Chapter 10

Summary

*Parkia timoriana*, a tree bean called “Yongchak” by the local community of Manipur is a legume consumed as popular food locally though it is uncommon to other parts of the country. Although less familiar in the larger part of the country, it is a very popular giant legume in northeast India, particularly Manipur. The entire pods are consumable irrespective of the stages of maturation. They have been substantially consumed as vegetables.

Legumes contain many antinutrients so far known to occur in foods like tannins, phytate, trypsin inhibitors, $\alpha$-galactosides, saponin, lectins, goitrogens, polyphenols, cynogenic glycosides etc. which have harmful effects on the body and is a major reason of less consumption of the legume as foods. Hence, trials on the processing for reduction of antinutrients of *P. timoriana* are necessary to improve the nutritional quality of the legume. This study was therefore undertaken to investigate the effects of processing on some nutritional and antinutritional factors in premature seed, premature pod and mature seed of *P. timoriana* by adopting economically viable and acceptable processing techniques like dehulling, water soaking, boiling, pressure cooking, germination, dry autoclaving, roasting, steaming, frying, soaking in water suspension of spices powder of jeera, coriander, ginger and turmeric, citric acid soaking and sodium bicarbonate either singly or in combination.
At the beginning of the study, different samples of *P. timoriana* such as mature whole seed (MWS), decoated mature seed (DMS), mature seed coat (MSC), premature whole seed (PWS) and premature pod (PP) were analysed for chemical composition. Comparatively higher values possessed by DMS were 26.10% crude protein (dry matter : DM), 28.89% crude fat (DM) and 810.00mg/100g total free amino acids (fresh matter : FM). PP exhibited higher value with records of 27.00% crude fibre (DM), 5320.00mg/100g reducing sugar (DM) and 180.32mg ascorbic acid/100g (FM). Higher values possessed by PWS were 99.75 μg/100g folic acid (FM), 66.39% crude carbohydrate (DM) and 8500.00 mg/100g total soluble sugar (DM) respectively. All samples could serve as good sources of minerals (Tables 2.1 and 2.2). Total soluble sugars of DMS and MWS were largely composed of non reducing sugars. However, MSC and PWS exhibited higher contents of total phenols while all other samples possessed very low levels of flavonoids relative to total phenols level. DMS and PP were noted for possessing low amounts of tannins and phytate respectively. PWS possessed lower trypsin inhibitor activity (2.75 units/mg) than DMS and mature whole seed.

The green premature seeds of the legume cannot be subjected to various processing treatments similar to mature seeds. Heat treatment methods of processing of premature seeds of *P. timoriana* usually included boiling, pressure cooking, frying and steaming and trial for searching the most effective processing method which would reduce the antinutritional substances along with envisaging on the changes of nutritional substances had been carried out.
In premature seed only boiling + draining and frying caused reduction in crude protein by 33.01% and 30.67% respectively whereas in fat the value decreased by pressure cooking + draining (25.37%) relative to the value of unprocessed seed. An increase in the crude fibre content was noted after pressure cooking + drained. No significant change was found in the ash value in all the processing treatments compared to control (5.66%) except frying with reduction by 28.62%. Total crude carbohydrate content was increased by 10.70% and 10.50% due to frying and boiling + draining respectively. Energy value, levels of total free amino acid and folic acid were retained due to all processings. Only frying could cause reduction of non-reducing sugars by 38.29% while total soluble sugars and reducing sugars got significant reduction of their levels in the ranges of 15.29-41.18% and 15.79-44.74% respectively due to all the processings. Minimum reduction of ascorbic acid was observed in steaming. Pressure cooking + draining caused lesser reduction of total phenol (13.33%) while boiling+draining resulted greater reduction of total phenols. Frying retained flavonoid level at the control value.

All processings did not lead to reduction of antinutrients. Steaming impacted tannins reduction by 8.0% while other treatments did it in the range of 16.66-21.00%. Pressure cooking+draining seemed to retain phytate level at control value but remaining treatments reduced it (19.82-25.50%). TIA reduction of 55.27% was produced by pressure cooking + draining while remaining treatments did it at greater extent (61.82-74.18%).

During envisaging on the change of nutritional substances of premature pod due to processings it was ascertained that only pressure cooking + draining caused reduction of crude protein (16.36%). Crude
fibre was increased after frying (14.80%) while reduction (5.19–12.20%) was noted due to other processings. All the processings except frying caused increase of crude carbohydrate. None of the treatments caused significant reduction of fat but regarding ash it was done by pressure cooking + draining. Only frying caused reduction of non reducing sugars (75.18%). Majority of treatments impacted reduction of total soluble and reducing sugars as only boiling + draining retained its level. Significant reduction of total free amino acids was recorded with pressure cooking + draining and steaming whereas for methionine only this latter treatment did not cause affection. Reduction of folic acid and ascorbic acid due to treatments had been recorded to be 24.90 – 57.40% and 32.46 – 58.21%.

Steaming caused increase of total phenols (38.90%) and other treatments decreased them (17.49 – 53.91%). All cases of flavonoids were reduction (mean value being 82.20%) and for phytate it could be achieved with steaming (10.72%) and frying (20.59%).

Crude protein content in the mature unprocessed seed was found to be 21.71%. Upon decortication the value increased to the extent of 20.22%. All the processing treatments except WS + D, WS + D + B + Dr, G + D, G + D + B + Dr, DA + D, TS + D, TS + D + B + Dr and CAS + D caused reduction of the level of protein relative to the value of decorticated seed. CoS + D + B + Dr significantly reduced (P < 0.05) the level of protein below the level of control. Compared with protein level of decorticated seed, R + D caused significant reduction (P < 0.05) to a level insignificantly varied (P > 0.05) with those left after JS + D, JS + D + B + Dr, GS + D + B + Dr, CAS + D + B + Dr and SBS + D + B + Dr but at level not below the value of the control. The protein value comparable to control were noted to be those left after WS + D + PC + Dr, WS + D
+ F, R + D, CS + D, CS + D + B + Dr, JS + D, JS + D + B + Dr, GS + D, GS + D + B + Dr, CoS + D, SBS + D, SBS + D + B + Dr and CAS + D + B + Dr. Except these treatments and CoS + D + B + Dr all other treatments were noted to provide increased protein compared to control.

Decortication brought significant increase of fat and after treatments such as R + D, CAS + D, CoS + D, SBS + D and SBS + D + B + Dr did not cause significant variation of fat values with that of decorticated seed whereas WS + D + PC + Dr, TS + D, TS + D + B + Dr, CS + D, CS + D + B + Dr, JS + D, JS + D + B + Dr and CoS + D + B + Dr produced insignificantly varied values of fat compared to the control value. Affection (P < 0.05) of fat was noted in treatment by GS + D + B + Dr (34.73%) followed by CAS + D + B + Dr (23.79%), G + D + B + Dr (21.67%) and WS + D + B + Dr (10.00%).

Crude fibre content was significantly reduced after decortication (table 4.2A). Processings by R + D, TS + D, GS + D and GS + D + B + Dr retained the control value (4.77%). Treatments viz. WS + D, WS + D + B + Dr, WS + D + PC + Dr, DA + D, G + D + B + Dr, CAS + D, CAS + D + B + Dr, TS + D + B + Dr, CS + D, CS + D + B + Dr, JS + D + B + Dr, CoS + D, CoS + D + B + Dr and SBS + D + B + Dr were not statistically discrimated from crude fibre value of decorticated seed (2.56%). Relative to the control value of fibre, treatments by G + D + B + Dr, CAS + D, CAS + D + B + Dr, TS + D + B + Dr, CS + D + B + Dr, JS + D + B + Dr and SBS + D + B + Dr caused greater reduction.

Ash content was not changed significantly due to treatments viz. D, WS + D, WS + D + B + Dr, WS + D + PC + Dr, WS + D + F, CS + D, G + D, G + D + B + Dr, DA + D, R + D, JS + D, JS + D + B + Dr,
SBS + D and CS+D+B+Dr compared to control value(4.98%). However, ash level was brought down significantly below the level of control following treatments of CAS + D, CAS + D + B + Dr, TS + D, TS + D + B + Dr, GS + D, GS + D + B + Dr, CoS + D, CoS + D + B + Dr and SBS + D + B + Dr (mean reduction : 43.37%).

Decortication reduced the content of total crude carbohydrate significantly in mature *P. timoriana* seed. Total crude carbohydrate content of decorticated seed and value left after the treatment G + D were noted to be insignificantly varied (P > 0.05). The level of control was regained after treatments by WS + D + B + Dr, R + D, WS + D + PC + Dr, G + D + B + Dr, TS + D, TS + D + B + Dr, JS + D, CoS + D and SBS + D + B + Dr. Treatments like CoS + D + B + Dr, CS + D + B + Dr, JS + D + B + Dr, GS + D + B + Dr and CAS + D + B + Dr impacted increase of total crude carbohydrates over the level of control with greater effect of the latter two, the percent increases being 27.91 and 28.70 respectively.

Increase of energy was noted upon removal of seed coat of mature seed. Treatments such as WS + D + B + Dr, CS + D, CS + D + B + Dr, DA + D, JS + D, GS + D and CAS + D + B + Dr were found to retain the control value (490.00 K cal/100g). The energy value of decorticated seed (514.00 K cal/100g) was statistically similar with any of the value obtained after R + D, CAS + D, CoS + D, CoS + D + B + Dr, SBS + D and SBS + D + B + Dr. A significant reduction of 7.79% compared to control (490.00K cal/100g) was found following GS + D + B + Dr. Slight increase in energy was found to be due to CAS + D (Table 4.2B).
The value of reducing sugar in unprocessed seed of *P. timoriana* was found to be 912.53 mg/100g. Relative to control level reduction of reducing sugar was caused by TS + D (29.14%), R + D (39.47%) and WS + D + F (40.08%). Treatments which raised the level of reducing sugars were JS + D (149.59%), JS + D + B + Dr (78.37%), WS + D + B + Dr (65.34%) and G + D (57.80%).

Unprocessed mature seed of *P. timoriana* was found to contain 6853.34 mg/100g non-reducing sugars. Most of the treatments viz. D, WS + D + B + Dr, WS + D, WS + D + PC + Dr, WS + D + F, CS + D, CS + D + B + Dr, DA+D, R+D, JS + D, JS + D + B + Dr, G + D + B + Dr, TS + D + B + Dr, CoS + D, CoS + D + B + Dr, CAS + D + B + Dr and SBS + D brought in insignificant change of non-reducing sugars as compared with control value. Only a few of the treatments increased non-reducing sugars level viz. CAS + D (30.99%), GS + D + B + Dr (32.51%), TS + D (35.26%) and GS + D (63.05%). Reduction of non-reducing sugar relative to control value was found after treatment with SBS + D + B + Dr (24.79%) and G + D (65.37%). None of the soaking treatments affected reduction of non-reducing sugars. Among treatments consisting of draining of cooking liquid, lowering of non-reducing sugars was noticed only with SBS + D + B + Dr (24.79%) (Table 5.3).

It was observed that among oligosaccharides of unprocessed *P. timoriana* mature seeds so far known to occur, stachyose exhibited higher content (2.48%) followed by those of raffinose (1.72%), sucrose (0.51%) and verbascose (0.36%). WS + D + B + Dr reduced significantly the contents of stachyose, sucrose, raffinose and verbascose by 17.34%,
23.53%, 29.65% and 63.89% respectively. However, WS + D + PC + Dr was able to reduce the contents of raffinose (33.14%) and verbascose (66.67%), but insignificant change was recorded for sucrose and stachyose. It seemed that total content of raffinose, verbascose and stachyose could not be reduced by decortication, whereas WS + D + B + Dr and WS + D + PC + Dr brought down the content by 25.44% and 17.95% respectively (Table 5.3).

Total soluble sugar of unprocessed mature *P. timoriana* seed was 7765.87 mg/100g. Decortication was not associated with significant change of total soluble sugars content. Treatments such as CAS + D, TS + D, GS + D and GS + D + B + Dr increased the content of total soluble sugars by 30.65%, 27.69%, 60.39% and 34.82% respectively whereas maximum reduction of 50.89% was observed during germination (Table 5.2).

The total phenol content of unprocessed mature seed was reduced significantly by decortication. Treatments such as WS + D + B + Dr, CoS + D and CAS + D + B + Dr impacted not significant variation of total phenols content relative to decoated seed value. Result of processings such as WS + D, WS + D + PC + Dr, G + D + B + Dr, TS + D, TS + D + B + Dr, JS + D, JS + D + B + Dr, GS + D, GS + D + B + Dr, CoS + D + B + Dr, CAS + D, SBS + D and SBS + D + B + Dr were uncertain regarding change relative to control or decorticated seed. Drastic reduction of phenolic compounds compared to control value was observed due to treatments of WS + D + B + Dr (63.91%), CoS + D (56.21%) and CAS + D + B + Dr (57.29%). The level of phenolic compounds was elevated magnificently (104.79 – 166.92%) due to treatments such as WS + D + F, DA + D and R + D relative to control value (Table 6.1).
Control, decorticated and water soaked + decorticated seeds possessed insignificantly varied amounts of flavonoids. In cotyledonous portion, CAS + D, CS + D, JS + D and SBS + D did not cause any significant change of flavonoid whereas TS + D and GS + D effected increase and decrease respectively. Drastic reduction of flavonoids can be accounted from the treatments viz. WS + D + PC + Dr, WS + D + F, DA + D, R + D, GS + D, GS + D + B + Dr, CoS + D, CoS + D + B + Dr and SBS + D + B + Dr ranging from 58.88 – 92.89%. Reduction of flavonoids was also recorded when WS + D was followed by B + Dr or PC + Dr and similar change was also observed when CAS + D, CS + D, JS + D, SBS + D were followed by B + Dr. Flavonoid level was elaborately magnified by treatment such as G + D (167%) and G + D + B + Dr (137.56%) and producing of such effect was followed by TS + D (91.88%), TS + D + B + Dr (57.36%), JS + D (46.70%) and CAS + D (46.19%). It is noticeable that elevation of flavonoids during G + D and G + D + B + Dr took place amidst retention of the level of total phenolic compounds (Table 6.1).

Total free amino acids of the fresh unprocessed seed was 700mg/100g. All the processing treatments consisting of decortications viz.WS + D + F, DA + D, R + D, JS + D, CoS + D + B + Dr and SBS + D + B + Dr produced values which were statistically not discriminated from the control. Decortication increased total free amino acid (15.71%) significantly. Treatments viz.CS + D, CS + D + B + Dr, TS + D, CoS + D, CAS + D and SBS + D retained total free amino acid at the level of decorticated seed. It was observed that total free amino acids increased after D, CS + D, CS + D + B + Dr, TS + D, CoS + D, CAS + D and
SBS + D (mean increase being 18.09%). JS + D + B + Dr caused drastic reduction of total free amino acids (55.71%) while other treatments viz. WS + D + B + Dr, WS + D + PC + Dr, G + D + B + Dr, GS + D + B + Dr an CAS + D + B + Dr also reduced it with average value of 19.50% (Table 7.1).

Methionine content of the mature seeds of *P. timoriana* treated by WS + D + B + Dr, WS + D + PC + Dr, TS + D + B + Dr, JS + D and CAS + D were insignificantly varied with the value of control (242.09 mg/100g). Methionine value of decorticated seed was comparable with those given by treatments: G+D, G+D+B+Dr, GS+D, GS+D+B+Dr and CoS+D. Treatments with G + D, G + D + B + Dr, GS+D, GS+D+B+Dr and CoS+D increased methionine content to 73.92%, 64.88%, 29.32%, 21.28% and 11.68% respectively relative to control. None of the soaking treatments caused any significant change in methionine content (except GS+D, CoS+D) but with the following of boiling + draining treatment from soaked and decorticated samples, only with SBS + D treated sample was noted to associate with significant methionine decrease. Among the several treatments done, only WS + D + F, R + D and SBS + D + B + Dr affected methionine severly (57.59-74.70%) relative to its amount in mature seed (Table 7.2).

The folate content of fresh matter of *P. timoriana* was 3.24μg/100g. The value increased upon decortication (7.53μg/100g). Samples treated with WS + D + PC + Dr and SBS + D + B + Dr were insignificantly varied from the control value. All the processing treatments consisting of decortications viz. WS + D, WS + D + B + Dr, WS + D + F, DA + D, R + D, G + D, G + D + B + Dr, CAS + D, CAS + D + B + Dr, TS + D, TS
+ D + B + Dr, CS + D, CS + D + B + Dr, JS + D, JS + D + B + Dr, GS + D, GS + D + B + Dr, CoS + D and SBS + D were statistically not discriminated from decorticated seed. Significant decrease of folic acid was recorded during PC + Dr (4.94 μg/100g) followed from WS + D and during B + Dr followed from TS + D and SBS + D. Compared to control, pronounced increase of folic acid was found during all the processings except WS + D + PC + Dr and SBS + D + B + Dr. It was also observed that G + D (146.91%) and TS + D (160.18%) produced higher elevation of folic acid content (Table 8.1).

For ascorbic acid, decorticated seed possessed higher value (22.20 mg/100g) than the fresh mature unprocessed seed (15.46 mg/100g) (Table 8.1). Processing treatments such as WS + D, R + D, CS + D, GS + D and SBS + D retained the control value. The remaining treatments except decortication affected ascorbic acid relative to the control value. In the cotyledonous portion, decline of ascorbic acid was noted due to all soaking treatments. Significant decrease of ascorbic acid was recorded during PC + Dr followed to WS + D and during B + Dr followed to CS + D, CoS + D, CAS + D, GS + D, JS + D, TS + D and SBS + D. Drastic reduction of ascorbic acid was conspicuous with treatments by CS + D + B + Dr (71.09%), G + D + B + Dr (70.76%), GS + D + B + Dr (63.71%) and CoS + D + B + Dr (53.30%). Lesser reduction of the vitamin was also caused by some treatments viz. WS + D + B + Dr, DA + D, CoS + D, CAS + D and SBS + D + B + Dr (mean reduction : 20.57%) (Table 8.1).

Effect of different processings on antinutrients namely tannins, phytate and trypsin inhibitors were studied. The tannin content of mature
unprocessed seed of *P. timoriana* was found to be 460.00 mg/100g. A decrease in the value was noted after decortication (350.14 mg/100g) and it was statistically comparable with those values produced after CAS + D + B + Dr, TS + D + B + Dr, JS + D, JS + D + B + Dr, GS + D, GS + D + B + Dr and CoS + D + B + Dr. Mean reduction of tannins due to these treatments was 42.78%. Significant elevation of tannins level over the value of control had been caused by WS + D + F (146.13%), DA + D (574.95%), R + D (506.53%), CS + D (77.17%), CS + D + B + Dr (51.96%) and G + D (201.11%). CoS + D and G + D + B + Dr retained the control value. The study pointed out that irrespective of the soaking carried out in water, sodium bicarbonate and citric acid solutions, spice suspensions at room temperature, proceeding of treatments with D + B + Dr gave no discrimination of tannins level (Table 5.1).

Mature unprocessed seed was found to contain 851.58 mg/100g phytate which did not vary significantly with those recorded after D, WS + D, WS + D + B + Dr, R + D, G + D, JS + D, GS + D, GS + D + B + Dr and CoS + D treatments. Higher reduction (79.58%) was recorded after WS + D + F and it was followed with the impact of SBS + D, SBS + D + B + Dr, CAS + D + B + Dr and CAS + D which gave matching values of phytate (mean reduction: 44.45%). Though germination along with decortication did not cause significant reduction, B + Dr followed from it brought significant decline. Enhancement of phytate level was found due to TS + D, TS + D + B + Dr, JS + D + B + Dr, DA + D and CoS + D + B + Dr ranging from 18.52 - 58.71% (Table 5.1).

After decortication of the mature unprocessed seed of *P. timoriana* containing 7.44 TI units/mg sample, the value increased to 9.93 TI units/
mg sample. Higher and invariable values of TIA were of D, G + D and SBS + D. Compared to control value treatments viz. WS + D + F, WS + D + PC + Dr, CS + D + B + Dr, WS + D + B + Dr, JS + D + B + Dr, CoS + D, CAS + D + B + Dr had given outcome as reduction with respective values of 19.62%, 29.30%, 30.11%, 34.01%, 35.89%, 39.92% and 42.47%. However, treatments which impacted drastic affection of TIA as compared with the value of control were GS + D + B + Dr (53.63%). CoS + D + B + Dr (63.84%) and G + D + B + Dr (68.41%). Among all soaking + decortication treatments only CoS + D caused reduction (39.92%) relative to unprocessed value. In cotyledonal portion, the calculated reductions produced for TIA from JS, CAS, TS, GS, CS, WS and CoS were respectively 18.53%, 20.74%, 25.07%, 26.89%, 27.79%, 32.73% and 54.98%. During boiling and draining treatment after SBS + D, TS + D, WS + D, CS + D, CoS + D, JS + D, CAS + D and GS + D, TI activity were reduced by 23.66%, 26.21%, 26.50%, 27.48%, 39.82%, 41.04%, 45.62% and 52.47% respectively. It was observed that germination for 6 days did not result to significant change of TIA in cotyledonal mass, whereas for this availing level reduction of 72.83% was brought in by B + Dr.

From the mode of change of tannins, phytate and TIA during processing of premature seed, it was suggested that their removal was better ensued due to boiling + draining and it was followed by frying, steaming and pressure cooking + draining. On the other hand based on the mode of change of tannins and phytate during premature pod processing, it was assumed for this case that frying did better for reduction of their interference and; steaming, pressure cooking + draining and boiling + draining followed it. For premature entire pod it was deduced from
calculation that boiling + draining, steaming and frying would exert almost equal effect for reducing interference of tannins, phytate and TIA. In this regard importance of pressure cooking was predicted to be not much inferior. Moreover, α-galactosides have been probably reduced significantly during premature seed frying. Due to processing TIA of premature seeds have been reduced by 55.27–74.18% while tannins and phytate of premature pods and its seeds were by 8.00–25.50 % only.

Due to processing, none of components of proximate composition of premature seed and premature pod was affected drastically. Same processing did not cause drastic reduction for each of methionine folic acid and ascorbic acid in both premature pod and premature seed.

Processing of mature seed which would better reduce the problems of tannins, phytate and TIA was assumed to be CAS + D + B + Dr. Regarding such problem reduction, it is considered that processing such as GS + D + B + Dr, G + D + B + Dr, CoS + D + B + Dr and D followed it in this order. Cases of drastic reduction of components of proximate composition of mature seed were only : 57.23% and 73.16% reduction of crude fibre by G + D + B + Dr and CAS + D + B + Dr respectively, 66.26% reduction of ash by CoS + D + B + Dr, CAS + D + B + Dr (45.98%) and GS + D + B + Dr (37.95%). Interestingly significant reduction of proteins caused only by CoS + D + B + Dr was noted to be not extensive (17.55%).

About the fate of methionine, folic acid and ascorbic acid during these processings, the case of affection was only for ascorbic acid (45.08 – 70.76%) due to above four processings other than D.

Processings such as WS + D + F, DA + D and R + D caused significant increase of total phenols. Inspite of reduction of phenolic
compounds by other treatments; G + D + B + Dr, GS + D + B + Dr and CoS + D + B + Dr retained them. But these latter two treatments caused significant reduction of flavonoids.

Other important findings of the study are

A. For mature seed

1. Significant reduction of tannins by processings consisting of spice treatments except TS + D and CoS + D.

2. All processings done with chemical treatments (CAS + D, CAS + D + B + Dr, SBS + D, SBS + D + B + Dr) caused significant reduction of phytate.

3. Generally adopted processing methods-WS + D + B + Dr, WS + D + PC + Dr and WS + D + F; all processings practised with soaking in spice suspension and boiling (except TS + D + B + Dr) effected significant reduction of TIA.

4. Among 23 processing methods adopted only CoS + D + B + Dr caused significant reduction of protein by merely 17.55%.

5. Processings which caused significant increase of flavonoids were G + D, G + D + B + Dr, TS + D, TS + D + B + Dr, JS + D and CAS + D.

6. Total free amino acids had been increased by TS + D, CoS + D, CAS + D and SBS + D.
B. For premature pod and premature seed

1. Significant change of fat could not be resulted due to processings adopted (except for premature seed by pressure cooking + draining).

2. Folic acid and total free amino acids in premature seed could not be significantly affected due to processings adopted.

3. During frying of premature seed level of flavonoids was observed to be maintained.

4. An increase in the total phenols content was found in premature pod due to steaming.