengan kepadatan, kapasitas hidrasi, indeks hidrasi, kapasitas pemuaian, dan indeks pemuaian yang sangat rendah dibanding kacang hijau dan kacang polong. Kacang pantai memiliki jumlah protein kasar, abu, serat kasar, dan polifenol yang lebih tinggi, namun memiliki kadar pati yang lebih rendah dari kacang hijau dan kacang polong. Tanpa perlakuan, biji kacang pantai memiliki serapan air sangat rendah sehingga perlu perlakuan mekanis untuk meningkatkan persentase serapan air. Rendemen sekam kacang pantai 3-6 kali lebih tinggi dibanding kacang hijau dan kacang polong, sedangkan kandungan protein kasar pada sekam 2-5% lebih tinggi. Sekam kacang pantai, dhal, dan seluruh biji merupakan sumber mineral makro dan mikro yang lebih baik dibanding kacang polong dan kacang hijau. Struktur mikroskopis elektron serat kasar sekam kacang pantai sangat kompak dan mirip dengan kacang hijau dan kacang polong. Menurunkan kekerasan biji kacang pantai dengan perlakuan mekanis atau kimia akan memperluas pemanfaatannya sebagai sumber nutrisi bagi manusia.

*[**Kata kunci:** Kacang pantai, kekerasan biji, penyerapan air, struktur sekam]*

INTRODUCTION

Legumes are one of the world's most important sources of food supply, especially in developing countries, in terms of food energy as well as nutrients. Common legumes are a good source of proteins, vitamines and certain minerals. They do not only add to variety in the human diet, but also serves as an economical source of supplementary protein, espe-cially in under developed and developing countries. They are an excellent source of complex carbo-hydrates (El-Faki *et al*. 1984; David *et al*. 2010) and polyunsaturated free fatty acids. Dry mature legume seeds are consumed in large quantities in the Middle Eastern countries (Kuzayli *et al*. 1966; Akroyd and Doughty 1969). However, common legumes (peas and beans) have several undesirable attributes, such as long cooking times, hard to germinate (imbibi-tions), being enzyme inhibitors, phytates, flatus factors and phenolic compounds, which should be removed or eliminated for effective utilization (Aguilera and Rivera 1992; Castellanos *et al*. 1995; Martin-Cabrejas *et al*. 1995). Hardness of any pea causes more time to cook, more energy as well as less availability of the nutrients from that pea. Therefore, it is necessary to find out suitable method to overcome these hurdles by studying various treatments with these peas.

Grain quality of common peas is determined by factors such as acceptability by the consumer, soaking characteristics, cooking quality and nutritive value. Acceptability characteristics include variety of attributes, such as grain size, shape, colour, appearance, storage stability, cooking properties, quality of the product obtained and flavour. Efforts to develop technological processes are needed to transform the hard-to-cook and hard-to-imbibiate peas into edible and useful products. Several economic alternatives to utilize hard-to-cook common peas have been proposed, including dehulling, extrusion, solid state fermentation, production of protein concentrates and isolates and starch fractions (Phirke and Bhole 2000; FAO 2011; Salve *et al*. 2012).

Beach pea (*Lethyrus maritimus* L.) is a legume crop having very high potential nutritive value, but the information in the literature is very limited. This crop is not well familiar to the consumers, farmers and plant breeders. Processing treatments can reduce the hardness of the peas and make it suitable for good food. These treatments can reduce the cooking time as well as cost of processing. Such type of treated peas can be utilized for preparation of various protein rich products. The present treatments given to the peas are very simple and these can be done at home scale level to overcome the hardness of peas (Jood *et al*. 1986, 1988; Plhak *et al*. 1989; Bressani and Garcia-Vela *et al*. 1990). The present investigation was, therefore, under taken to study the effects of soaking and cooking on the physico-chemical and nutritive value of beach pea seeds as compared with the green pea and field pea seeds.

MATERIALS AND METHODS

Materials

The mature pods of beach were collected from different locations of Newfoundland, St. John's, Canada in October 2010-November 2011. The grains and pod shells were separated manually. The total fresh weight and recovery of grains and pod shells were recorded immediately after harvesting and separating, before samples were dried, ground and stored for processing and chemical analysis. Seeds of green pea (*Pisum sativum* L.) and field pea (*Lathyrus sativus* L.) were produced from Crop Science and Plant Ecology Department, University of Saskatchewan, and Agriculture Food Diversification Research Centre, Unit-100-101, Morden Canada, respectively. The seeds of beach pea were small, round, black and green coloured, green pea seeds were round, big green coloured, whereas field pea seeds were irregular in shape, off-white and wrinkled.

Methods

The processing methods employed in this study were soaking, soaking and dehulling, soaking plus cooking and direct cooking.

Soaking

Seeds of beach pea (mature, black seeds and immature, green seeds) free from dust and other extraneous materials were mechanically slightly cracked with the help of pestle and mortar. These cracked seeds and whole seeds of green pea and field pea were soaked in distilled water for 12 hours (1:4 w/v) and dried in hot-air oven at 50-55^{o}C to a constant weight.

Soaking and Dehulling

Seeds of beach pea (mature and immature) were mechanically cracked with pestle and mortar and second lot of composite seeds were soaked in concentrated sulphuric acid for 30 minutes, washed with distilled water and then soaked in distilled water for 12 hours (1:4, w/v). Green pea and field pea seeds were directly soaked in distilled water for 12 hours (1:4, w/v). After soaking all seeds were manually dehulled to separate seed coat from dhal and dried in hot-air oven at 50-55^{o}C to a constant weight.

Soaking Plus Cooking

Clean dry seeds were soaked as above in water (1:4 w/v) for 12 hours and boiled in same water for 30 minutes. The cooked seeds were dried at 50-55^{o}C to a constant weight.

Dirrect Cooking

Clean seeds were directly boiled in a volume of distilled water (1:4 w/v) up to 30 minutes and dried in a hot-air oven at 50-55°C to a constant weight.

After soaking, soaking and dehulling, soaking plus cooking and direct cooking, all seeds were removed from the water, drained, surface water removed by filter paper and then weighed for the determination of water uptake. The loss in weight was calculated by taking weights before and after different treatments. The electron-microscopic photographs of hull crude fibre were taken with the help of electron-microscope.

Chemical Analysis

Moisture, crude protein and crude fiber were determined by standard method of AOAC (AOAC 1990). For determination of mineral constituents, dried and ground samples (1-2 g) were subjected to dry ashing in well cleaned (soaked in chromic sulphuric acid solution for 48 hours followed by thorough washing with deionized water and igniting at 450°C) porcelain crucibles at 550°C in a muffle furnace. The resultant ash was dissolved in 5 ml of $HCl/H_2O/HNO_3$ (2:3:1, v/v/v) and warmed on a hot plate until brown fumes disappeared. To the remaining content in each crucible, 5 ml of deionized water were added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask by filtering through a whatman No. 42 filter paper and volume made up to the mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrophotometry.

The concentration of elements (Ca, Na, K, Mg, Mn, Zn, Fe, Cu, Li, Al and Si) in each solution, prepared as described above was determined using a PerkinElmer 8650 atomic absorption spectrophotometer (PerkinElmer Co., Montreal, PQ). Calibration curves of absorbance values versus concentration of each element at appropriate concentrations (to obey Beer's-Lambert Law) was constructed using their respective standards of 1,000 µg l^{-1} (Fisher Scientific, Unionville, ON). A path length of 10 cm was used and concentration of each element in sample was calculated as mg 100^{-1} g of dry matters. Phosphorus content of the digest was determined colourimetrically according to the method described by Nahapetian and Bassiri (1979). To 0.5 ml of the diluted digest, 4 ml of demineralized water, 3 ml of 0.75 M H_2SO_4, 0.4 ml of 10% (w/v) $(NH_4)_6Mo_7O_{24}.4H_2O$ and 0.4 ml of 2% (w/v) ascorbic acid were added and mixed. The solution was allowed to stand for 20 minutes and absorbance reading was recorded at 660 nm. The content of P in the extracts was determined using standard curve obtained for KH_2PO_4 and expressed as mg P per 100 g of sample.

Tristimulus colour parameters, namely Hunter L (100, white; 0, black), a (+, red; -, green) and b (+, yellow; -, blue) values of the sample were determined by surface reflectance measurements using a Colormet colourimeter (Instrumar Engineering Limited, St. John's, Newfoundland) as described by Shahidi *et al*. (1992). The unit was standardized with a B-143 white calibration tile. Its Hunter values were L, 94.5 ± 0.2; a, -1.0 ± 0.1 and b, 0.0 ± 0.2.

All physical and chemical constituents were analyzed by using three replications. The results obtained in the present investigation were statistically analyzed by using randomized block design given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The grain weight of three pea's ranged from 25.25 to 3.01 g per 100 seeds, the lowest seed weight was in beach pea and the highest was in green pea. The density among the three varieties of peas the highest being of green pea (1.27 g cm^{-3}) and the lowest being in beach pea (0.56 g cm^{-3}). Beach pea had significantly lower grain weight and density than green pea and field pea. Hydration capacity, hydration index, swelling capacity and swelling index of beach pea were lower than those of the other two peas. Hence, it may also require more time to imbibiate (germination) and cooking, which is not useful for saving time and fuel energy. These parameters indicated that the seed of beach pea is very hard and light in weight and takes more time to cook (hard-to-cook) and imbibiate (germination).

These physico-chemical parameters noted above are playing an important role in cooking legumes. The results of the present study are lower than those mentioned by previous workers (Ojomo and Chheda 1972; Ahmed and Shehata 1982; Sharma 1989; Latunde-Dada 1991; Bishnoi and Khetar paul 1993) for other several legumes. They also noted that these parameters are very important for judging the cooking time and preference by the consumer and processors.

The preliminary results showed that when beach pea seeds were soaked in the distilled water without any treatment, they were remain as it is up to 7 days, without imbibitions, floating on the water. After that fungus growth was started. Due to this difficulty the mechanical cracking treatment to the beach pea seeds was given. These results indicate that before utilization beach pea seeds have to be given some treatments such as hot water, mechanical or chemical treatment to make their outer cover loose to imbibiate water easily and make it soft for food preparation.

The recovery of dhal and hull, the content of moisture and crude fibre, and the effect of soaking, cooking and soaking plus cooking on dhal and hull are presented in Table 1. Percentage of dhal in beach pea seeds soaked in sulphuric acid and water was higher (74.04%) than that of the mechanical cracked and soaked seeds, but the hull percentage was lower (25.96%). This may be due to acid treatment that dissolved some portions of the seed coat and increased the percentage of dhal.

Beach pea seeds contained 32-33% hull and 68-69% dhal. The ratio between dhal to hull was very low than that of green pea and field pea. Green pea contained 90.50% dhal and 9.50% hull and field pea had 95.00% dhal and 5.00% hull. Beach pea contained 20-25% less dhal recovery and 4-6% higher hull recovery as compared to the green pea and field pea.

The moisture content of beach pea dhal and hull was more than that of the green pea and field pea. The percentage of crude fibre in beach pea dhal was higher (2.46%) than that of green pea (1.40%) and field pea (1.37%), but the crude fibre content in beach pea hull was lower (35.5-36.5%) than that of green pea (50.50%) and field pea (46.61%). The results of beach pea were higher than the earlier reports, but the results of green pea and field pea are similar to the earlier workers (Watt and Merrill 1963; Kuzayli *et al*. 1966; Kadwe *et al*. 1974; Khalil *et al*. 1986; Phirke and Bhole 2000; Salve *et al*. 2012). The moisture content after 12 hour soaking was highest in beach pea than that in green pea and field pea. This was may be due to the mechanical cracking and sulphuric acid treatment to the seeds.

Field pea had whiter colour value (86.02) than beach pea (83.35) and green pea (80.87). Green pea had higher white colour value (68.20) than field pea (66.50) and beach pea (47.27). Cooking of beach pea seeds lowered the white colour value of dhal and hull. Green pea had higher green colour value than beach pea and field pea. Soaking of beach pea seeds increased yellow colour value of dhal but it then lowered due to the cooking treatment.

The effect of soaking, cooking and soaking plus cooking on water uptake, loss in weight and protein content of beach pea, green pea and field pea are presented in Table 2 and 3. Mechanically cracked, soaked and cooked seeds of beach pea absorbed more water than other peas. Directly cooked seeds absorbed very less amount of water and also had very less loss in weight. Soaking and then cooking seeds loosed more weight in field pea than beach pea

Table 1. Recovery of dhal and hulls, moisture, crude fibre content and hunter colour of different peas.

Type of pea	Recovery (%)	Moisture (%)	Crude fiber (%)	Hunter colour values		
				L	a	B
Beach pea, mature						
Dhal	69.40 ± 1.40	70.20 ± 0.57	2.46 ± 0.03	83.35 ± 0.13	-0.70 ± 0.00	20.72 ± 0.24
Hulls	30.60 ± 1.35	59.83 ± 2.81	35.54 ± 0.20	47.27 ± 0.10	1.72 ± 0.05	12.00 ± 0.10
Beach pea, immature						
Dhal	64.11 ± 1.30	68.56 ± 1.54	2.20 ± 0.05	82.82 ± 0.05	-1.05 ± 0.06	20.57 ± 0.05
Hulls	35.89 ± 1.51	60.66 ± 0.75	37.51 ± 0.18	47.60 ± 0.08	0.75 ± 0.06	12.95 ± 0.06
Soaking[1]						
Dhal	74.04 ± 1.22	67.40 ± 2.30	2.30 ± 0.06	83.92 ± 0.05	-0.97 ± 0.05	22.77 ± 0.05
Hulls	25.96 ± 0.92	61.78 ± 1.96	37.03 ± 0.70	50.40 ± 0.14	0.55 ± 0.06	13.67 ± 0.05
Cooking[1]						
Dhal	66.95 ± 1.13	64.71 ± 1.14	2.13 ± 0.60	78.52 ± 0.05	-0.77 ± 0.05	18.85 ± 0.06
Hulls	33.05 ± 1.08	55.39 ± 1.98	37.69 ± 0.32	45.95 ± 0.24	2.52 ± 0.05	11.55 ± 0.06
Green pea						
Dhal	90.50 ± 2.13	55.71 ± 0.88	1.40 ± 0.05	80.87 ± 0.05	-5.42 ± 0.10	17.05 ± 0.24
Hulls	9.50 ± 0.78	57.36 ± 1.65	50.50 ± 0.26	68.20 ± 0.08	-0.80 ± 0.00	15.67 ± 0.19
Field pea						
Dhal	95.00 ± 0.90	53.13 ± 0.90	1.37 ± 0.06	86.02 ± 0.13	0.00 ± 0.00	16.17 ± 0.05
Hulls	5.00 ± 0.85	49.65 ± 0.85	46.61 ± 0.44	66.50 ± 0.14	0.07 ± 0.14	14.10 ± 0.14

All observations are mean of duplicate analysis ± Standard deviation.

[1]Composite sample (black + green).

Table 2. Effect of soaking, cooking and soaking plus cooking on different peas.

Treatment/parameter	Beach pea	Green pea	Field pea[1)]
Control			
Moisture (%)	9.96 ± 0.29	8.20 ± 0.23	8.60 ± 0.05
Soaking			
Water uptake (%)	73.77	104.10	99.71
Moisture (%)	46.25	57.25	55.91
Loss in weight (%)	9.60	12.74	11.94
Hunter colour values			
L	74.12 ± 0.13	74.53 ± 0.06	76.26 ± 0.13
a	-1.35 ± 0.06	-3.11 ± 0.05	0.07 ± 0.05
b	14.32 ± 0.05	16.36 ± 0.21	15.13 ± 0.09
Cooking			
Water uptake (%)	43.83	57.91	48.54
Moisture (%)	34.08	38.99	36.79
Loss in weight (%)	5.19	3.66	6.10
Hunter colour values			
L	73.07 ± 0.11	78.50 ± 0.16	83.72 ± 0.13
a	-1.30 ± 0.00	-2.37 ± 0.05	-0.80 ± 0.00
b	18.42 ± 0.10	17.17 ± 0.28	17.80 ± 0.08
Soaking plus cooking			
Water uptake (%)	106.00	155.93	164.54
Moisture (%)	68.53	60.43	68.53
Loss in weight (%)	16.29	14.56	16.75
Hunter colour values			
L	64.35 ± 0.13	73.25 ± 0.06	77.30 ± 0.14
a	0.47 ± 0.05	-2.77 ± 0.05	-0.07 ± 0.05
b	16.45 ± 0.06	21.37 ± 0.25	24.65 ± 0.26

[1)]Canadian variety, ± standard deviation.

Table 3. Protein content in different pea's seed, dhal and hull.

Pea	Protein content		
	Whole seed	Dhal	Hull
Beach pea			
Mature grains	28.03 ± 1.37	38.04 ± 0.56	13.45 ± 0.42
Immature grains	29.60 ± 0.26	40.11 ± 0.34	14.55 ± 0.21
Soaking composite seeds	32.35 ± 0.60	39.76 ± 0.07	15.55 ± 0.28
Cooking composite seeds	23.09 ± 0.27	37.50 ± 0.12	19.50 ± 0.47
Green pea	23.51 ± 0.39	26.48 ± 0.41	11.64 ± 0.08
Field pea	23.64 ± 0.07	29.31 ± 0.28	9.74 ± 0.23

All observations are mean of triplicate analysis ± standard deviation.

and green pea. Directly cooked seeds of beach pea absorbed very less water and also loose less in weight. It was observed that those seeds absorbed more water; these seeds were very good for separating the hull from the cotyledons. From these all parameters it was found that the beach pea seeds were very hard-to-cook and imbibiate and it required processing treatments. Similar type of phenomenon on bean was reported by Martin-Cabrejas *et al.* (1995), Castellanos *et al.* (1995) and FAO (2011).

The colour intensity of seed flour of three peas also affected due to the processing treatments. The white colour values reduced nearly about 10 times in beach pea due to soaking and cooking treatments than the other treatments. Yellow colour values were higher in field pea and green pea due to the soaking plus cooking treatment. This indicates that browning reaction may be occurring more in these peas.

Soaking treatment increased the protein content in beach pea but it decreased due to cooking. The original protein content in seeds, dhal and hull was higher in the beach pea than that in other peas. The increase in crude protein content due to the soaking treatment may be due to the dissolution of proteins covalently bonded to starch (Sattar *et al*. 1989). Increase in protein may be due to increase in non-protein nitrogen (El-Shimi *et al*. 1984). The protein content of legumes has been shown to generally increase during soaking and germination (Kylen and McCready 1975; Hsu *et al*. 1980; Igbedioh *et al*. 1994; Khalil and Mansour 1995). The hull and dhal of beach pea had higher amount of crude protein than other peas. The protein content in beach pea immature grain dhal was highest (40.11%) and lowest in green pea (26.48%).

Mineral composition of beach pea whole seed, dhal and hull is given in Table 4. From all macro-minerals, calcium (Ca) was the most abundant in whole seed than in the hull and dhal. Potassium (K) was the major macro-mineral in hull. The Ca to P ratio was higher in hull (3.50) than that in the whole seed (1.85) and dhal (0.09). Except Ca all other macro-minerals were higher in dhal than that in the whole seed and hull, but Ca to P ratio was lowest. Except Mn all other micro-minerals were higher in dhal, mostly Al content was 37.87 mg 100^{-1} g as compare with the hull (4.18 mg 100^{-1}g) and whole seed (4.02 mg 100^{-1}g). Overall mineral content was higher in dhal than the whole seed and hull. These results showed that the whole seed as well as hull and dhal separately would constitute a valuable source of essential minerals. This study indicated that there is very minute effect and no loss in the mineral content in all three peas due to processing treatments.

The values obtained are comparable with earlier reports on legume seeds, such as the African locust bean, groundnut (Oyenuga 1968), lathyrus and medicago (Varnaite 1984), cowpea (Jagadi *et al*. 1987), review of legumes (Salunkhe and Kadam 1989) and bambara groundnut, kidney bean, lima bean and pigeonpea (Apata 1994). However, compare with the other Mexican and North American beans (Meners *et al*. 1976; D'mello *et al*. 1985; Zacharie and Ronald 1993; Barrado *et al*. 1994) all minerals were higher in seeds, hull and dhal of beach pea. Variation in the content of minerals for beach pea may be due to genetic origin, geographical source and the levels of soil fertility.

Whole seeds and hull contained higher amount of Ca than the P and this is a good correlation for ideal growth and bone formation. Sodium content was lower in whole seed, hull and dhal as compare to other macro-minerals and this is good for health because of the relationship that sodium diet has to hypertension in human (Dahl 1972). The bioavailability of iron, zinc, copper, manganese, selenium and other trace elements and their requirements to the animals and human as well explained by earlier workers (Fairweather-Tait 1992; Wenlock 1992). Zinc and copper are essential for normal life in animals and man and appear to play an important role in a large number of biological processes (Jackson and Lowe 1992; Mills 1992). Comparing the all mineral contents in beach pea seed, hull and dhal with other legumes, it is indicated that beach pea is a very good source of macro- and micro-minerals.

The electron-microscopic structure of beach peas' hull crude fibre is shown in Figure 1. Beach pea grain crude fibre structure showed very tiny tips and compact. But due to sulphuric acid treatment the compact structure became flat, soft and loose. When the seeds were directly cooked for 30 minutes then the top structure of the fibre became swollen and large. In green pea hull structure showed very

Table 4. Mineral composition of seeds, dhal and hulls of beach peas (mg 100^{-1}g).

Mineral element	Seeds	Dhal	Hulls
Macro-elements			
Calcium	144.18 ± 0.61	155.37 ± 1.13	279.69 ± 2.23
Phosphorus	413.16 ± 1.22	638.87 ± 6.17	79.78 ± 0.42
Sodium	84.14 ± 0.43	141.09 ± 8.20	165.56 ± 1.73
Potassium	475.83 ± 1.00	1166.14 ± 4.33	643.47 ± 3.12
Magnesium	179.73 ± 1.28	244.63 ± 2.45	230.47 ± 3.11
Micro-elements			
Manganese	3.50 ± 0.58	2.91 ± 0.18	4.66 ± 0.21
Zinc	2.97 ± 0.08	8.50 ± 0.78	1.93 ± 0.08
Iron	9.37 ± 0.21	17.04 ± 0.33	11.21 ± 0.40
Copper	0.85 ± 0.16	0.60 ± 0.08	0.50 ± 0.03
Lithium	0.90 ± 0.12	1.95 ± 0.17	1.66 ± 0.18
Aluminum	4.49 ± 0.29	37.87 ± 1.37	4.18 ± 0.18

All results are mean values of triplicate analysis, composite seeds of beach pea, ± standard deviation.

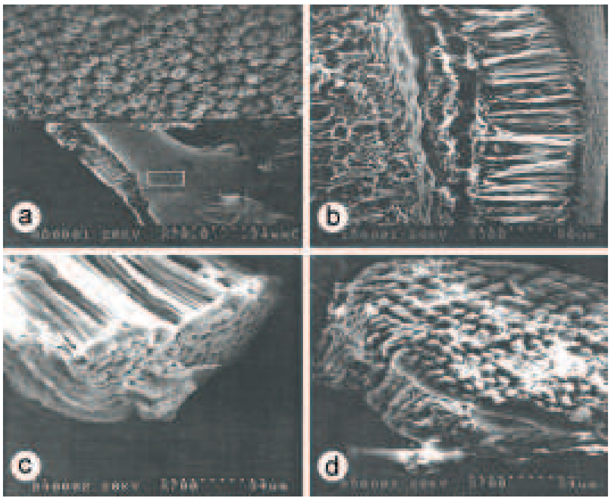

Fig. 1. Electron microscopic structure of beach pea seed coat; (a) crude fibre structure, (b) cross section of fiber structure, (c) effect of cooking treatment on crude fibre structure, (d) effect of H_2SO_4 treatment on crude fibre structure.

differently like an open flower and swollen and not compact with tiny tips. Beach pea shell might be very tight due to their genetic make up and some chemical constituents than the other peas. Due to processing, i.e. soaking and cooking, chemical treatment looses the compactness of beach pea shell and makes it soft.

CONCLUSION

Considering all physico-chemical parameters and crude fibre structure of beach pea compared with other peas, the beach pea seeds were very hard-to-cook and hard-to-imbibiate, but it has higher nutritional value. Therefore, it is necessary to study the effect of other treatments such as scarification, hot water or salt in hot water treatments on the beach pea hardness. These results indicated that before using beach pea for any type of food preparation, it should be processed with hot water or make scarification to lose the outer shell of the pea. It will help to reduce the cooking time, cost and energy as well as increase nutrient availability. Beach pea is a good source of nutrient as compare to the green pea and field pea.

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