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Effect of Domestic Processing Methods on Dry Matter, Total Sugar, Phenolics and Mineral Composition in Different Developmental Stages of *Parkia roxburghii* G. (Don.) Pods

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Abstract

Parkia roxburghii is considered delicious in the Northeastern part of India, especially in the state of Manipur. Though it is widely used, information about the biochemical composition and its changes, after processing, is hardly available. In the present experiment, effect of processing methods on dry matter, soluble sugar, phenolics and mineral composition in different developmental stages of *P. roxburghii* pods were studied. Total soluble sugar (TSS), total phenols (TP), and orthodihydric phenols (ODHP) were determined, also sodium (Na), potassium (K), sulphur (S) and phosphorus (P) were estimated. Calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn), iron (Fe), copper (Cu) and cobalt (Co) were analyzed in an atomic absorption spectrophotometer. Processing methods reduced dry matter, soluble sugar and phenolics in all the stages of the pod. TP and ODHP lost up to the extent of 72.78% in tender stage due to ordinary cooking, while higher loss of ODHP recorded in immature stage of the pod due to pressure cooking. Ca, Mg, K and Zn in different stages were found to be affected significantly by different methods of cooking, while no such changes were observed in case of S, P, Fe, Mn and Cu. The level of iron amongst the micro minerals is appreciably high recording up to 51.0 mg/100 g in the immature stage of the pod. As iron, zinc and manganese are antioxidant micronutrients, their higher presence in *P. roxburghii* might be of some nutritional importance.

Keywords: minerals, *Parkia roxburghii*, phenolics, processing methods, soluble sugar

Introduction

There are at least 3000 edible plant species known by man out of which, merely 300 crops contribute to more than 90% of the world's calorie intake, and only 120 crops are economically important on an international scale which implies that world's food security rests on a slender base of 4% of known edible plants (Cooper *et al*., 1996). Therefore, from the point of view of meeting the challenges of food security, it is necessary to widen the food base by establishing more and more new food crops.

Due to topography and climatic conditions the North-Eastern region of India is noted for its great diversity of edible plants. This is evidenced by the fact that about 40% of the total flora of the country is said to be represented in the north eastern part of India, which means an approximate number of 6000 to 7000 species. Out of these some of the plants are used as edible green vegetables, edible fruits and for other purposes. Many investigators feel that the nutritional value of the identified wild edible plants worked out, so that their contribution to human health in terms of nutrition can be recommended for the benefit of people at large scale (Barua *et al*., 2007; Kayang, 2007; Ramachandra, 2007). As the legumes are a member of the *Leguminoseae* family, *P. roxburghii* (common name: Parkia or tree bean; Local name: Yongchak) also shares some of the anti-nutritional substances, endemic to legumes (Salam *et al.*, 2010). It is important to reduce these anti-nutrients to improve the biological utilization of the plant. In India, the most important/common domestic processing and cooking methods include soaking, hulling, germination, ordinary and pressure cooking. These methods may reduce the anti-nutrients in legumes. There are a number of reports dealing with such information in the case of popular legumes, whereas no information is available regarding *P. roxburghii,* which is considered nutritious in this part of the country, especially in the state of Manipur and its adjoining areas. This paper reports part of a series of system-

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atic investigations undertaken to determine the biochemical composition of this lesser known legume (Salam *et al*., 2009; 2010; Sharma *et al*., 1993).

Materials and methods

Different stages of *P. roxburghii* pods were collected from a plant grown at Iroisemba, near the Central Agricultural University campus, and classified them into 3 groups based on the mean thickness of the pod measured at the site of seeds as tender (6 mm and below), immature (6.1 to 10 mm) and mature (more than 10 mm). All the pods were scrapped to remove the outer green peel. The margin of the pods were neatly removed with the help of a knife and cut into 10 cm (approximate) pieces. They had been divided into three groups of equal weights. Out of which, two groups had been subjected to different methods of cooking following the method of Saroj and Neelam (1994), while the third group was kept as control. All the process/cooked pods were air dried and kept in the oven at 60±5°C for 48 hours. The loss in dry matter was found out by subtracting the weight from the control and reported in percentage. The moisture free samples were then ground using a Remi grinder and subsequently sieved (1 mm). The powder samples were collected and kept for various analyses.

The ethanol extract evaporated to dryness and dissolved in a known volume of water, used for the determination of total soluble sugar, total phenols, and orthodihydric phenols as per the methods of Morris (1948), Bray and Thorpe (1954) and Mahadevan and Sridhar (1986).

Wet digestion method of Capar *et al*. (1978) was followed for the analysis of mineral elements. Sodium (Na) and potassium (K) were estimated in a systronics-105 flame photometer. Sulphur (S) and phosphorus (P) were estimated in a UV-VIS double beam spectrophotometer following the procedures described by Tandon (1993). Calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn), iron (Fe), copper (Cu) and cobalt (Co) were analyzed in a Parkin Elmer atomic absorption spectrophotometer, Analyst AA-200. Standard errors of mean differences (S. Ed±) and critical differences were calculated as per standard statistical procedures.

Fig. 1. Flowers and pods of *P. roxburghii* plant. (A) Flowering plant, (B) Inflorescence, (C) Flowers on a head/capitulum, (D) Different types of flowers (E) Plant with pods (F) Mature pods and (G) Pods being sold in the market

Results

Changes in dry matter (DM) and total soluble sugar (TSS) content in pods: DM content increased from 19.1% in tender pod to 26.7% in mature pod. Processing methods affect DM content in all stages of the pod (Fig. 2A). Pressure cooking (PC) indicated higher loss of DM recording up to 27.7% in tender stage of the pod (Fig. 2B). Similarly, TSS content increases with the age of the pod by containing 6.92 % in raw tender pod to 8.06% in the mature pod (Fig. 3A). However, the effect of processing methods was more pronounced in case of TSS recording a loss of 78.36% of TSS by PC in the mature stage of the pod (Fig. 3B).

Changes in phenolics in the pods: Total phenol (TP) decreases with the age of the pod by containing 61.42 mg/g in tender, 52.25 mg/g in immature and 37.70 mg/g in mature raw pods, which decreased to 16.72, 17.82 and 13.58 (mg/g) in ordinary cooking (OC) and to 20.10, 18.71 and 15.72 (mg/g) in PC (Fig. 4A). Different processing methods removed total phenols up to the extent of 72.78%, 65.89% and 63.98% of the original content in tender, immature and mature stages of the pod by OC and 67.27%, 64.19% and 58.30% by PC, respectively (Fig. 4B).

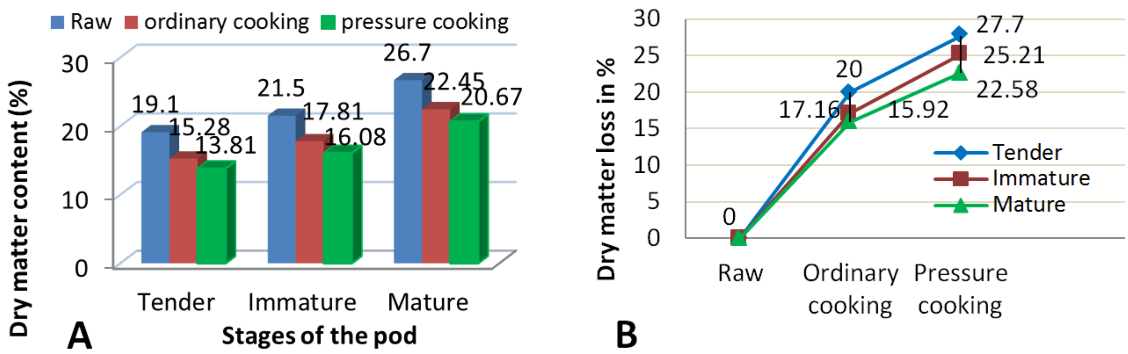

Fig. 2. Effect of different processing methods on dry matter content: (A) Bar graph showing changes in dry matter and (B) line graph showing degree of loss out of the total content in different stages of the P. *roxburghii* pods

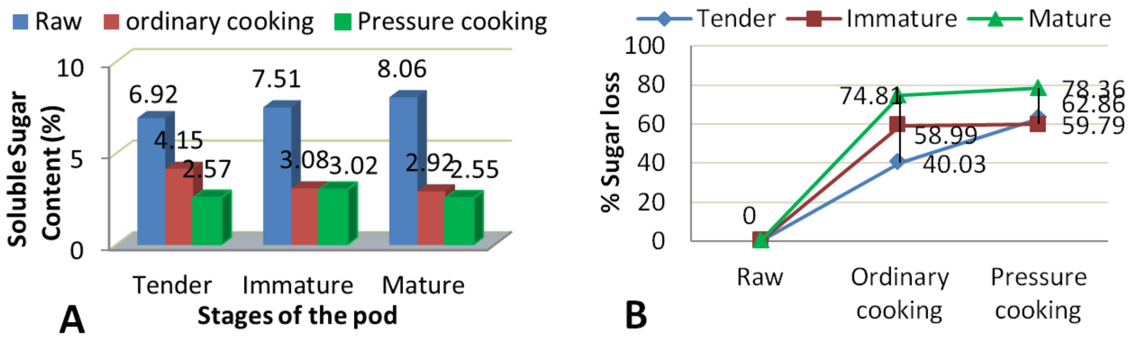

Fig. 3. Effect of different cooking methods on total soluble sugar (TSS) content in P. *roxburghii*: (A) Bar graph showing changes in TSS content and (B) line graph showing degree of loss out of the total content in different stages of the pod

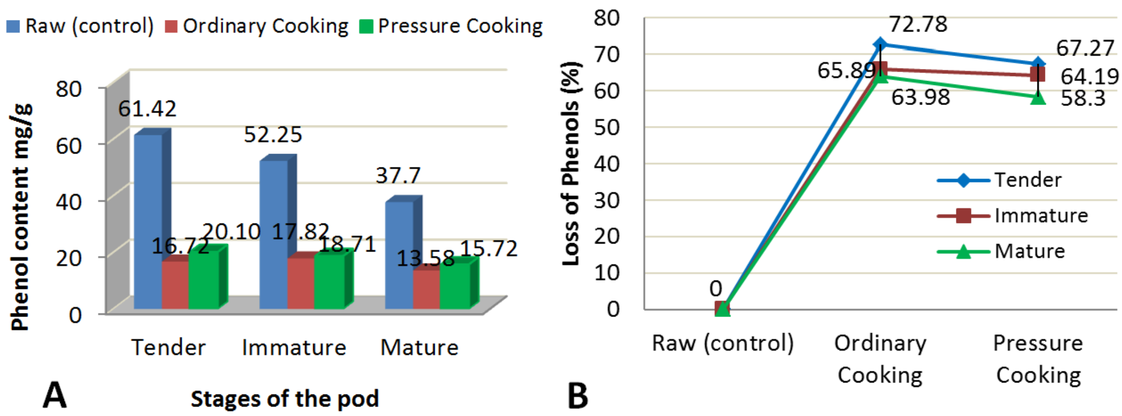

Fig. 4. Effect of different processing methods on total phenol (TP) content in P. *roxburghii*: (A) Bar graph showing changes in TP content and (B) line graph showing degree of loss out of the total content in different stages of the pod

The same trend was also observed in orthodihydric phenols (ODHP). ODHP in the raw pod decreased with the pod maturation, which decreased to 0.63, 0.54 and 0.52 mg/g in OC and to 0.74, 0.35 and 0.52 mg/g in PC (Fig. 5A). ODHP removed due to different processing methods was 81.14%, 76.21% and 51.85% by OC and 77.84%, 84.58%% and 51.85% by PC, respectively (Fig. 5B).

Changes in mineral content in the pods: Tab. 1 indicates changes in the major element composition in different stages of the pod. Ca content in raw tender (238 mg/100 g), immature (404.01 mg/100 g) and mature (398.53 mg/100 g) pods decreased to 174.02, 288.01 and 250.01 mg/100 g due to OC, while it decreased to 177.92, 328.52 and 300.52 mg/100 g due to PC. Mg and K content (226.20 and 2760 mg/100 g) in tender stage of the pod decreased to 156.20 and 2400 (mg/100 g) in ordinary cooking and to 150.0 and 2440 (mg/100 g) in pressure cooking. Similar trends were observed in immature

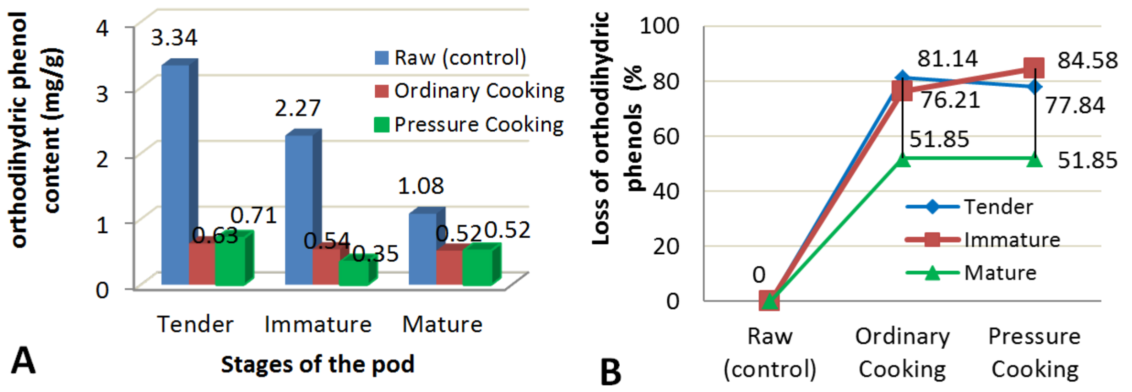

Fig. 5. Effect of different cooking methods on orthodihydric phenol ODHP) content in P. *roxburghii*: (A) Bar graph showing changes in ODHP content and (B) line graph showing degree of loss out of the total content in different stages of the pod

Tab. 1. Effect of cooking methods on major element content in different developmental stages of *P. roxburghii* pod (mg/100 g)

Major Element	Cooking methods	Stages			Mean Stages
		Tender	Immature	Mature	
Ca	Raw	238.00^{a}	404.01^{a}	398.53^{a}	346.85
	Ordinary Cooking	174.02^{b}	288.01^{b}	250.01^{b}	237.35
	Pressure Cooking	177.92^{b}	328.52^{b}	300.52^{c}	268.99
	Mean (Methods)	196.65	340.18	316.35	
Mg	Raw	226.20^{a}	302.20^{a}	231.70^{a}	253.37
	Ordinary Cooking	156.20^{b}	188.65^{b}	172.60^{b}	172.48
	Pressure Cooking	150.0^{b}	205.70^{b}	212.25^{b}	189.32
	Mean (Methods)	177.47	232.18	205.52	
K	Raw	2760.0^{a}	2740.0^{a}	2530.0^{a}	2676.67
	Ordinary Cooking	2400.0^{b}	2450.0^{b}	2430.0^{b}	2426.67
	Pressure Cooking	2440.0^{b}	2460.0^{b}	2360.0^{b}	2420.00
	Mean (Methods)	2533.3	2550.0	2440.0	
S	Raw	89.37	78.97	83.70	84.01
	Ordinary Cooking	94.56	84.17	81.57	86.77
	Pressure Cooking	76.85	83.22	78.74	79.60
	Mean (Methods)	86.93	82.12	81.34	
P	Raw	201.0	203.7	211.0	205.23
	Ordinary Cooking	188.9	190.3	169.7	182.97
	Pressure Cooking	201.2	205.1	190.3	198.87
	Mean (Methods)	197.03	199.70	190.33	

	Ca		Mg		K		S		P	
	Methods	Stages	Methods	Stages	Methods	Stages	Methods	Stages	Method	Stages
S.Ed±	17.59	17.59	18.11	18.11	55.14	55.14	4.38	4.38	7.03	7.03
CD/$_{.05}$	48.83	48.83	50.26	NS	153.08	NS	NS	NS	NS	NS
CD/$_{.01}$	80.98	80.98	83.36	-	253.88	-	-	-	-	-

Note: NS=Non-significant; Different letters in a column indicate significance at 5% level and mature stages of the pod. Ca, Mg and K in different stages were found to be affected significantly by different methods of cooking, while no such changes were observed in case of S and P. Tab. 2 indicates the changes of minor elements in different stages of the pod. Cooking methods did not affect any significant changes in respect of Fe, Mn and Cu, however, significant changes were observed in case of Zn. Zn content in tender (10.05), immature(10.15) and mature(6.18 mg/100 g) raw pods decreased to 6.10, 6.12 and 3.12 mg/100 in ordinary cooking and to 7.50, 7.13 and 6.0 mg/100 g in pressure cooking. The degree of minerals loss due to different processing methods is indicated at Fig. 6(A-I). Percent removal of Ca was 26.88% to 37.27% by OC, while it was 25.51% to 37.57% in Mg and 3.95% to 13.04% in K (Fig. 6A-C). Processing methods seemed to be less effected on S, P and Fe content of the pods (Fig. 6D-F). S and Fe content even increased due to processing methods recording a gain of 6.58% and 12.33% in OC and 5.38% and 20.54% in PC. However, the degree of loss was higher in case of Zn, Mn and Cu, recording up to 49.51%, 66.67% and 40% by OC and up to 29.75%, 33.33% and 10% by PC, respectively, in different stages of the pod (Fig. 6G-I).

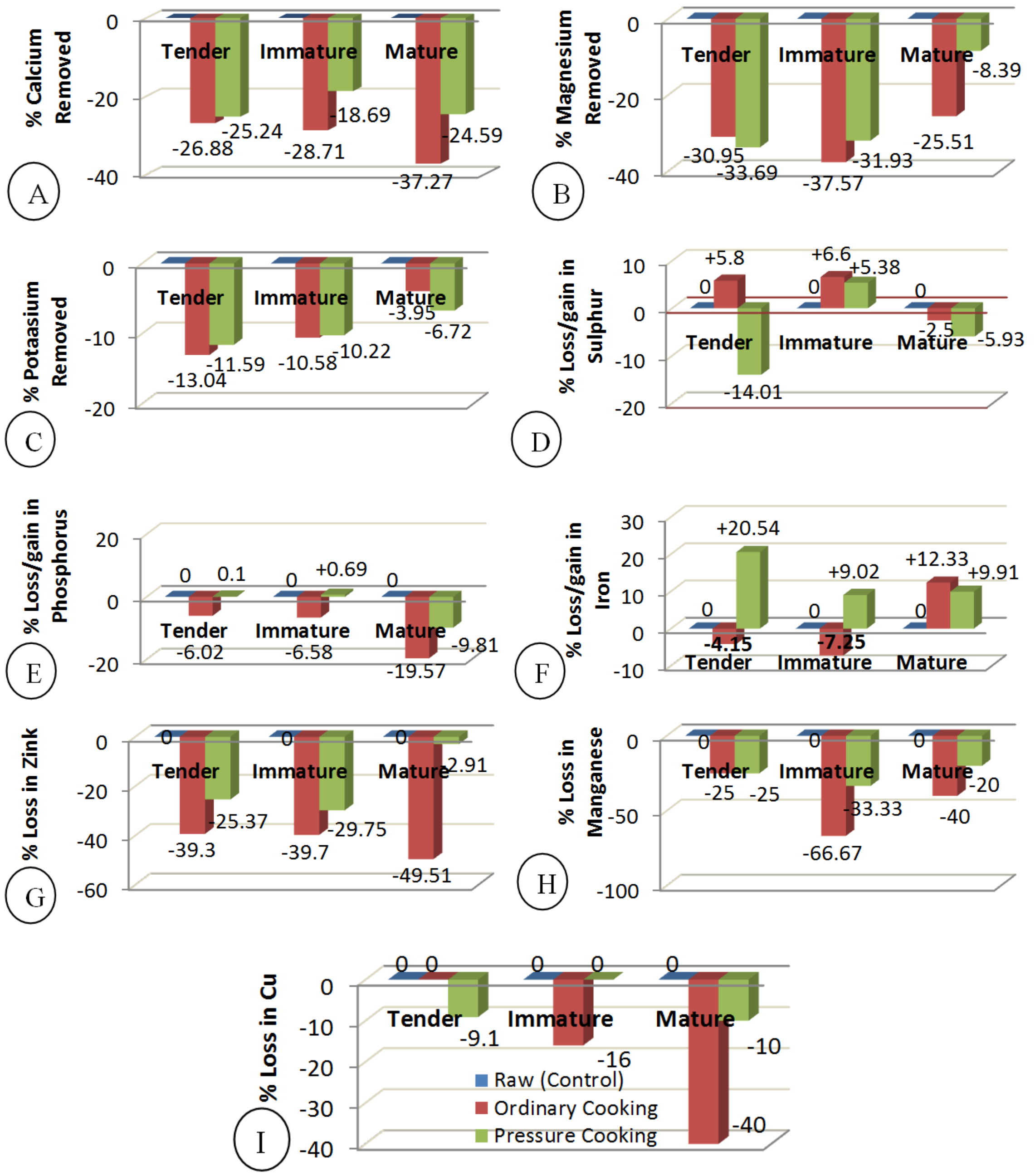

Fig. 6(A-I). Bar graph showing per cent loss/gain out of the respective total element content due to different processing methods in different stages of P. *roxburghii* pods.(A) Calcium, (B) Magnesium, (C) Potassium, (D) Sulphur, (E), Phosphorus, (F) Iron, (G) Zink, (H) Manganese and (I) Copper. (Legend: Raw (control), Ordinary cooking and Pressure cooking)

Tab. 2. Effect of cooking methods on minor element content in different developmental stages of *P. roxburghii* pod (mg/100 g)

Major Elements	Cooking methods	Stages: Tender	Stages: Immature	Stages: Mature	Mean Stages
Fe	Raw	48.2	51.0	45.4	48.20
	Ordinary Cooking	46.2	47.3	51.0	48.17
	Pressure Cooking	58.1	55.6	49.9	54.53
	Mean (Methods)	50.83	51.30	48.77	
Zn	Raw	10.05^{a}	10.15^{a}	6.18^{a}	8.79
	Ordinary Cooking	6.10^{b}	6.12^{b}	3.12^{b}	5.11
	Pressure Cooking	7.50^{b}	7.13^{b}	6.0^{a}	6.88
	Mean (Methods)	7.88	7.80	5.10	
Mn	Raw	4.0	9.0	5.0	6.0
	Ordinary Cooking	3.0	3.0	3.0	3.0
	Pressure Cooking	3.0	6.0	4.0	4.33
	Mean (Methods)	3.33	6.0	4.0	
Cu	Raw	5.5	6.0	5.0	5.50
	Ordinary Cooking	5.5	5.0	3.0	4.50
	Pressure Cooking	5.0	6.0	4.5	5.17
	Mean (Methods)	5.33	5.67	4.17	
Co	Raw	ND	ND	ND	-
	Ordinary Cooking	-	-	-	
	Pressure Cooking	-	-	-	

	Fe		Zn		Mn		Cu		Co	
	Methods	Stages	Methods	Stages	Methods	Stages	Methods	Stages	Methods	Stages
S.Ed±	2.96	2.96	0.63	0.63	1.09	1.09	0.49	0.49	-	-
CD/$_{.05}$	NS	NS	1.75	1.75	NS	NS	NS	NS	-	-
CD/$_{.01}$	-	-	2.90	2.90	-	-	-	-	-	-

Note: ND=Not detected; Different letters in a column indicate significance at 5% level

Discussion

DM and TS increased with the advancement of the pod (Fig. 2A and 3A), while TP and ODHP decreased (Fig. 4A and 5A). Processing methods reduced DM, TSS, TP and ODHP content in all the stages, the degree of loss in DM, TP and ODHP being higher before the pod matured (Fig. 2B, 4B and 5B). This may be due to the reason that as the pod advances, more and more cell walls are lignified thereby inhibiting loss due to leaching. However, contrary to this, higher loss of TSS was recorded in the mature stage of the pod indicating accumulation of water soluble sugars when the pod matured (Fig. 3B). Out of the two processes, pressure cooking increased loss of dry matter, as well as soluble sugar, which may be due to the fact that boiling at higher pressure rendered complex substances broken down into simpler units, increasing loss due to leaching. Cooking as well as autoclaving brought about slight decrease in glucose, fructose and sucrose levels and increased oligosaccharide content of all the varieties of lima bean (Ologhobo and Fetuga, 1988). Processing methods also influenced total phenolics in selected dry beans (Boateng *et al.*, 2008). Significant reductions in case of phenolics and phytic acids, due to different processing methods, were also reported (Sinha and Kawatra, 2003).

Among the elements tested, Ca and Zn were the only ones differed significantly in various stages of the pod (Tab. 1 and 2). K was found to be the most abundant mineral found in the pods, recording up to 2760 mg/100 g in the tender stage of the pod, which is followed by Ca (404.01 mg/100 g), Mg (302.20 mg/100 g) and P (211 mg/100 g), respectively (Tab. 1).

Among the micro elements, Fe (51 mg/100 g) recorded to be the most abundant element, which is followed by Zn (10.15 mg/100 g), Mn (9 mg/100 g) and Cu (6 mg/100 g) (Tab. 2). This might be of nutritional importance, especially in the part of the world where anemia and iron deficiency is relatively rampant as in the case of *P. thonningii* (Jimoh and Oladiji, 2005). Iron, zinc and manganese are antioxidant micronutrients and their high presence in *P. roxburghii* could therefore boost the immune system (Talwar *et al.*, 1989).Though, both cooking methods did not differ significantly, the degree of loss was often found to be higher in case of ordinary cooking (Fig. 6A-I). Similar findings were also reported by other researchers, which may be due to leaching of minerals on account of the enhanced permeability of the seed coat by the process of cooking (Kingsley, 1995; Meiners *et al.*, 1976). However, S and Fe increased due to processing methods, recording a gain of 6.58% and 12.33% in OC and 5.38% and 20.54% in PC (Fig. 6D and F). These results were in agreement with the reports of Chitra *et al*. (1996), who studied the effect of processing on various pulses and reported to have little effects on calcium, magnesium and iron contents. The increased in concentration of these elements may be due to complex formation at high temperature as phytic acid was reported to form an insoluble phytin compound with these elements (Thimmaiah, 2006). Such observations were also reported by Kingsley (1995). Cobalt was not detected in *P. roxburghii* pods.

Conclusion

P. roxburghii was a good source of Ca, K, P, Fe, Zn, Mn and Cu. In spite of being a leguminous plant, which was generally prone to many anti-nutritionals and toxic factors, especially more, so in the case of non-conventional legumes, parkia contains less amounts of anti-nutrients (Salam *et al.,* 2010). Due to its wide adaptability in different soils, in varied altitudes as well as due to its nutritious pods and prolong availability for use, *P. roxburghii*, if properly exploited may be a nutritious vegetable supplement for the human consumption at large.

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