RESEARCH PAPER

Improvement of traditional methods for the development of edible flour from Indian horse chestnut (*Aesculus indica*)

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Abstract

Indian horse chestnut is a good source of starch but contains toxic compounds such as saponins which make it a bitter and unsuitable for consumption. Studies were undertaken to remove the saponins content from the horse chestnut mass by following pre-treatments including traditional techniques. Nuts after dehulling were crushed/grated into a mass which was treated with various treatments. Various pretreatments like soaking, blanching, cooking, pressure cooking were standardized individually. Then, best selected treatments were further evaluated on the basis of maximum removal of saponins content and sensory characteristics. Treatment having minimum saponins content and higher sensory characteristics scores was selected for making the flour.

Keywords: Indian horse chestnut, *Aesculus indica* colebr, saponins, sensory, soaking, blanching, cooking

Indian horse chestnut (*Aesculus indica* colebr.) is a native of North West Himalaya, though it is also found in other temperate regions of Asia, Europe and North America, having 17 species of Aesculus genus widely distributed throughout the temperate regions of the world. *Aesculus indica* Colebr. known as Indian horse chestnut, is found in the Himalayan region, at an elevation between 2,000 and 3,000 metres (Parmar and Kaushal, 1982) in the moist, shady ravines of Kashmir, Himachal Pradesh and Uttrakhand in India. In HP, the trees of this species are widely distributed in the various districts including Solan, Shimla, Sirmour, Kullu, Kangra, Mandi, Chamba etc.

The flowers of tall, deciduous, spreading, shady tree appear during the months of May-June while the nuts mature during October month. Its fruit is known as capsule which is smooth and spineless and contains shiny seeds (conker). The seed is sometimes wrinkled, darker and smaller than that of *A. hippocastanum* (Parmar and Kaushal, 1982). Its nut is a very good source of starch that can be utilized for preparation of various products (Uppal, 1952). The nut, however, contains anti-nutritional factor like saponins (aesculin) which make it inedible and poisonous. Beside saponins, other compounds including toxin and phyto-chemicals like nicotine, quercitin, quercitrin, rutin and shikimic acid are also found in this nut. Toxicity caused by this nut leads to muscle twitching, weakness, lack of coordination, dilated pupils, vomiting, diarrhoea, depression, paralysis and stupor. At the same time, the nut is also used to treat animals from various diseases. The crushed nuts if fed to cattle are reported to improve the quality and quantity of milk. Some animals like deer and squirrels remain unaffected even after consumption of its nuts. The nuts have also been used in ethnoveterinary medicine for treating horses also (Anon, 2013).

In the areas, where this nut is available in abundance, native people debitter it by traditional technology involving simple soaking and leaching treatments. Nuts are put in the pits during the season and during winter they are taken out of the pits and crushed into a mass. The mass is then, put in the wooden tubs and dipped in water. This water soaking is carried out being employed every day and this practice lasts for months together. The mass is considered to be safe when the draining water is tested for its bitterness. If the soaking water is not bitter then from this treated mass *tattwakhar*, a type of *halwa* (an Indian confectionary) is made and used as *phalahar* (non-cereal food) during fasts in certain parts of HP(India) (Rajasekaran and Joginder, 2009). The pre-treatments are considered most important unit operations to remove anti-nutritional factor like saponins from Indian horse chestnut. The common pre-treatments like water soaking, blanching, cooking, pressure cooking do cause some losses yet, they are necessary steps before drying to remove saponins. Therefore, the present investigations were aimed to remove the saponins content from the grated mass of horse chestnut with the broad objective to improve traditional pretreatment and standardize them for the removal of anti-nutritional factor (saponins).

Material and Methods

Indian horse chestnuts harvested at optimum maturity were procured from Chota Bhangal area of district Kangra (HP) and analysed for various physico-chemical characteristics under lab condition. The nuts were dehulled manually and grated with the help of mechanical grater and the grated mass was put under various treatments (soaking, blanching, cooking and pressure cooking) as described in the subsequent section.

Soaking

The grated mass was mixed with water in 1:15 ratio in SS containers and the whole mixture was agitated vigorously for 15 minutes. It was left undisturbed for 24 h and then, water from the mixture was drained out and replaced with same quantity of water by

siphoning and again this mixture was agitated vigorously for 15 minutes. This process was repeated after every 24 hours till the 48th day.

Blanching

In another treatment, the grated mass was blanched for different time intervals (6, 8, 10 and 12 minutes). Then, this blanched mass was further mixed in water in the ratio of 1:15 and repeated the same process as mentioned earlier for soaking, till the 36th day.

Table 1: Physico-chemical characteristics of Indian horse chestnut

Characteristics	Mean ± SE
Capsule weight (gm)	31.73±1.16
Capsule size	
(a) Length (cm)	2.70±0.17
(b) Diameter (cm)	4.16±0.17
Volume of capsule (cm^3)	1.30±0.1
No. of nuts per capsule	1.00±0
Colour of nuts	Dark brown
Weight of nuts per capsule (g)	27.73±1.73
Colour of the kernel	Light brown
Colour of the kernel flesh	Creamish white
Weight of the kernel per nut (g)	24.20±1.16
Moisture (%)	47.50±2.02
Total solids (%)	52.50±3.46
Starch (%)	30.10±1.16
Reducing sugars (%)	4.56±0.12
Total sugars (%)	5.34±0.12
TSS (^{o}B)	9.80±0.12
pH	6.50±0.12
Crude Protein (%)	4.37±0.06
Total Protein (mg/100g)	84.50±2.89
Crude fibers (%)	0.41±0.01
Phenols (mg/100g)	398.75±14.53
Oil (%) on dry weight basis	1.60±0.06
Ash (%)	1.72±0.01
Saponins (%)	9.03 ±0.17

Cooking

The grated mass was cooked for different time intervals (20, 30 and 40 minutes) and was further

soaked in water in the ratio of 1:15 and repeated the same process as mentioned for soaking earlier, till 32nd day.

Table 2: Effect of water soaking treatments on the sensory characteristics of grated mass of Indian horse chestnut

Treatments	Sensory characteristics			
	Colour	Taste	Aroma	Overall acceptability
S_1 (12 days soaking)	7.90	3.00	5.20	5.00
S_2 (16 days soaking)	7.90	3.40	5.30	5.10
S_3 (20 days soaking)	7.80	3.90	5.40	5.20
S_4 (24 days soaking)	7.50	4.30	5.45	5.40
S_5 (28 days soaking)	7.40	4.80	5.70	5.60
S_6 (32 days soaking)	7.20	5.20	5.80	5.70
S_7 (36 days soaking)	7.20	5.60	5.90	5.90
S_8 (40 days soaking)	7.10	6.10	6.20	6.20
S_9 (44 days soaking)	7.00	6.00	6.10	6.20
S_{10} (48 days soaking)	6.80	6.00	6.10	6.10
$CD_{(0.05)}$	0.14	0.20	0.20	0.23

Pressure cooking

The grated mass was cooked under pressure for different time intervals (10, 20 and 30 minutes). Then, the same process as mentioned for soaking treatment was followed till 32nd day. The best treatment was selected from each pre-treatments (soaking; blanching and soaking; cooking and soaking; pressure cooking and soaking) on the basis of best sensory characteristics of grated mass. All the best selected pre-treatments were compared for final selection on the basis of sensory characteristics and minimum saponins content.

Physico-chemical and sensory analysis

Indian horse chestnut were analyzed for various physico-chemical characteristics. Size of the capsule was measured by Vernier calliper and expressed in millimeter (mm). Capsule weight was measured by using top pan balance and expressed as gram (g) per capsule. The colour of capsules was observed visually. Number of nuts per capsule were counted manually. Weight of nuts per capsule was determined by using weighing balance and expressed as gram per capsule. The colour of nuts was observed visually by comparing with the colour cards of Royal Horticulture Society, London. The colour of the kernel and kernel flesh was observed visually. Weight of the kernel per nut was measured by using weighing balance and expressed as weight of the kernel per nut.

Table 3: Effect of blanching treatments on the sensory characteristics of grated mass of Indian horse chestnut

Treatments	Sensory characteristics			
	Colour	Taste	Aroma	Overall acceptability
B_1V_1 (6 min blanching + 24 days soaking)	8.50	7.40	6.20	7.60
B_1V_2 (6 min blanching + 28 days soaking)	8.30	7.60	5.90	7.70
B_1V_3 (6 min blanching + 32 days soaking)	8.00	7.80	5.70	7.80
B_1V_4 (6 min blanching + 36 days soaking)	7.60	8.00	5.70	7.90
B_2V_1 (8 min blanching + 24 days soaking)	8.40	7.60	6.50	7.70
B_2V_2 (8 min blanching + 28 days soaking)	8.20	7.80	6.80	7.80
B_2V_3 (8 min blanching + 32 days soaking)	7.90	8.00	5.90	7.90
B_2V_4 (8 min blanching + 36 days soaking)	7.50	8.20	5.90	7.90

B_3V_1 (10 min blanching + 24 days soaking)	8.30	7.80	6.20	7.70
B_3V_2 (10 min blanching + 28 days soaking)	8.00	8.00	6.40	7.80
B_3V_3 (10 min blanching + 32 days soaking)	7.80	8.50	6.60	8.30
B_3V_4 (10 min blanching + 36 days soaking)	7.40	8.20	6.30	8.00
B_4V_1 (12 min blanching + 24 days soaking)	8.20	7.90	6.10	7.70
B_4V_2 (12 min blanching + 28 days soaking)	8.00	8.00	6.50	7.80
B_4V_3 (12 min blanching + 32 days soaking)	7.70	8.00	6.30	7.80
B_4V_4 (12 min blanching + 36 days soaking)	7.30	8.20	6.20	7.80
$CD_{(0.05)}$	0.34	0.21	0.22	0.19

Among the different chemical characteristics of Indian horse chestnut, moisture content of fresh nuts was estimated by drying the weighed samples to a constant weight in a hot air oven at 70±1°C. Loss in weight of fresh nuts after drying, represented the moisture content and was expressed as per cent (W/W), whereas, total solids were estimated by subtracting moisture content from the fresh weight of the nut (Ranganna, 2009). Starch content was determined by the method given by Ranganna (2009), while sugars were estimated as per the standard procedure given by Lane and Eynon (1923). Total soluble solids (TSS) was determined using hand refractometer and after correcting the readings for temperature variation and expressed as degree Brix (°B). The pH of fresh nuts was determined by using a digital pH meter (CRISON Instrument, Ltd, Spain). Protein in fresh nuts was determined by Lowry's method as described by Sadassivam and Manickam (1991). Total fiber content was estimated by the method given by Gould

(1978). The total phenols content was determined by the Folin-Ciocalteu procedure given by Singleton and Rossi (1965). Ash content was determined by using muffle furnace at temperature of 550°C as given by Ranganna (2009). The oil content of the fresh fruit was estimated by using soxhlet apparatus with petroleum ether as solvent. The quantitative estimation of saponins content in fresh fruit as well as among the different treatments was carried out as per the standard procedure given by Obadoni and Ochuko (2001).

Sensory analysis of different pretreatments was carried out by using 9 point hedonic scale as described by the (Joshi, 2006).

Table 4: Effect of cooking treatments on the sensory characteristics of grated mass of Indian horse chestnut

Treatments	Sensory characteristics			
	Colour	Taste	Aroma	Overall acceptability
C_1V_1 (20 min cooking + 20 days soaking)	7.70	7.30	6.10	7.10
C_1V_2 (20 min cooking + 24 days soaking)	7.40	7.40	5.80	7.20
C_1V_3 (20 min cooking + 28 days soaking)	7.20	7.50	5.60	7.30
C_1V_4 (20 min cooking + 32 days soaking)	6.80	7.60	5.60	7.30
C_2V_1 (30 min cooking + 20 days soaking)	7.60	7.30	6.40	7.10
C_2V_2 (30 min cooking + 24 days soaking)	7.40	7.50	6.70	7.20
C_2V_3 (30 min cooking + 28 days soaking)	7.10	7.80	5.80	7.50
C_2V_4 (30 min cooking + 32 days soaking)	6.70	7.80	5.50	7.30
C_3V_1 (40 min cooking + 20 days soaking)	7.40	7.50	6.10	7.10
C_3V_2 (40 min cooking + 24 days soaking)	7.20	7.50	6.60	7.20
C_3V_3 (40 min cooking + 28 days soaking)	6.80	7.60	6.30	7.30
C_3V_4 (40 min cooking + 32 days soaking)	6.40	7.70	6.20	7.20
$CD_{(0.05)}$	0.31	0.09	0.27	0.09

Statistical Analysis

The data pertaining to the sensory evaluation of grated mass of different treatments were analyzed by Randomized Block Design (RBD), as described by Mahony (1985), whereas the data pertaining to the saponins content of the grated mass was analysed using Completely Randomized Design (CRD) (Cochran and Cox, 1967).

Table 5: Effect of pressure cooking treatments on the sensory characteristics of grated mass of Indian horse chestnut

Treatments	Sensory characteristics			
	Colour	Taste	Aroma	Overall acceptability
P_1V_1 (10 min pressure cooking + 20 days soaking)	7.90	6.70	6.30	6.60
P_1V_2 (10 min pressure cooking + 24 days soaking)	7.70	6.70	5.90	6.70
P_1V_3 (10 min pressure cooking + 28 days soaking)	7.60	6.80	5.70	6.80
P_1V_4 (10 min pressure cooking + 32 days soaking)	7.50	6.70	5.60	6.70
P_2V_1 (20 min pressure cooking + 20 days soaking)	7.40	6.70	6.50	6.80
P_2V_2 (20 min pressure cooking + 24 days soaking)	7.30	6.90	6.30	7.00
P_2V_3 (20 min pressure cooking + 28 days soaking)	7.20	7.50	5.90	7.10
P_2V_4 (20 min pressure cooking + 32 days soaking)	7.10	7.50	6.00	7.00
P_3V_1 (30 min pressure cooking + 20 days soaking)	7.00	6.90	6.20	6.70
P_3V_2 (30 min pressure cooking + 24 days soaking)	6.70	6.80	6.70	6.90
P_3V_3 (30 min pressure cooking + 28 days soaking)	6.60	6.70	6.40	6.80
P_3V_4 (30 min pressure cooking + 32 days soaking)	6.50	6.70	6.30	6.70
$CD_{(0.05)}$	0.33	0.23	0.19	0.04

Results and Discussion

Physical characteristics

The average length, diameter, weight and volume of fresh Indian horse chestnut capsule were recorded (Table 1) to be 2.70±0.17 cm, 4.16±0.17 cm, 31.73±1.16 g and 1.30±0.1 cm³, respectively. There results t are near to the values reported earlier by Parmar and Kaushal (1982) and Majeed *et al.* (2009). A single nut was observed in each capsule, whereas, the weight of the nut and kernel per nut were recorded as 27.73±1.73 g and 24.20±1.16 g, respectively. The colour of the nut was recorded to be dark brown, whereas, the colour of kernel and kernel flesh was recorded as light brown and creamish white. Similar results have been reported earlier by Parmar and Kaushal (1982), Majeed *et al.* (2009).

Chemical characteristics

The moisture content as 47.50±2.02 per cent and the total solids as 52.50±3.46 per cent in the Indian horse chest nut were recorded, while, TSS and pH of this fruit were found as 9.80±0.12°B and 6.50±0.12, respectively (Table 1). These results are in confirmation to the results reported by Parmar and Kaushal (1982), Majeed *et al.* (2009) and Baraldi *et al.* (2006). The nut contains 4.56±0.12 and 5.34±0.12 per cent reducing and total sugars, respectively (Table 1). These observations are also within the range as reported by Parmar and Kaushal (1982), Baraldi *et al.* (2006) and Ocokoljic *et al.* (2011) in Indian horse chestnut. The saponins content and starch content were found to be 9.03 ±0.17 per cent and 30.10±1.16 per cent respectively, which are almost similar to the ones reported earlier (Parmar and Kaushal, 1982; Baraldi *et al.* 2006; Ocokoljic *et al.* 2011; Singh *et al.*

Table 6: Comparison of main pre treatments

|	Sensory characteristics				Saponins content (%)
	Colour	Taste	Aroma	Overall acceptability	
T_1 (40 days soaking)	7.10	6.1	6.20	6.20	0.78
T_2 (10 min blanching + 32 days soaking)	7.80	8.3	6.60	8.10	0.29
T_3 (30 min cooking + 28 days soaking)	7.10	7.7	5.80	7.40	0.36
T_4 (20 min pressure cooking + 28 days soaking)	7.20	7.5	5.90	7.10	0.51
$CD_{(0.05)}$	0.05	0.05	0.07	0.06	0.11

2004 and Bombardelli *et al.* 1996) in the same nut. The results of some chemical characteristics of this nut in the present studies, like phenols (398.75±14.53 mg per 100g), oil (1.60±0.06 %), crude fibre (0.41±0.01 %), total protein (84.50±2.89 µg per 100g). and ash (1.72±0.01 %) corroborated to the values documented by Parmar and Kaushal (1982)[1], Majeed *et al.* (2010), Lemajic *et al.* (1985), Lukic (1993), Ocokoljic *et al.* (1997), Baraldi *et al.* (2006) and Ocokoljic *et al.* (2011) in the same nut.

Effect of pre-treatments

Pre-treatments employed affected the true quality of the material to some extent especially in case of colour, texture, taste, sugars and starch, but the most important quality characteristics influenced was the saponins. Various pre-treatments like water soaking (Table 2), blanching with water soaking (Table 3), cooking with water soaking (Table 4), pressure cooking with water soaking (Table 5) were used for removal of saponins content from the grated mass of Indian horse chestnut. These all pre-treatments were compared on the basis of sensory characteristics of grated mass like colour, taste, aroma and overall acceptability. The best pre-treatments on the basis of maximum scores for sensory characteristics were selected and were further compared with each other for final selection.

Data of water soaking treatment (Table 2) revealed that S_8 (colour 7.10, taste 6.10, aroma 6.20, overall acceptability 6.20) treatment was the best on the basis of its higher sensory scores. Data of blanching + soaking treatment (Table 3) revealed that best treatment was B_3V_3 (colour 7.80, taste 8.50, aroma 6.60,

overall acceptability 8.30) was selected on the basis of its higher sensory scores. Data of cooking + soaking treatment (Table 4) revealed that the best treatment was C_2V_3 (colour 7.10, taste 7.80, aroma 5.80, overall acceptability 7.50) was selected best on the basis of its higher sensory scores. Results on pressure cooking + soaking treatment (Table 5) revealed that the best treatment was P_2V_3 (colour 7.20, taste 7.50, aroma 5.90, overall acceptability 7.10) was selected on the basis of its higher sensory scores. All these pre-treatments were selected mainly on the basis of taste and overall acceptability scores keeping in mind the removal of bittering component (saponins) besides giving minor importance to other attributes.
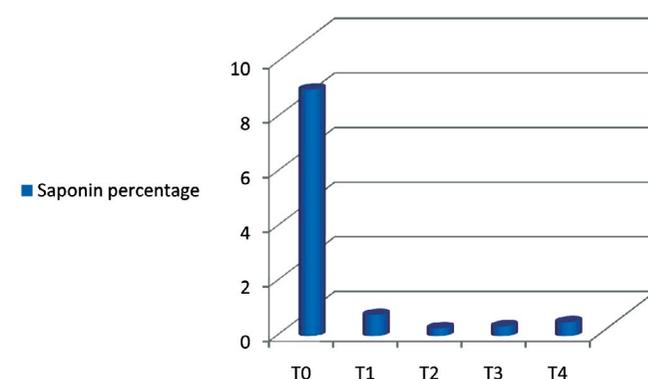
Fig. 1: Effect of different treatments on saponin content of Indian horse chestnut

T_0 = Saponin content of Indian horse chestnut

T_1 = Saponin content after 40 days soaking treatment

T_2 = Saponin content after 10 min blanching + 32 days soaking treatment

T_3 = Saponin content after 30 min cooking + 28 days soaking treatment

T_4 = Saponin content after 20 min pressure cooking + 28 days soaking treatment

The taste scores increased with the passage of soaking time in respective, pre-treatments because of decrease in bitterness caused by removal of saponins. The reason for decrease in colour with increase in treatment period could be due to less retention of natural colour because of leaching. So higher scores of taste and overall acceptability of pretreated horse chestnut mass was apparently due to the maximum reduction in the saponins content which could have lead the judges to give the higher scores to the respective pre-treatments.
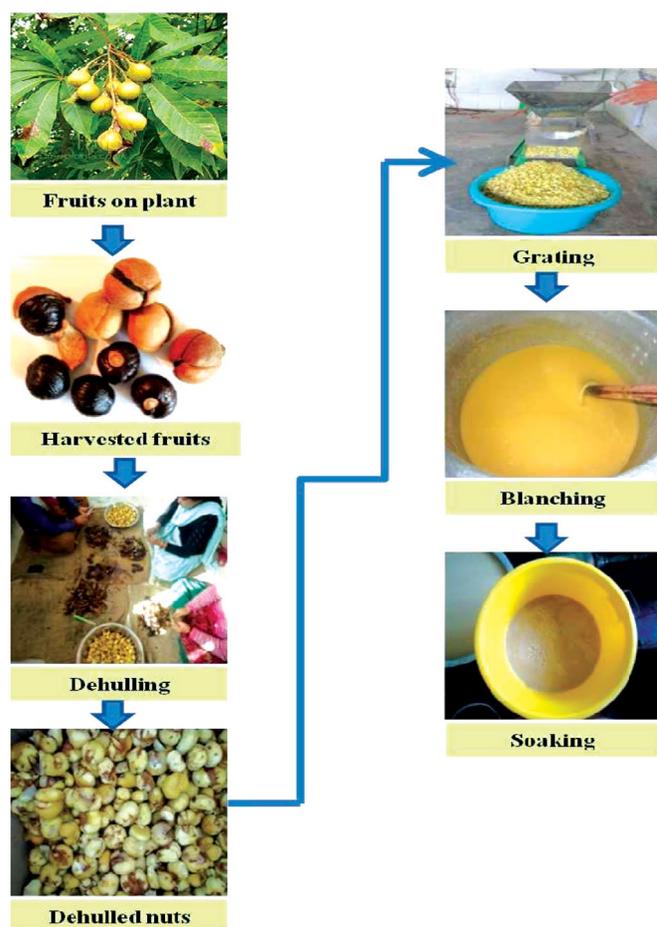

Fig. 2: Standardized unit operations for the removal of saponins from Indian horse chestnut

Among the best selected pre-treatments, T_2 (blanching 10 min + soaking 32 days) treatment (Table 6) was selected finally on the basis of its maximum sensory characteristics scores viz., colour,

taste, aroma and overall acceptability. This treatment shows maximum removal of saponins content in comparison to other selected pretreatments (Figure 1). The reason for comparatively best colour score of this treatment might be due to the retention of natural colour observed in grated material. Higher taste score was because of minimum bitterness due to saponins removal. Aroma was not much affected by blanching treatment.

The best score for overall acceptability might be on the basis of acceptable taste. Thus, on the basis of maximum sensory scores and minimum saponins content left in pretreated grated mass of horse chestnut, T_2 treatment was adjusted to be the best. Similarly, Nwosu (2010) have observed that 48 h soaking reduced saponins (0.42-0.24%), 8 min blanching reduced saponins (0.42-0.36 %) and 60 min cooking reduced saponins (0.42-0.28%) in asparagus bean, John *et al*. (2009) have observed 100 per cent reduction of saponins after 12 h soaking and 15 min autoclaving in navy bean, while Nwosu (2011) have observed that 8 min blanching reduced saponins (840-20 mg/100g) and 100 per cent reduction after 20 min cooking in oze seed. Saleh *et al*. (2006) have also observed that 12 h soaking and 15 min autoclaving reduced saponins (0.91-0.51 mg/g) in chickpea seed.

Conclusion

To remove the saponins content from the horse chestnut mass, various pre-treatments were followed and the best treatments were selected on the basis of sensory characteristics. Among the soaking pretreatments S_8 (40 days soaking) treatment was found to be the best, whereas, among the blanching + soaking pretreatments, B_3V_3 (10 min + 32 days soaking) treatment was selected. Out of the cooking + soaking pretreatments, C_2V_3 (30 min +28 days soaking) was selected and among the pressure cooking + soaking pretreatments, P_2V_3 (20 min + 28 days soaking) treatment was selected for further comparison.

Finally while comparing the 4 best selected pretreatments mentioned above B_3V_3 (10 min blanching + 32 days soaking) was found to be the best on the basis of sensory characteristics and maximum

removal of saponins content from 9.03 to 0.29 per cent. Thus debittered mass of Indian horse chestnut can be made into flour for the development of various value added products (Figure 2).

Acknowledgements

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