NMHS
National Mission on Himalayan Studies

Standard Operating Procedure (SOP)
Functional foods R&D Centre and dissemination of the developed technology

NMHS Project: Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of Himachal Pradesh

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Study was conducted to extract dietary fibre from bamboo shoots and to utilize it in cereal and dairy products. The shoots of four species viz., Dendrocalamus strictus,Dendrocalamus hamiltonii, Phyllostachys reticulate and Bambusa nutans harvested at 30, 40, 50and 60 cm height were used and analyzed for different quality attributes. D. hamiltonii at 60 cmlength recorded the maximum crude fibre (2.15%) and hence was utilized for extraction ofdietary fibre by enzymatic-gravimetric method. Among 27 treatments, the highest total dietaryfibre yield (70.25%) was obtained from (enzymes incubation temperature and time combinationof 100°C for 30 min in α-amylase, 45°C for 60 min in protease and 40°C for 4 h in cellulase).The bamboo shoot powder contained higher value for crude protein (10.49%), cellulose(89.07%) and hemicellulose (30.85%) while extracted dietary fibre contained higher amount oftotal dietary fibre (70.25), insoluble dietary fibre (63.41%), soluble dietary fibre (6.84%) andlignin (99.80%). Water holding capacity (15.39 mL/ g), oil holding capacity (7.93 mL/ g),swelling capacity (27.23 mL/ g) and bulk density (0.652 g/ cm3) were significantly higher inextracted dietary fibre. The extracted dietary fibre packed in HDPE jars retained better quality atambient condition during storage as compared to rest of the packaging materials. The bambooshoot powder and extracted dietary fibre were incorporated in cereal and dairy products forenrichment. Dietary fibre can be supplemented at a level of 8 per cent while bamboo shootpowder at 6 per cent in cookies which can be stored up to 3 months in PET jars and LDPEpouches. However, the quality was better in PET jars. Out of 6 treatments of pasta, a level of 8per cent for both bamboo shoot powder and dietary fibre gave the better product which can bestored for three months with minimal quality changes. The bamboo shoot powder and dietaryfibre incorporated in yoghurt was found to be the best at a level of 1.0 and 1.5 per cent,respectively. For incorporation in paneer, a level of 2.5 per cent gave the product of betterquality. The yoghurt and paneer packed in polystyrene cups and LDPE pouches, respectively canbe stored up to ten days under refrigerated condition. The study revealed that incorporation ofbamboo shoot powder and bamboo dietary fibre can enhance the nutritional (protein and fibre)quality. Incorporation of extracted dietary fibre can enhance the protein as well as dietary fibre indifferent products. However, the dietary fibre was higher in extracted dietary fibre incorporatedproducts and protein in bamboo shoot powder incorporated products. Henceforth, it is concludedthat bamboo shoot can be successfully converted into powder and dietary fibre can be extractedfrom the powder. These can be safely be utilized for the development of functional food productslike cookies, pasta, yoghurt and paneer.

1. **Studies on extraction of dietary fibre from bamboo grown in Himachal Pradesh and its utilization for nutritional supplementation**

Step 1: Evaluation of bamboo shoots for physico-chemical characteristics

The bamboo shoots of different species (Table-1) harvested at 30, 40, 50 and 60 cm height were analyzed for various physical and chemical characteristics. The species which contained the maximum crude fibre was selected for preparation of powder.

Species	Stage of harvesting of bamboo shoot (cm)
Dendrocalamus strictus	30, 40, 50 and 60
Dendrocalamus hamiltonii	30, 40, 50 and 60
Phyllostachys reticulata	30, 40, 50 and 60
Bambusa nutans	30, 40, 50 and 60

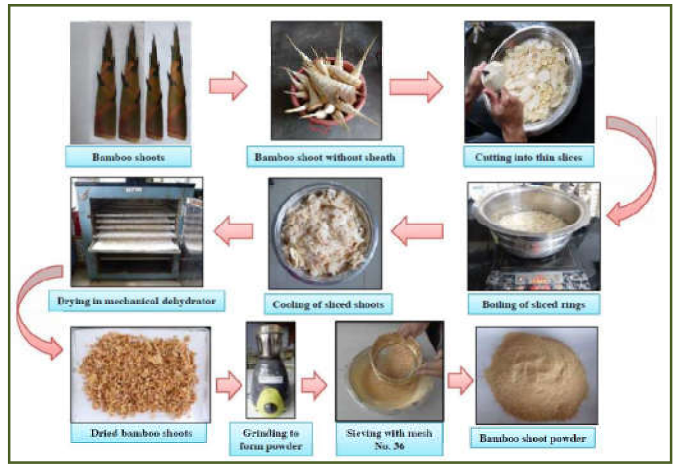
Step 2: Standardization of technique for preparation of bamboo shoot powder

The bamboo shoot containing highest crude fibre was taken for preparation of powder. The shoot with sheath was washed to remove any adhering dirt, dust or any other foreign material. The sheath was removed for extraction of tender shoot. The bamboo shoots were cut into thin slices. The fresh shoots contain hydrogen cyanide (HCN), a toxic substance which needs to be removed prior to use for edible purposes. The bamboo shoot slices were soaked in water for 24 h. These slices were then boiled for 90 min. The water was drained and the slices were allowed to cool down at room temperature. The bamboo shoot slices were dried in a mechanical dehydrator at 60±2°C for 5 h i.e. until it reached equilibrium moisture content. The slices were converted into powder with the help of a grinder. The powder was passed through a sieve of 36 mesh size and stored in polyethylene pouches with proper sealing until further use.

Preparation of Bamboo shoot powder

Fresh bamboo shoots
⇩
Washing
⇩
Removing outer sheath
⇩
Washing
⇩
Cutting into thin slices
⇩
Soaking in water for 24 hours
⇩
Boiling for 90 minutes
⇩
Straining of excess water
⇩
Allowing to cool down at room temperature
⇩
Spreading in single layer on dehydrator tray
⇩
Drying in mechanical dehydrator at 60°C for 5 hours
⇩
Grinding into powder using grinder
⇩
Sieving using 36 mesh sieve
⇩
Packaging (LDPE pouch)
⇩
Storage at ambient condition

Preparation of bamboo shoot powder



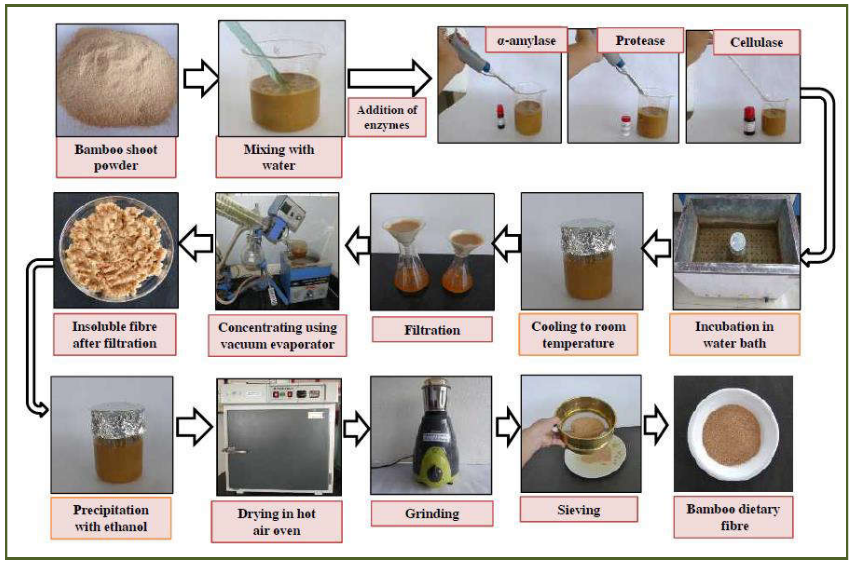
Step 3: Optimization of technique for isolation of dietary fibre from bamboo shoots

Bamboo shoot with highest crude fibre content was used for preparation of powder. The powder was prepared and utilized for isolation of dietary fibre. The dietary fibre was isolated by using enzymatic - gravimetric method. The extraction was carried out by using the enzymes *viz.* heat stable α - amylase, protease and cellulase (Table-2). The bamboo shoot powder was mixed with distilled water (a solid liquid ratio of 1:3) in a beaker and mixed well with a glass stirring rod. A 200 μL heat stable α - amylase (Activity ≥4000 U/ gds) per gram sample was added into the beaker and incubated in a water bath. The pH of the mixture was then adjusted to 6.8 with 1 mol/ L NaOH. A 2 mL neutral protease (Activity≥2000 U/ gds) per gram sample was added into the beaker and incubated in a water bath. Subsequently, the pH was adjusted to 6.0 with 1 mol/ L HCl. 1800 μL cellulose (Activity≥1800 U/gds) per gram sample was added into the beaker followed by incubation in a water bath. Then, the treated sample was filtered through a Whatman No. 1 filter paper and the filtrate was concentrated to one-third of its initial volume using a rotary evaporator at 50°C under vacuum. The concentrated sample was added into a quadruple volume of 95 per cent alcohol and kept undisturbed for 30 min. After removing the alcohol, the residue was collected and oven-dried at 60°C for 5 h in order to obtain dietary fibre. The extracted dietary fibre was ground into fine powder using a grinder and sieved with stainless steel sieve (No. 36). The best time and temperature combination based on the performance of high dietary fibre yield and functional properties was selected. The ground dietary fibre powder was thenstored in LDPE pouches for further use. The dietary fibre was extracted by using different time-temperature combination.

Incubation time and temperature of heat stable α - amylase, protease and cellulase for Extraction of dietary fibre from bamboo shoot

Treatment	α-amylase		Protease		Cellulase	
	Temp. (°C)	Time (min)	Temp. (°C)	Time (min)	Temp. (°C)	Time (h)
T_1	80	15	35	40	30	3.5
T_2	90	15	40	40	30	3.5
T_3	100	15	45	40	30	3.5
T_4	80	30	35	60	30	4.0
T_5	90	30	40	60	30	4.0
T_6	100	30	45	60	30	4.0
T_7	80	45	35	80	30	4.5
T_8	90	45	40	80	30	4.5
T_9	100	45	45	80	30	4.5
T_{10}	80	15	35	40	40	3.5
T_{11}	90	15	40	40	40	3.5
T_{12}	100	15	45	40	40	3.5
T_{13}	80	30	35	60	40	4.0
T_{14}	90	30	40	60	40	4.0
T_{15}	100	30	45	60	40	4.0
T_{16}	80	45	35	80	40	4.5
T_{17}	90	45	40	80	40	4.5
T_{18}	100	45	45	80	40	4.5
T_{19}	80	15	35	40	50	3.5
T_{20}	90	15	40	40	50	3.5
T_{21}	100	15	45	40	50	3.5
T_{22}	80	30	35	60	50	4.0
T_{23}	90	30	40	60	50	4.0
T_{24}	100	30	45	60	50	4.0
T_{25}	80	45	35	80	50	4.5
T_{26}	90	45	40	80	50	4.5
T_{27}	100	45	45	80	50	4.5

Standardization of technique for isolation of dietary fibre from bamboo shoots



Unit operations for extraction of dietary fibre using enzymatic method

Bamboo shoot powder
⇩
Mixing with distilled water (solid liquid ratio of 1:3)
⇩
Adding heat stable α - amylase (Activity ≥4000 U/gds; 200 μL/g sample) to a mixture
⇩
Incubating in water bath
⇩
Adjusting pH of mixture to 6.8 with 1 mol/L NaOH
⇩
Adding neutral protease (Activity≥2000 U/gds; 2 mL/g sample)
⇩
Incubating in water bath
⇩
Adjusting pH of mixture to 6.0 with 1 mol/L HCl
⇩
Adding cellulase (Activity≥1800 U/gds; 1800 μL/g sample)
⇩
Incubating in water bath
⇩
Filtering of the treated extract through Whatman No.1
⇩
Concentrating the filtrate to one-third of the initial volume using rotary evaporator at 50°C under vacuum
⇩
Adding concentrate and filtrateinto quadruple volume of 95% ethanol
⇩
Keeping the mixture undisturbed for 30 minutes
⇩
Removing alcohol and collecting deposit
⇩
Drying in oven at 60°C for 4-5 hours
⇩
Grinding into fine powder using a grinder
⇩
Sieving with stainless steel sieve (No. 36)
⇩
Packaging
(LDPE pouch, ALP pouch, PET jar and HDPE jar)
⇩
Storage at ambient condition

Step 4: Utilization of bamboo shoot powder and bamboo dietary fibre in food products

The bamboo shoot powder and bamboo dietary fibre were incorporated in different cereal products such as cookies, pasta, and milk products such as yoghurt and paneer in order to enhance their functional properties. The standardization of ingredients, method of preparation and optimization of incorporation levels in these products are discussed here under:

Cookies

Step 1: Standardization of recipe for cookie preparation

Recipe for cookie preparation

Ingredients	Recipe I	Recipe II	Recipe III	Recipe IV	Recipe V
Refined wheat flour (g)	100	100	100	100	100
Vegetable ghee (g)	40	40	40	45	50
Sugar powder (g)	35	35	35	45	50
Skim milk powder (g)	10	10	10	10	10
Salt (g)	0.75	0.8	0.85	0.9	1.0
Sodium bicarbonate (g)	1	1	1	1	1
Water (mL)	25	25	25	25	25

Step 2: Optimization of level of bamboo shoot powder supplementation in cookies

Optimization of level of bamboo shoot powder supplementation in cookies

Treatment	Refined wheat flour : Bamboo shoot powder
T1	100:0
T2	98:2
T3	96:4
T4	94:6
T5	92:8
T6	90:10

Step 3: Flow sheet for preparation of cookies

Refined wheat flour

Powdered sugar ⇨ ⇩ ⇦ Sodium bicarbonate

Sieving

Skimmed milk powder ⇨ ⇩ ⇦ Salt

Beating of powdered sugar and vegetable ghee until light and

Mixing of ingredients

⇩

Mixing thoroughly to form soft dough by adding water

⇩

Kneading dough for 10 minutes

⇩

Wrapping in aluminium foil

⇩

Allowing the dough to stand at room temperature (30 minutes)

⇩

Making balls from the dough

⇩

Rolling the dough to 0.6 cm thickness

⇩

Cutting into circular shape using cookie cutter having 4.0 cm diameter

⇩

Keeping the cut parts on a baking tray lined with butter paper

⇩

Baking in oven at 200°C for 20 minutes

⇩

Allowing the cookies to cool at room temperature

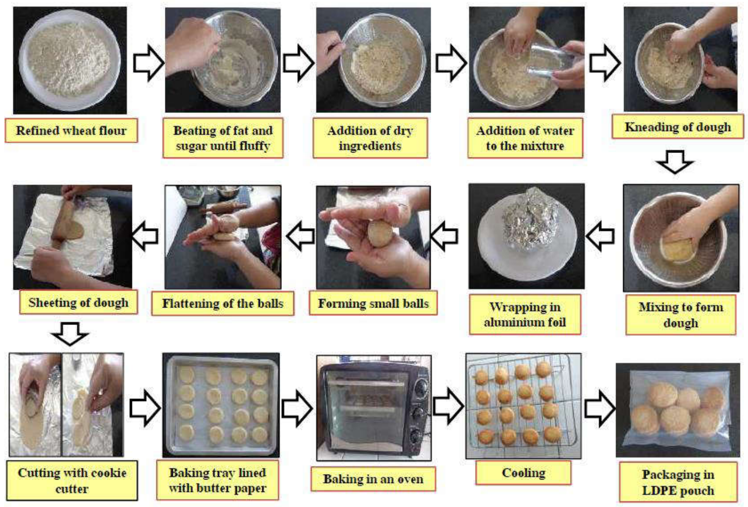
⇩

Packaging in LDPE pouches and PET Jars

⇩

Storage at ambient temperature

Step 4: Unit operations for preparation of cookies



Step 5: Optimization of level of bamboo dietary fibre supplementation in cookies

Optimization of level of bamboo dietary fibre supplementation in cookies

Treatment	Refined wheat flour : Bamboo dietary powder
T1	100:0
T2	98:2
T3	96:4
T4	94:6
T5	92:8
T6	90:10

Step 6: Detail of treatments of cookie selected for storage studies

The cookies of different selected treatments were prepared and packed in LDPE pouches and PET jars for quality evaluation at storage intervals of 0, 45 and 90 days.

Treatment	Description
T1	Cookies (100 % refined wheat flour)
T2	Cookies supplemented with shoot bamboo powder
T3	Cookies supplemented with bamboo dietary

Pasta

Step 1: Standardization of recipe and method for pasta preparation

Optimization of semolina: water combination for pasta preparation

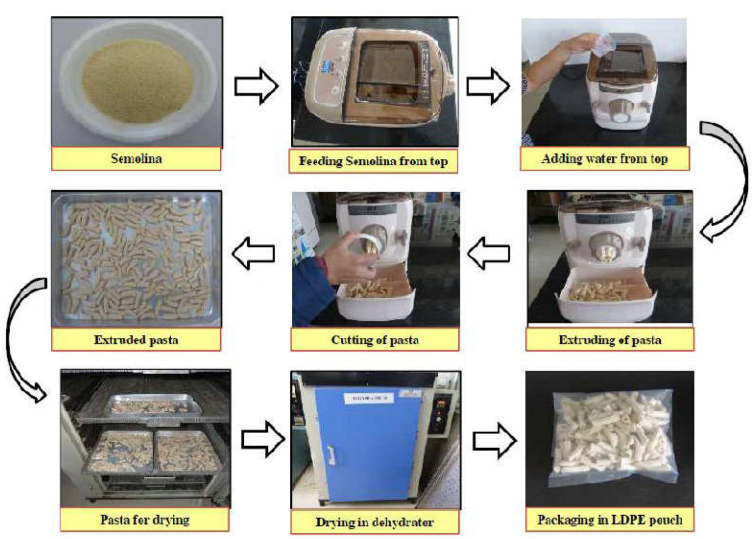
Formulation	Semolina (g)	Water (mL)
F1	200(g)	85(mL)
F2	200 (g)	90(mL)
F3	200 (g)	95(mL)

Step 2: Flow sheet for preparation of pasta

Semolina
⇩
Weighing
⇩
Sieving
⇩
Feeding from the top of Kent Pasta/ Noodle maker
⇩
Adding required amount of water
⇩
Allowing the mixture to mix thoroughly in the machine for 6-8 minutes for uniform distribution of water
⇩
Extruding through a die to obtain pipe rigate shape pasta
⇩
Cutting the pasta into 2 cm length manually
⇩
Drying at 60°C for 4-5 hours in mechanical dehydrator
⇩
Allowing the pastas to cool at room temperature
⇩
Packaging in LDPE pouch and PET jar
⇩
Storage at ambient temperature

Step 3: Unit operations for preparation of pasta

The weighed quantity of semolina was sieved and fed into the mixing chamber of Kent Noodle and Pasta Maker from the top. The lid of the appliance was closed and plugged in. The 'Auto' (automatic mode) key was pressed to start the appliance. The water was added in the right proportion after turning on the appliance. The mixing time was standardized (6-8 min) to ensure proper mixing. The pastas were extruded through a die to obtain pipe rigate shape and manually cut into 2 cm length. The extruded pasta of various formulations was dried in a mechanical dehydrator at 60±2°C for about 5 h or till its weight became constant. For sensory evaluation, the pasta was cooked in salted water (2%) in the ratio of 1:5 for 15 min. After cooking, the water was immediately drained and the hot pasta was served to a panel of ten judges.



Step 4: Optimization of level of bamboo shoot powder and bamboo dietary fibre for supplementation in pasta

Treatment	Semolina : Bamboo shoot powder	Semolina : Bamboo dietary fibre
T1	100:0	100:0
T2	98:2	98:2
T3	96:4	96:4
T4	94:6	94:6
T5	92:8	92:8
T6	90:10	90:10

Step 5: Detail of treatments of pasta selected for storage studies

The best treatments were selected for storage studies. The pastas of different treatments were prepared and packed in LDPE pouches and PET jars. The products were evaluated for various quality parameters at storage intervals of 0, 45 and 90 days. The detail of treatments of cookie selected for storage studies is presented in Table

Treatment	Description
T1	Pasta (100 % semolina)
T2	Pasta supplemented with bamboo shoot powder
T3	Pasta supplemented with bamboo dietary fibre

Yoghurt

Step 1: Standardization of recipe for yoghurt preparation

The standardized Amul tetra pack cow's milk (Fat-4.5% and SNF-8.5%) was boiled and allowed to cool to room temperature. The milk was poured into polystyrene cups (1000 mLcapacity) uniformly. Then the combined culture of Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus thermophilus @ 1 per cent was added to the milk (Table-11) with continuous stirring to ensure proper mixing of the combined culture with milk. The cups were covered with aluminum foil for incubation. The cups were incubated for 4 to 6 h at 43°C. The yoghurt prepared was refrigerated (5°C). These yoghurts inoculated with different levels of combined culture were subjected to sensory evaluation by a panel of ten judges. The best formulation was selected on the basis of highest sensory scores and was referred for further studies.

Step 2: Unit Operations for preparation of Yoghurt

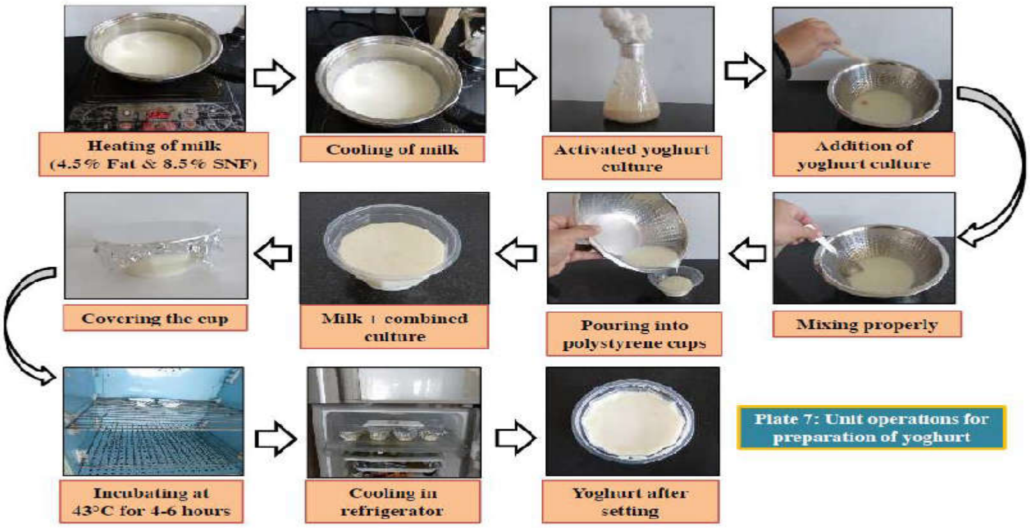


Plate 7: Unit operations for preparation of yoghurt

Step 3: Optimization of level of combined culture for yoghurt preparation

Formulation	Milk (mL)	Combined culture (mL)
F1	1000(mL)	1.0(mL)
F2	1000 (mL)	1.5(mL)
F3	1000 (mL)	2.0(mL)

Step 4: Unit operations for preparation of yoghurt

Standardized milk
(4.5% Fat and 8.5% SNF)
⇓
Boiling
⇓
Cooling
⇓
Adding rehydrated bamboo fibre ← Rehydration in water for overnight ← Bamboo powder/ Dietary fibre
⇓
Mixing/ Homogenizing
⇓
Inoculation of yoghurt mixed cultures
(*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) @ 1% in milk
⇓
Filling in polystyrene cups (100 mL)
⇓
Incubating for 4 to 6 hours (43°C)
⇓
Allowing to cool
⇓
Storing yoghurt cups at refrigerated condition (5°C)

Step 5: Optimization of level of bamboo shoot powder and bamboo dietary fibre enrichment in yoghurt

Treatment	Bamboo shoot powder (%)	Bamboo dietary fibre (%)
T1	0	0
T2	0.5	0.5
T3	1.0	1.0
T4	1.5	1.5
T5	2.0	2.0
T6	2.5	2.5

Step 6: Detail of treatments of yoghurt selected for storage studies

The yoghurt of different treatments selected earlier was prepared and kept for storage at refrigerated condition (5°C). The products (Table-14) were evaluated for various quality parameters at 0, 5 and 10 days of storage intervals.

Treatment	Description
T1	Yoghurt (without enrichment)
T2	Yoghurt enriched with bamboo shoot powder
T3	Yoghurt enriched with bamboo dietary fibre

Paneer

Step 1: Standardization of recipe for preparation of paneer

The paneer was prepared by using cow's milk and citric acid. The whole milk (Verka packet milk - 6 % fat) 1000 ml was heated to 82°C for 5 minutes and then allowed to cool to 70°C. At the same time, citric acid solution of different proportions (Table-15) was heated to 70°C and added to the milk with continuous stirring till coagulation and clear transparent greenish yellow whey separated.

Step 2: Unit operations for preparation of paneer

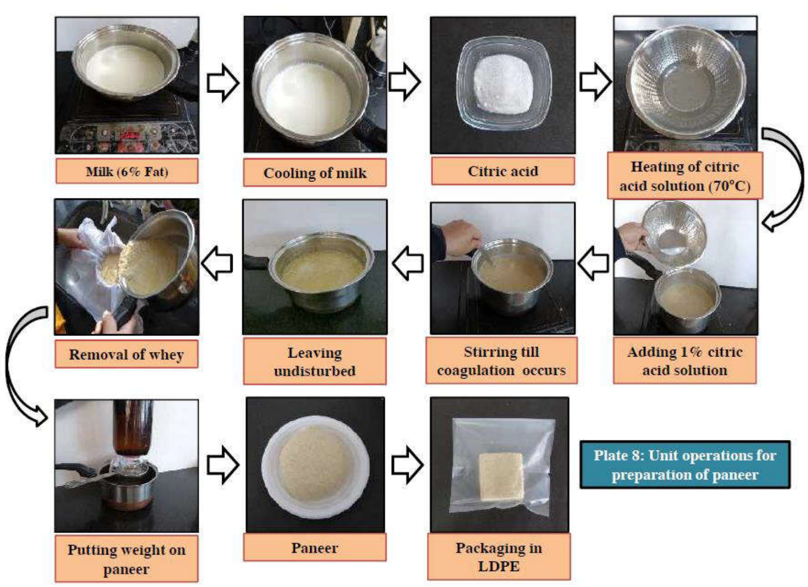


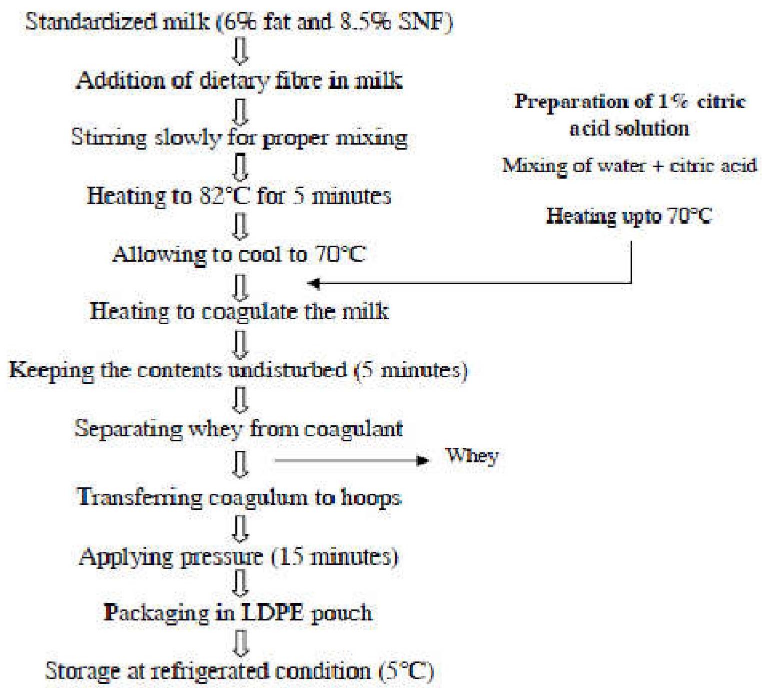
Plate 8: Unit operations for preparation of paneer

Step 3: Optimization of level of citric acid solution for paneer preparation

After coagulation, the contents were left undisturbed for 5 min and filtered in order to remove the whey. The coagulum was transferred to hoops and pressure was applied for about 15 min. The best milk and citric acid combination was selected on the basis of highest sensory scores.

Combination	Whole milk (mL)	Citric acid (%)
C1	1000	1.0
C2	1000	1.5
C3	1000	2.0

Step 4: Unit operations for preparation of paneer



Step 5: Optimization of level of bamboo shoot powder enrichment in paneer

Treatment	Bamboo shoot powder (%)	Bamboo dietary fibre (%)
T1	0	0
T2	0.5	0.5
T3	1.0	1.0
T4	1.5	1.5
T5	2.0	2.0
T6	2.5	2.5

Step 6: Detail of treatments of paneer selected for storage studies

The paneer of different treatments selected earlier were prepared and packed in LDPE pouches. The product (Table-18) was stored at refrigerated condition (5°C) and evaluated for various quality parameters at storage intervals of 0, 5 and 10 days.

Treatment	Description
T1	Paneer (without enrichment)
T2	Paneer enriched with bamboo shoot powder
T3	Paneer enriched with bamboo dietary fibre

2. Development of beverages from wild jamun (*Syzygium cumini L.)*

Step 1: Extraction of pulp: Fresh fruits of wild jamun were washed and pulp was extracted by four different methods:

- **Crushing followed by heating then pulping:** 5 kg of jamun fruits were randomly selected and crushed with the help of grater. The crushed material was heated for about 10 min then pulping was carried out by brush type pulper.
- **Crushing and pulping:** 5 kg of jamun were randomly selected and crushed with the help of grater followed by pulping with brush type pulper.
- **Hot pulping without crushing:** 5 kg of jamun were randomly selected and cooked under pressure in their own juice in low flame of LPG stove (719.64 KJ/ kg) for 10 min until pulp becomes loose enough for further pulping by brush type pulper.
- **Cold pulping without crushing:** Pulping of 5 kg of jamun fruits was done by putting them directly in the pulper.

Unit operations for the extraction of wild jamun juice

Step 2: Extraction of juice: After the extraction of pulp it was further treated by the use of different enzymes. Different concentrations of enzymes were used to treat the pulp for different time period at 45oC temperature. Details of the treatments are given in Table 1, 2 and 3.

Table 1 Treatment details of juice extraction using Pectinase enzyme

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9
Concentration (%)	0.02	0.02	0.02	0.04	0.04	0.04	0.08	0.08	0.08
Time (Min)	60	90	120	60	90	120	60	90	120

Table 2 Treatment details of juice extraction using Viscozyme enzyme

Treatment	T1	T2	T3	T4	T5	T6	T7	T8
Concentration (%)	0.05	0.05	0.1	0.1	0.5	0.5	1.0	1.0
Time (Min)	30	60	30	60	30	60	30	60

Table 3 Treatment details of juice extraction using the combination of Viscozyme +Pectinase (3:1) enzymes

Treatment	T1	T2	T3	T4	T5	T6	T7	T8
Concentration (%)	0.05	0.05	0.1	0.1	0.5	0.5	1.0	1.0
Time (Min)	30	60	30	60	30	60	30	60

Juice extracted by all these methods was compared on the basis of juice yield, viscosity and total soluble solids (TSS). The best selected enzyme combination (concentration and time) was used further for juice extraction from fruits on large scale. Extracted juice was stored in PET jars in deep freezer at -18oC before making the different products. Further, this juice after thawing at room temperature was used for the preparation of various beverages later.

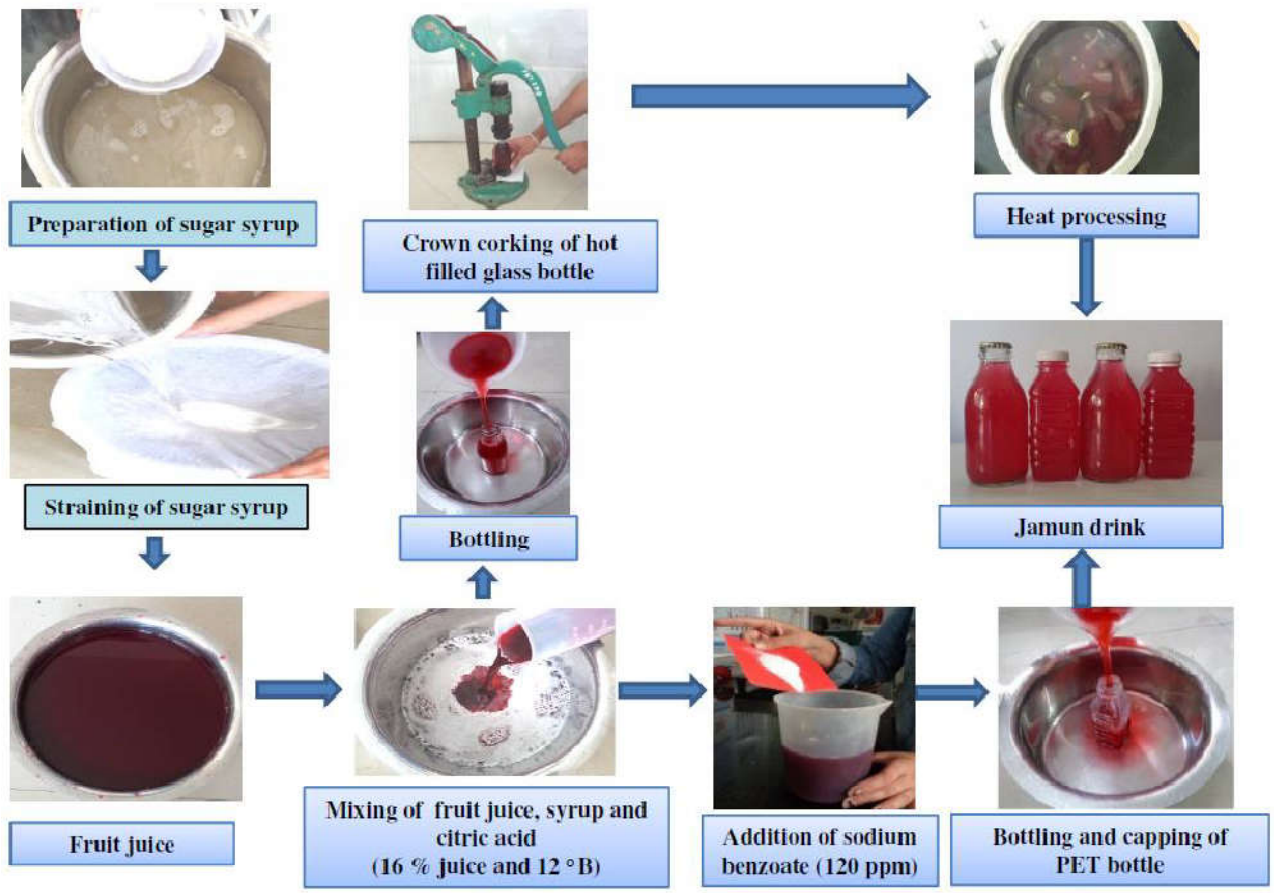
Step 3: Development of beverages: Different treatment combinations of juice were tried to develop beverages like drink, squash, appetizer and syrup. As this fruit contains sufficient amount of natural flavor and colour in its juice so no artificial flavour and colour were added to any of developed products.

Drink: Fruit drink was prepared by mixing different proportions of wild jamun juice in different combinations of sugar syrup as given in Table 4. To get the desirable concentration of acid (0.30%) in fruit drink, citric acid was added in different treatment combinations. Sodium benzoate (120 ppm) was added in all the treatments as a preservative. The drink was packed in pre-sterilized glass and PET bottles, each of 200 mL capacity. The drink was stored in ambient (20- 25oC) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of drink were carried out at zero, three and six months of storage.

Table 4: Treatment detail of fruit drink

Treatment	D1	D2	D3	D4	D5	D6	D7	D8
Juice (%)	10	12	14	16	10	12	14	16
TSS (°B)	12	12	12	12	15	15	15	15

Unit operations for the preparation of wild jamun drink

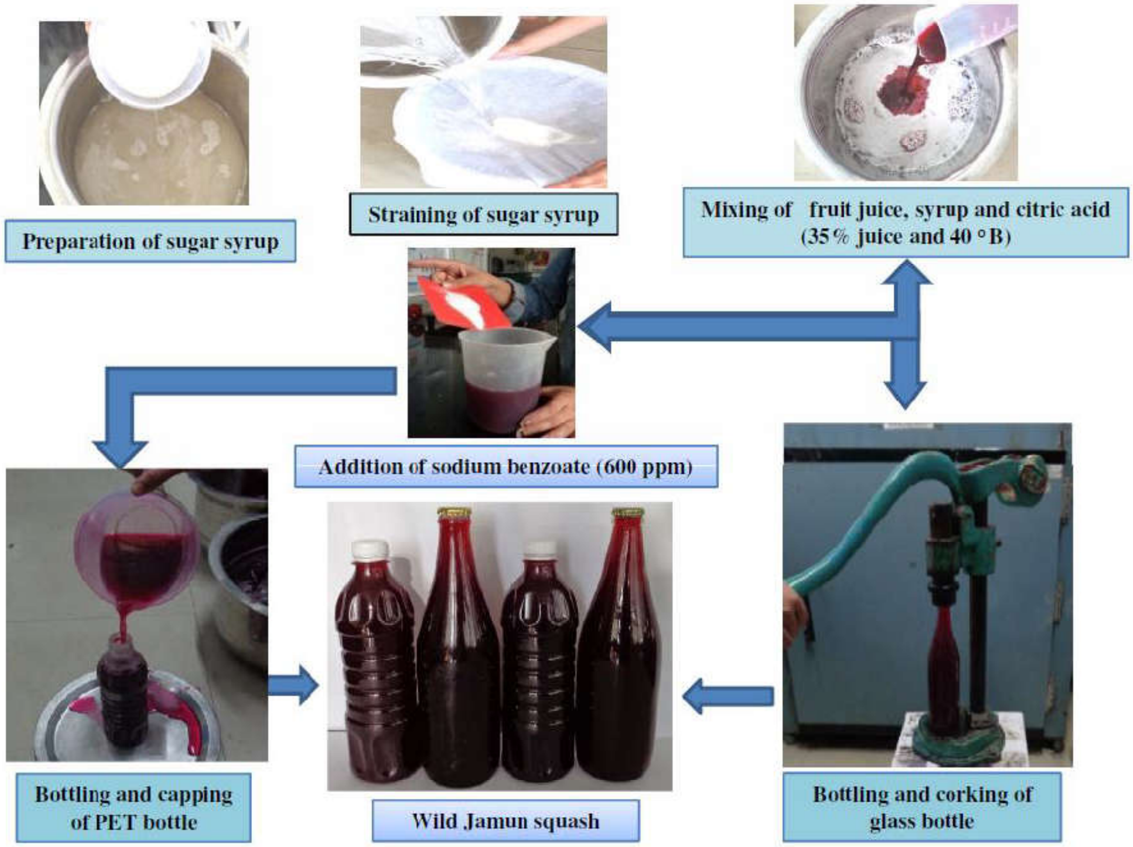


Squash: Wild jamun squash was prepared by mixing juice and sugar syrup in different combinations as mentioned in Table 5. To get the desirable concentration of acid (1.2%) in fruit squash, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added in all the treatments as a preservative. The squash was packed in pre-sterilized glass and PET bottles (700 mL capacity). All the packed products were properly labelled and stored in ambient (20- 25$_0$C) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of squash was carried out at zero, three and six months of storage.

Table 5: Treatment detail of fruit squash

Treatment	S1	S2	S3	S4	S5	S6	S7	S8
Juice (%)	25	30	35	40	25	30	35	40
TSS (°B)	40	40	40	40	45	45	45	45

Unit operations for the preparation of wild jamun squash

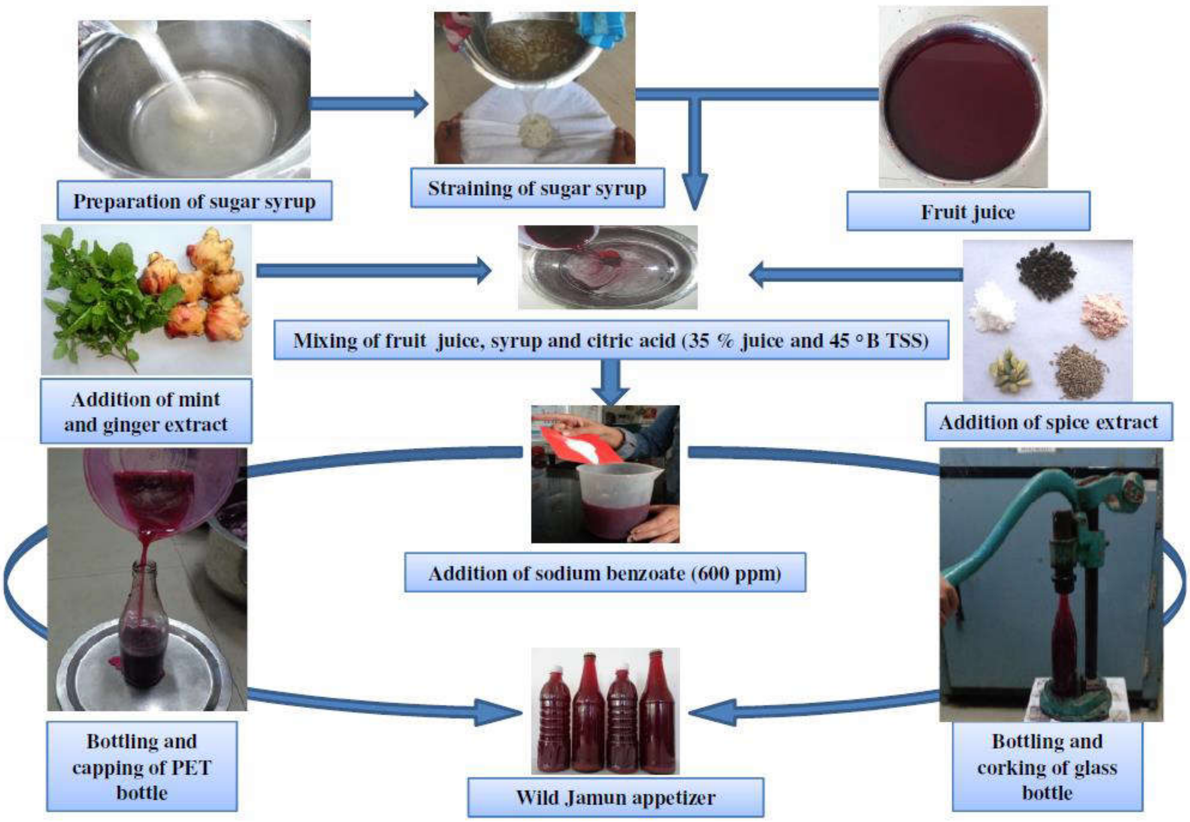


Appetizer: Wild jamun appetizer (spiced squash) was prepared by mixing its juice with sugar syrup in different combinations as given in Table 6. Spice extract was prepared by boiling a ground mixture of pre-determined quantities of spices like cardamom (1 g), cumin (2.5 g) black pepper (2.5 g) in 200 mL of water, common salt (5 g), black salt (5 g) then straining and mixing the extract with mint extract (10 mL) and ginger extract (15 mL). To get the desirable concentration of acid (1.20%) in appetizer, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added at the end of product preparation of appetizer in all the treatments. The appetizer was packed in pre-sterilized glass and PET bottles (700 mL capacity) and stored in ambient (20-25oC) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of appetizer was carried out at zero, three and six months of storage.

Table 6: Treatment detail of appetizer

Treatment	A1	A2	A3	A4	A5	A6	A7	A8
Fruit extract (%)	25	30	35	40	25	30	35	40
TSS (°B)	40	40	40	40	45	45	45	45

Unit operations for the preparation of wild jamun appetizer

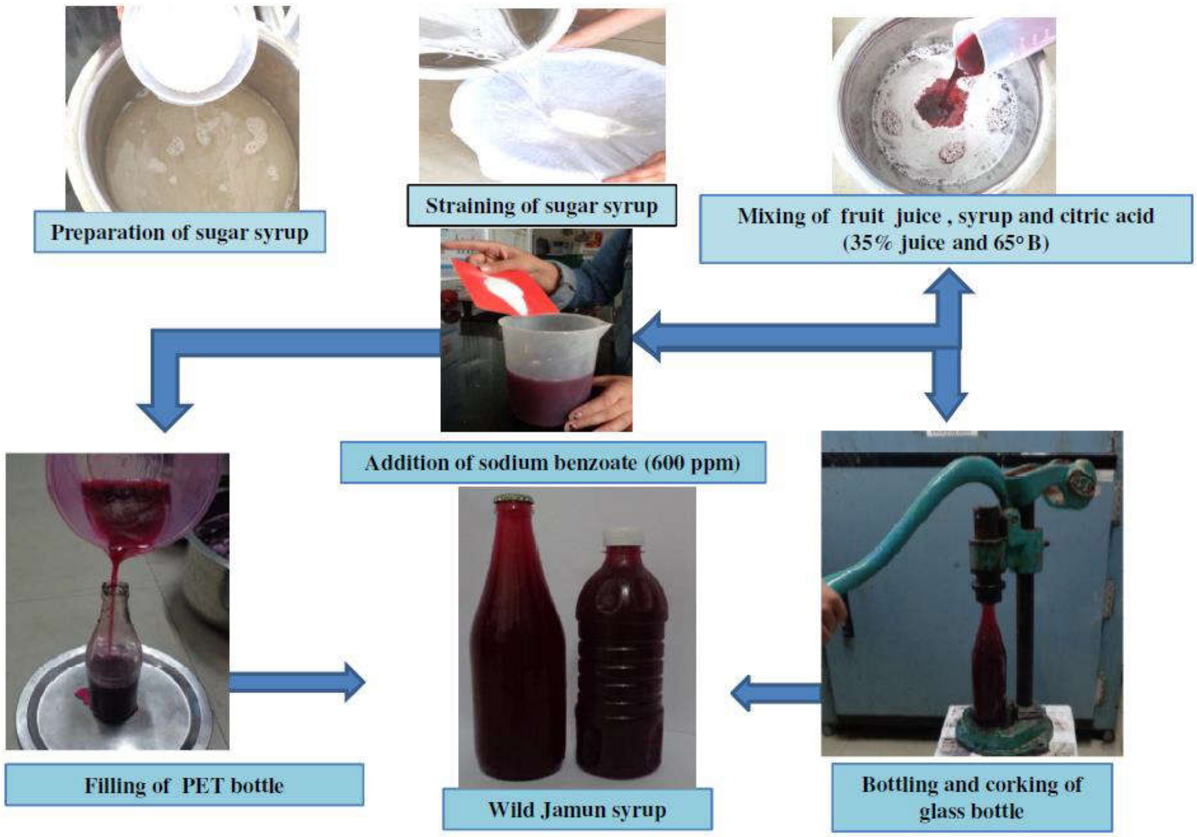


Syrup: Wild jamun syrup was prepared by mixing juice with sugar syrup in different combinations as given in Table 7. To get the desirable concentration of acid (1.50%) in syrup, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added to all the treatments as a preservative. The syrup was packed in pre-sterilized glass and PET bottles (700 mL capacity). The packed syrup was properly labeled and stored in ambient (20- 25oC) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of all the products were carried out at zero, three and six

Table 7: Treatment detail of syrup

Treatment	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Juice (%)	25	30	35	40	25	30	35	40
TSS (°B)	65	65	65	65	70	70	70	70

Unit operations for the preparation of wild jamun syrup



3. Preparation and preservation of persimmon (*Diospyros kaki L.)* pulp and its utilization in dairyproducts

Step 1: Evaluation of persimmon for physico-chemical characteristics: The fruits of persimmon (Table-1) were analyzed for different physico-chemical properties. Ten randomly selected fully ripened fruits were evaluated for physical characteristics. The matured as well as fully ripened fruits with and without peel were analyzed for different chemical parameters by following standard methods.

Table-1 Detail of forms of persimmon fruits for chemical evaluation

Treatment (T)	Detail of treatments
1	Firm/mature fruit with peel
2	Firm/mature fruit without peel
3	Fully ripened fruit with peel
4	Fully ripened fruit without peel

Glimpses of persimmon fruits from harvesting till fully ripened stage

Persimmon fruits on tree

Harvested persimmons

Sliced unripe persimmons

Ripe persimmons

Sliced ripe persimmons

Step 2: Preparation and preservation of pulp from fully ripened persimmon

1. Preparation of ripe persimmon pulp: The pulp was extracted by employing cold and hot pulping methods. The fully ripe persimmon fruits with peel and the fruits without peel were used to extract pulp. The procedure for extraction of pulp by hot and cold pulping method is detailed below:

i) Cold pulping: The ripe persimmons were thoroughly washed. The calyx was removed manually with the help of stainless-steel knife and cut into halves. The seeds and the peel (only in case of pulp without peel) were also removed manually. The fruits after cutting into small pieces were converted into pulp by grinding in a mixer cum grinder.

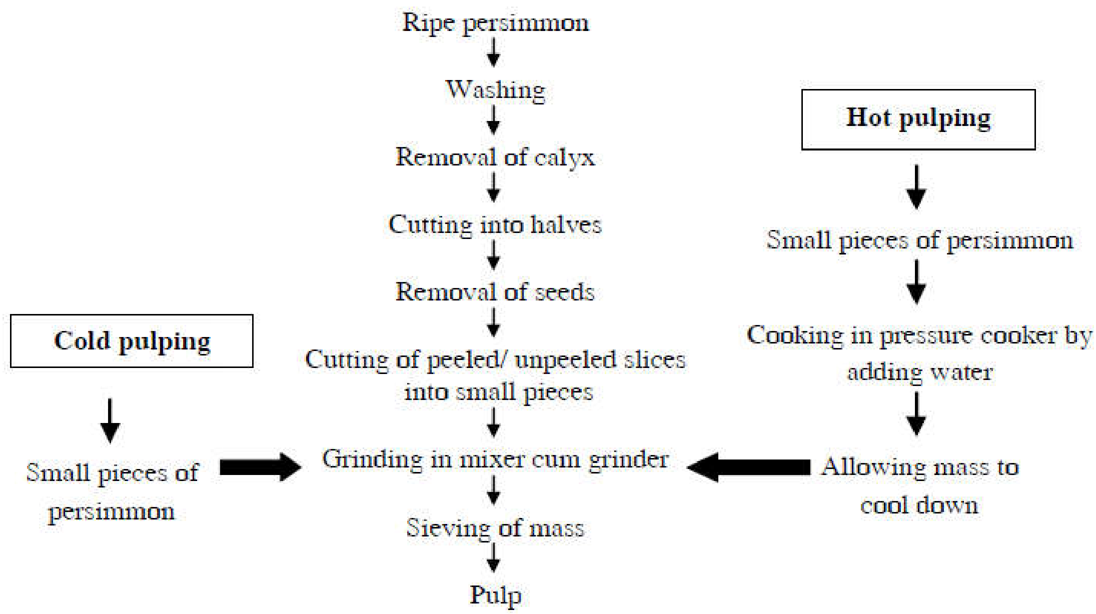
ii) Hot pulping: The procedure followed for extraction of pulp by hot pulping method was the same as discussed above except that the fruit pieces were heated in a pressure cooker (5 kg capacity) on a domestic gas stove with the addition of water @ 10% for 5 min and allowed to cool prior to grinding.

2. Selection of best treatment: The pulp of persimmon fruits with and without peel (Table-2) thus obtained by using hot and cold pulping methods were analyzed for different chemical and sensory parameters. The best treatment was selected keeping in view the retention of nutrients as well as higher sensory scores for further studies.

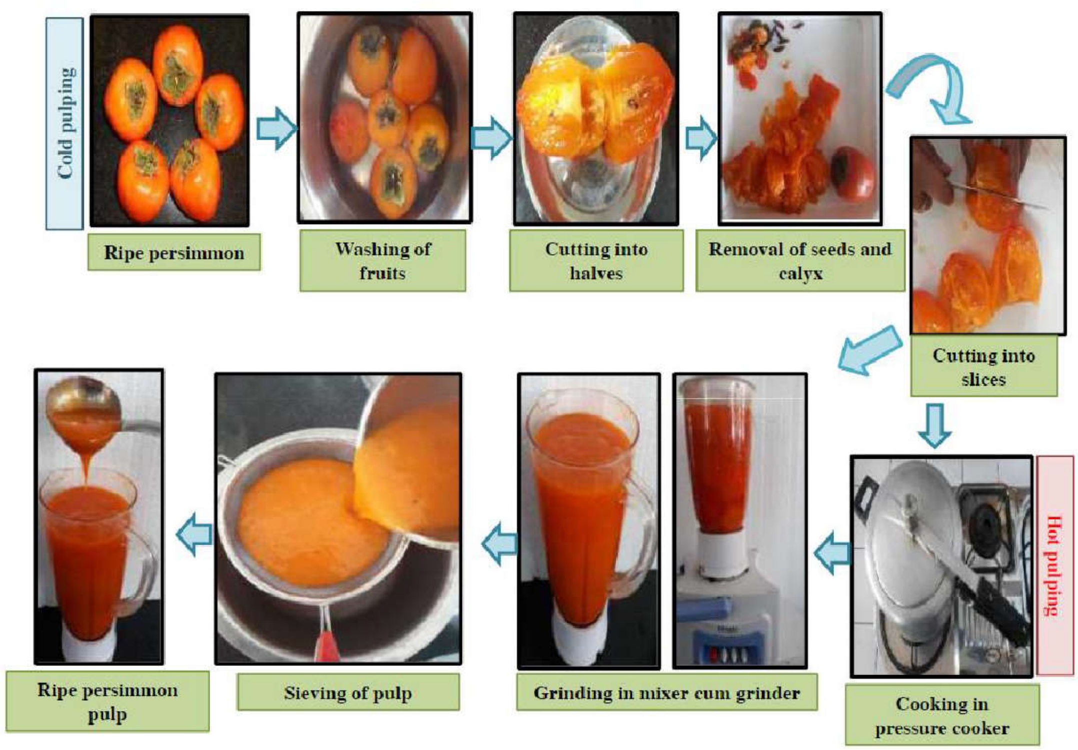
Table-2 Standardization of method for preparation of ripe persimmon pulp

Treatment (T)	Detail of treatments
T1	Cold pulping of fruits with peel
T2	Cold pulping of fruits without peel
T3	Hot pulping of fruits with peel
T4	Hot pulping of fruits without peel

Unit operations for preparation of ripe persimmon pulp



Unit operations for the preparation of persimmon pulp by using different methods



Step 3: Preservation of ripe persimmon pulp: The pulp of treatment selected earlier was prepared. Persimmon is a low acid fruit therefore the pulp was acidified by adding citric acid to a level of 0.4 per cent. The acidified pulp was preserved by using different methods (Table-3) as detailed below. Standard procedures were followed for preservation of pulp by different methods. The pulp was packed in different packaging material such as PET jars,

glass jars, glass bottles and cans as per the method of preservation. The pulp was evaluated for quality at different storage intervals of 0, 3 and 6 months.

Table-3 Treatment detail for preservation of ripe persimmon pulp

Treatment (T)	Detail of treatments
T1	Pulp + KMS (2000 ppm) in glass jars
T2	Pulp + sodium benzoate (2000 ppm) in glass jars
T3	Pulp + KMS (1000 ppm) + sodium benzoate (1000 ppm) in glass jars
T4	Pulp + KMS (2000 ppm) in plastic jars
T5	Pulp + sodium benzoate (2000 ppm) in plastic jars
T6	Pulp + KMS (1000 ppm) + sodium benzoate (1000 ppm) in plastic jars
T7	Pulp + pasteurization in glass bottles
T8	Pulp + pasteurization + sodium benzoate (1000 ppm) in glass bottles
T9	Pulp + pasteurization +KMS (1000 ppm) in glass bottles
T10	Pulp + pasteurization + KMS (1000 ppm) + sodium benzoate (1000 ppm) in glass bottles
T11	Canning
T12	Freezing

Step 4: Utilization of persimmon pulp in dairy products for the enhancement of the nutritional quality

1. Incorporation of persimmon pulp in burfi (Fudge)

Persimmon burfi was prepared by heating concentrated milk solids (khoa) in a pan with continuous stirring till pat formation. Then powdered sugar @ 30 per cent was added to it. The mixture of concentrated milk solids (khoa) and sugar was heated to near homogenous consistency followed by cooling and cutting into small cuboids and this sample was kept as control. For preparation of persimmon pulp burfi, different combinations (Table-4) of persimmon pulp (%) and khoa (%) were used. In all the combinations the concentration of sugar was kept constant (30%). When the homogenous consistency of khoa and sugar was obtained then the pulp was added heated for 5 minutes with continuous stirring cum scrapping. The prepared product was allowed to cool and then cut into small cuboids. The persimmon pulp burfi prepared of different combinations was subjected to sensory evaluation by a panel of ten judges. The product was kept for storage under ambient and refrigerated conditions and evaluated for quality at storage intervals of 0, 7 and 14 days.

Flow chart for preparation of persimmon burfi (fudge)

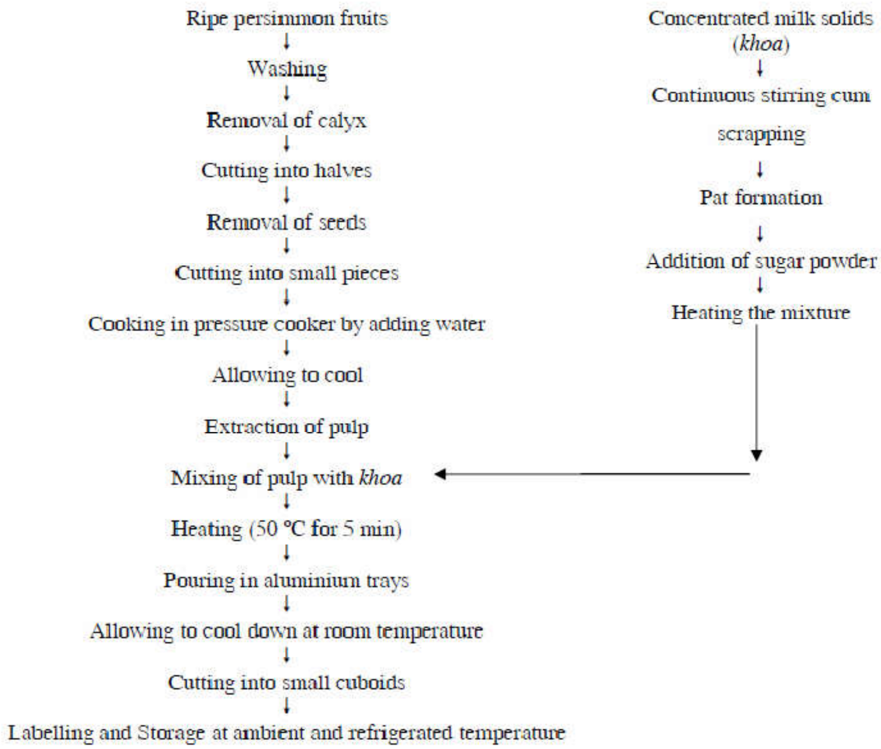
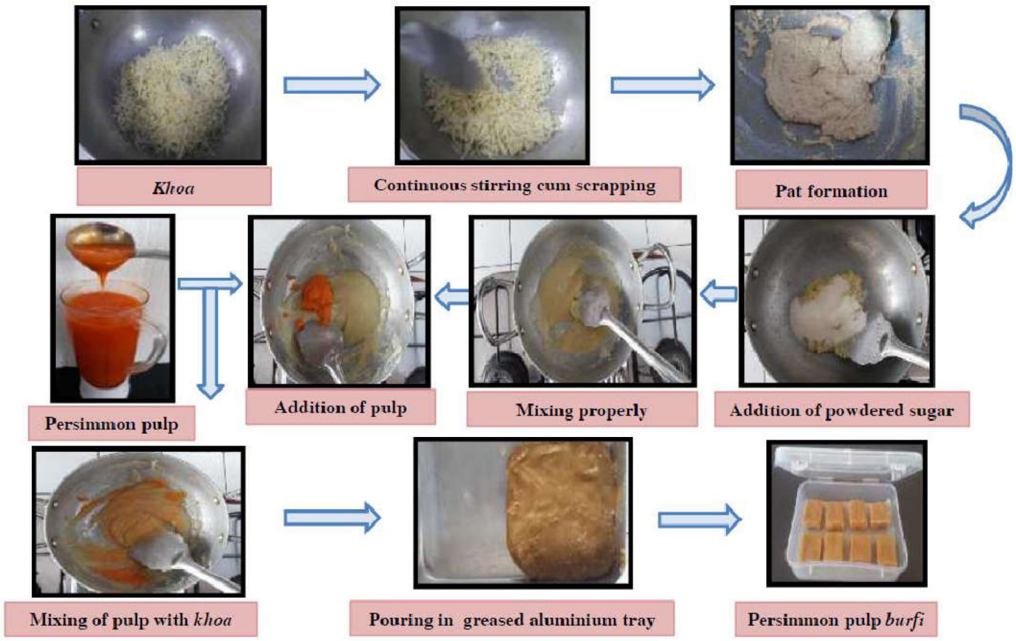


Table-4 Treatment detail of persimmon pulp burfi (fudge)

Treatment (T)	Khoa (%)	Persimmon pulp (%)
T1	100	0
T2	95	5
T3	90	10
T4	85	15
T5	80	20
T6	75	25
T7	70	30

Unit operations for the preparation of burfi incorporated with persimmon pulp



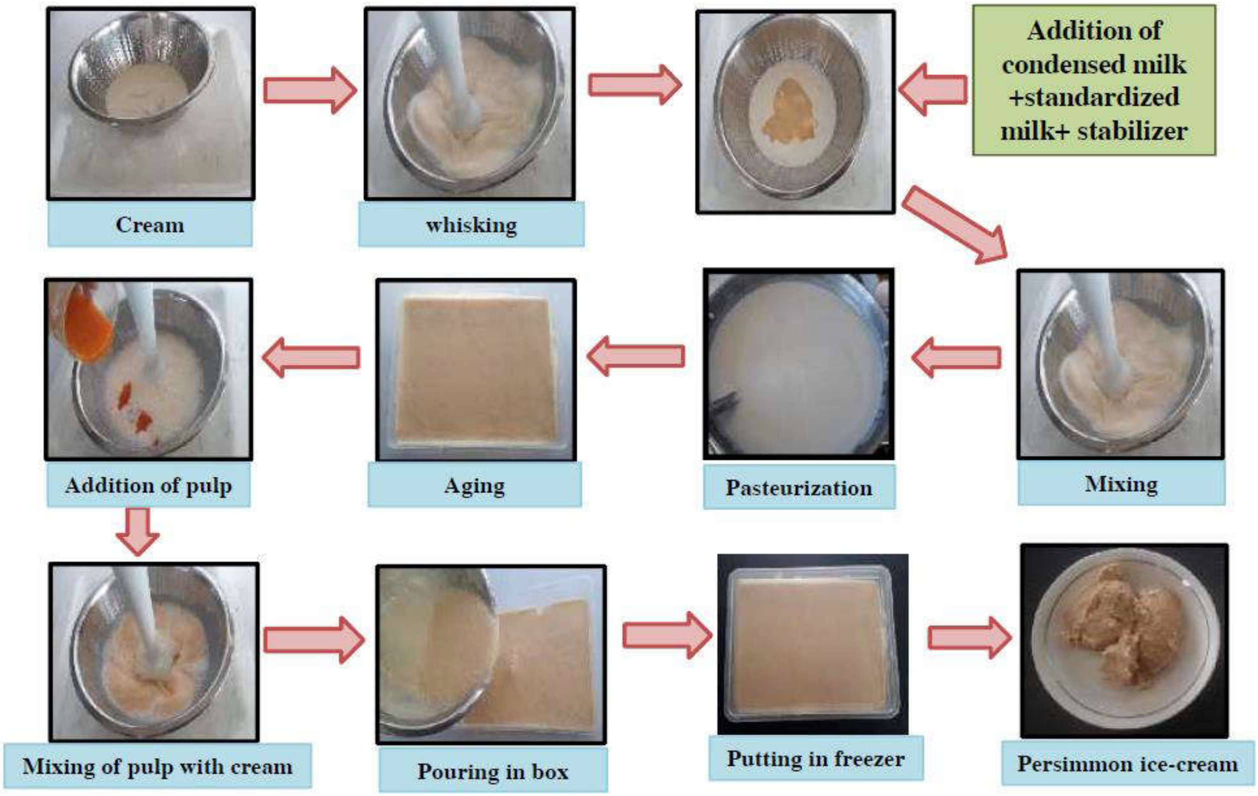
2. Incorporation of persimmon pulp in ice cream

The ice-cream was prepared using various ingredients whipping cream, condensed milk (300 ml) and persimmon pulp. The amount of condensed milk was kept at constant proportion whereas cream and persimmon pulp was used in different concentrations. Cream was taken in a bowl and whisked properly for 2-3 min and then condensed milk, standardized milk and stabilizer (@ 0.5%) were added to the cream and blended properly with cream. The mixture was then pasteurized at 85˚C for 25 s and allowed to cool down to room temperature. The mixture was poured in PET boxes and kept for aging in refrigerator was done at 4˚C for 24 h and then the extracted pulp was added and mixed uniformly with the help of blender. The prepared mixture was poured in PET boxes and kept in the freezer (-15˚C). The ice cream was evaluated for quality at storage intervals of 0, 7 and 14 days.

Treatment detail of persimmon pulp ice cream

Treatment (T)	Whipping cream (%)	Persimmon pulp (%)
T1	100	0
T2	70	30
T3	60	40
T4	50	50

Unit operations for the preparation of ice-cream incorporated with persimmon pulp



Flow chart for preparation of persimmon ice cream

Cream
↓
Whisking
↓
Addition of condensed milk, standardized milk and stabilizer
↓
Mixing
↓
Pasteurization (85°C for 25 secs)
↓
Aging (4°C for 24 hours)
↓
Mixing ← Addition of persimmon pulp
↓
Pouring in ice-cream box
↓
Labelling
↓
Putting in freezer (-15°C)
↓
Storage

4. Preparation Ready-to-serve (RTS) beverages from persimmon *(Diospyros kaki L.)*

Step 1: Evaluation of ripe persimmon fruit for physico-chemical characteristics.

The ripe persimmons fruits with and without peel were analyzed for different quality characteristics. Ten randomly selected fruits were evaluated for different physical characteristics and the data was recorded. The fruits with and without peel were also analyzed for different chemical parameters using standard methods.

Step 2: Standardization of method for persimmon pulp preparation.

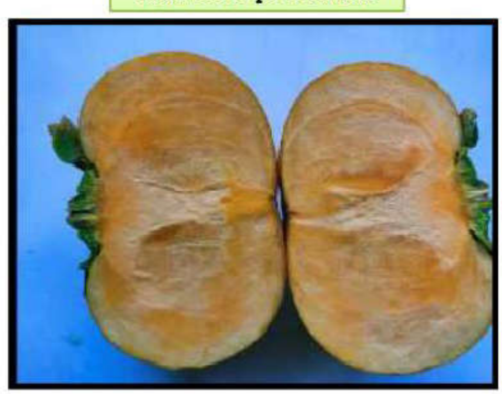
The pulp was extracted by employing cold and hot pulping methods. The persimmon fruits were divided into two lots comprising of fruits with peel and the fruits without peel. The pulp was extracted from fruits of both the lots by following the procedures as detailed below.

2.1 Extraction of persimmon pulp by cold pulping method:
The ripe persimmons were thoroughly washed. The calyx was removed manually with the help of stainless-steel knife and cut into halves. The seeds and the peel (only in case of pulp without peel) were also removed manually. The fruits were cut into small pieces and converted into pulp by grinding in a mixer cum grinder. The amount of water to be added for the preparation of ripe persimmon pulp was standardized. The different treatment combinations having varied quantity of water (5, 10 and 15%) were used for standardization of cold pulping method for preparation of ripe persimmon pulp.

Ripe persimmon fruits

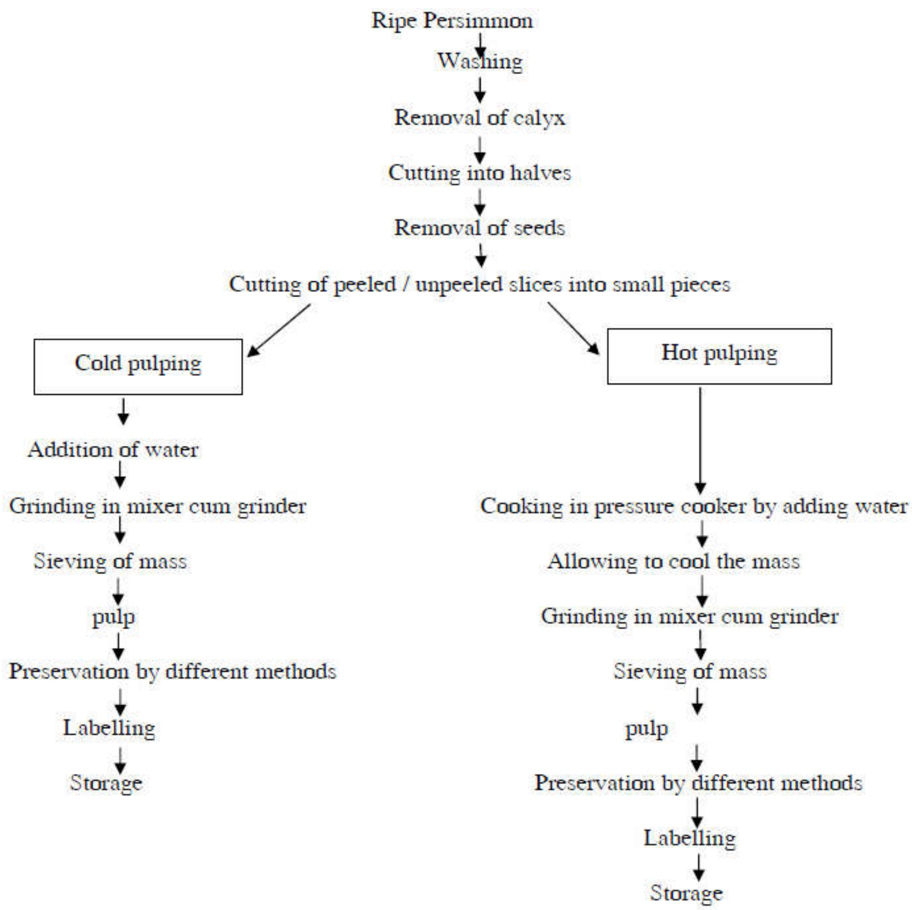
Persimmon fruits or tree

Harvested persimmon



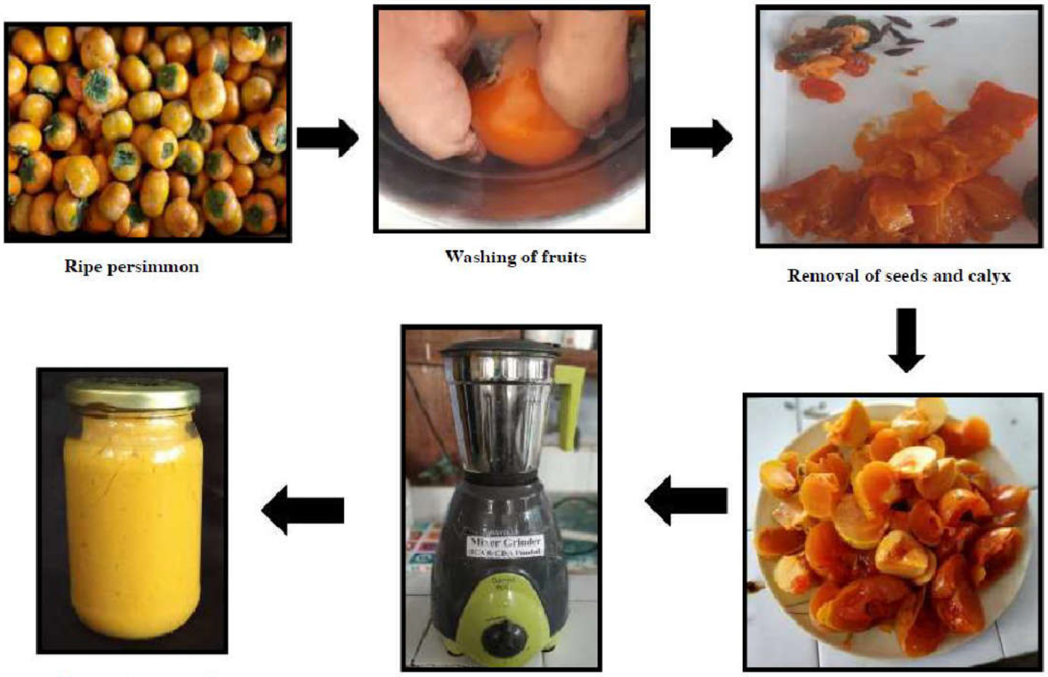
2.1.1 Selection of best treatment for pulp extraction by cold pulping: The pulp prepared by using different concentrations of water was analyzed for various chemical parameters and subjected to sensory evaluation by a panel of judges. The best treatment was selected on the basis of highest sensory scores and better chemical characteristics**.**

Flow sheet for preparation and preservation of persimmon pulp



2.2 Extraction of persimmon pulp by hot pulping method:
The procedure followed for extraction of pulp by hot pulping method was the same as discussed earlier except that the fruit pieces were heated in a pressure cooker (5 kg capacity) on a domestic gas stove. The different treatment combinations (Table-1) having varied quantity of water (5, 10 and 15%) and cooking time (5, 10, 15 min) were used for standardization of hot pulping method for preparation of ripe persimmon. The pulp of each combination was prepared by following different unit operations.

Preparation of ripe persimmon pulp by using cold pulping method



Preparation of ripe persimmon pulp by using hot pulping method

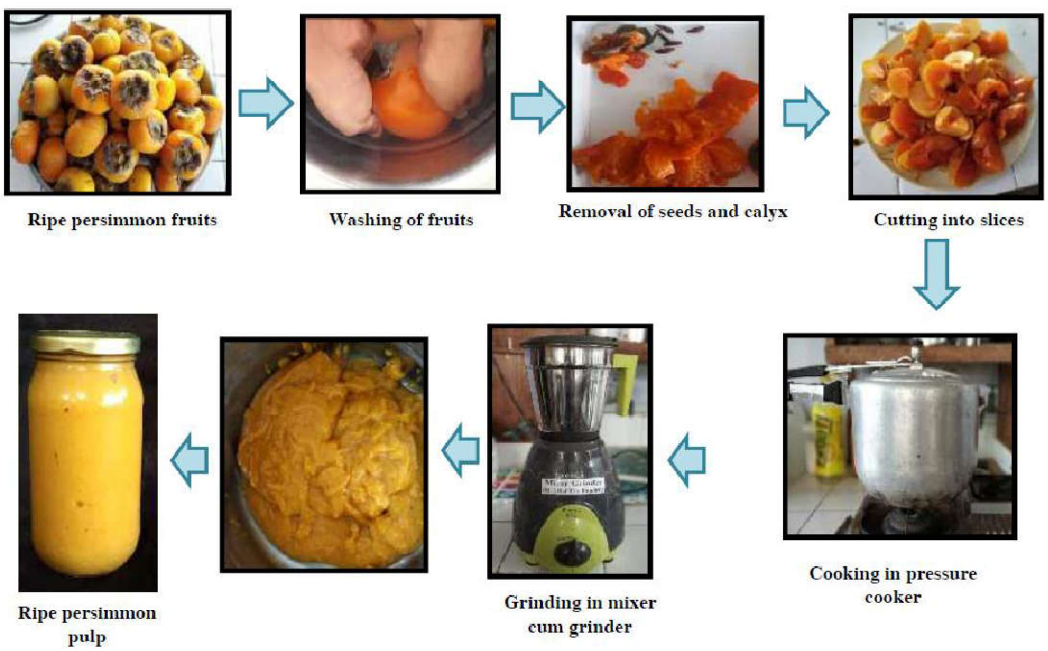


Table 1: Standardization of method for extraction of pulp by hot pulping method

Treatment	Water (%)	Cooking Time (min.)
T1	5	5
T2	5	10
T3	5	15
T4	10	5
T5	10	10
T6	10	15
T7	15	5
T8	15	10
T9	15	15

2.2.1 Selection of best treatment for pulp extraction by hot pulping: The pulp prepared by using different combinations of water (%) and cooking time (min) was evaluated for various chemical attributes and also subjected to sensory evaluation. The best combination was selected on the basis of highest sensory scores and better chemical characteristics.

Step 3: Standardization of method for preservation of persimmon pulp

The pulp of best treatment selected earlier for cold pulping method and hot pulping method was prepared and preserved by different methods. As per preservation method, the pulp was packed in glass jars and glass bottle. The product was properly labeled and kept at ambient temperature for storage studies. The quality evaluation studies were conducted at 0, 3 and 6 months of storage.

Treatment details for preservation of persimmon pulp prepared by cold pulping

Treatment (T)	Description(Cold pulping)	Description(Hot pulping)
T1	Pulp with peel + cold pulping + KMS (@ 2000 ppm) in glass jars	Pulp with peel + hot pulping + KMS (@ 2000 ppm) in glass jars
T2	Pulp with peel + cold pulping + sodium benzoate (@ 2000 ppm) in glass jars	Pulp with peel + hot pulping + sodium benzoate (@ 2000 ppm) in glass jars
T3	Pulp with peel + cold pulping + KMS (@ 1000 ppm) + sodium benzoate (@ 1000 ppm) in glass jars	Pulp with peel + hot pulping + KMS (@ 1000 ppm) + sodium benzoate (@ 1000 ppm) in glass jars
T4	Pulp with peel + cold pulping + pasteurization in glass bottles	Pulp with peel + hot pulping + pasteurization in glass bottles
T5	Pulp with peel + cold pulping + pasteurization + KMS (@ 1000 ppm) in glass bottles	Pulp with peel + hot pulping + pasteurization + KMS (@ 1000 ppm) in glass bottles
T6	Pulp with peel + cold pulping + pasteurization + sodium benzoate (@ 1000 ppm) in glass bottles	Pulp with peel + hot pulping + pasteurization + sodium benzoate (@ 1000 ppm) in glass bottles

Step 4: Utilization of persimmon pulp for development of Ready-to-Serve (RTS) beverages:

The ripe persimmon pulp was prepared as per the method selected earlier for cold pulping and for hot pulping and utilized for the development of RTS beverages. FSSAI specifications were followed for preparation of beverages. Different combinations of persimmon pulp (%), TSS (°B) and acidity (%) were tried to prepare the beverages. The prepared product was hot filled in sterilized glass bottles of 200 mL capacity and sealed by using crown corking machine. Then the product was heat processed at 85°C for 30 min. The bottles were allowed to cool at room temperature. The RTS beverage of different combinations was subjected to sensory evaluation by a panel of ten judges. The combination which got the highest score for overall acceptability was selected for further studies.

4.1 Persimmon based RTS beverages

i) Persimmon based RTS beverages using pulp extracted by cold pulping

The RTS beverages were prepared by using pulp extracted by cold and hot pulping method. The beverages having TSS of 10°B (Table-4), 12°B (Table-5) and 15°B (Table-6) were prepared. In each section the TSS of beverage was kept constant while varied combinations of pulp and acidity were employed. The RTS beverages in each experiment were subjected to sensory evaluation by a panel of judges to select the best one on the basis of higher sensory scores.

Table 4: Treatment combinations for RTS beverage of 10°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C1	10	10	0.3
C2	10	15	0.3
C3	10	20	0.3
C4	10	10	0.4
C5	10	15	0.4
C6	10	20	0.4
C7	10	10	0.5
C8	10	15	0.5
C9	10	20	0.5

Table 5: Treatment combinations for RTS beverage of 12°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C1	12	10	0.3
C2	12	15	0.3
C3	12	20	0.3
C4	12	10	0.4
C5	12	15	0.4
C6	12	20	0.4
C7	12	10	0.5
C8	12	15	0.5
C9	12	20	0.5

Preparation of persimmon RTS beverage

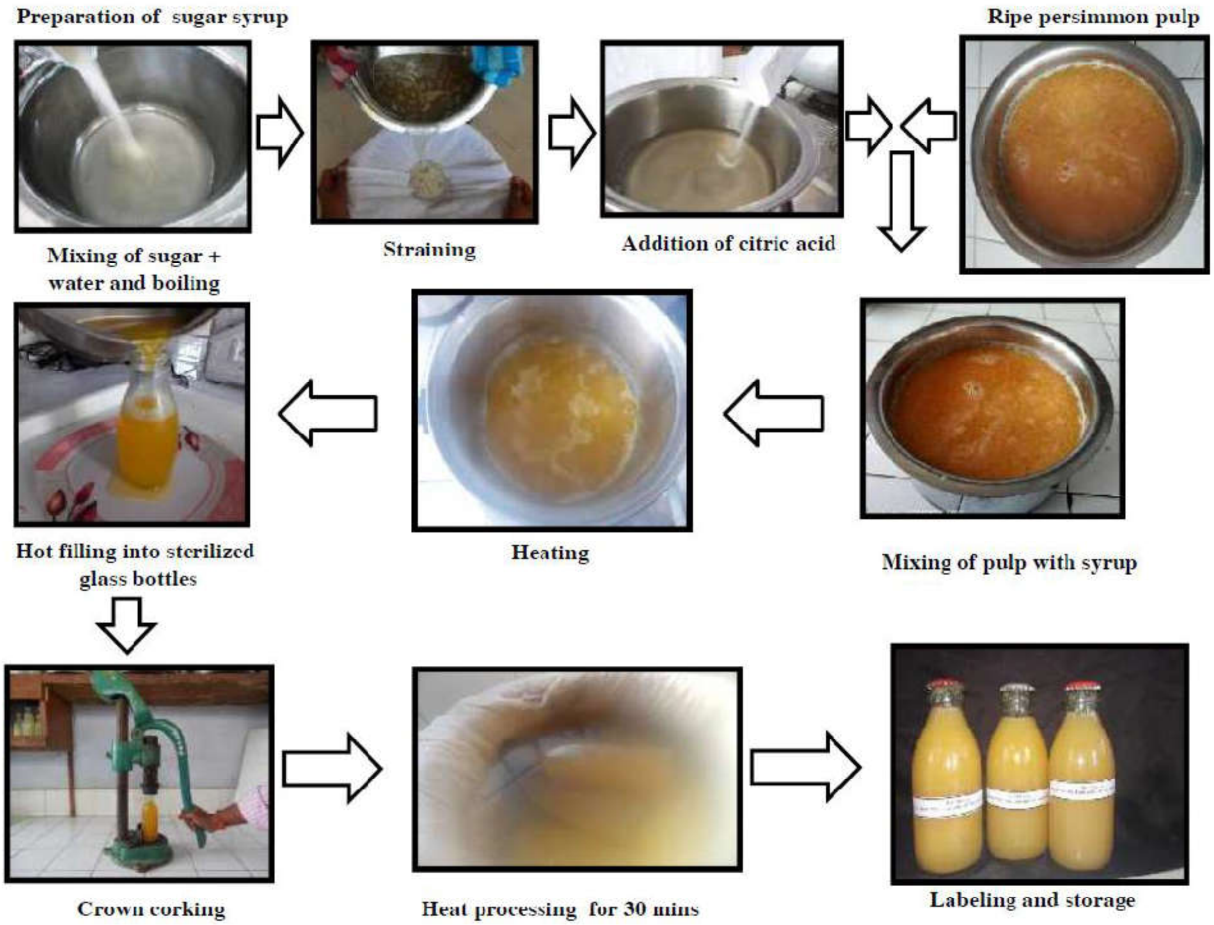


Table 6: Treatment combinations for RTS beverage of 15°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C1	15	10	0.3
C2	15	15	0.3
C3	15	20	0.3
C4	15	10	0.4
C5	15	15	0.4
C6	15	20	0.4
C7	15	10	0.5
C8	15	15	0.5
C9	15	20	0.5

ii) Persimmon based RTS beverages using pulp extracted by hot pulping

Similar experiments as discussed above for pulp extracted by cold pulping were laid out for use of pulp extracted by hot pulping method. The detail of treatments in each experiment is presented from Table 7 to 9. In each experiment the best treatment was selected on the basis of sensory evaluation.

Flow sheet for preparation of persimmon based RTS beverage

Ripe Persimmon
↓
Washing
↓
Cutting into halves
↓
Removal of seeds
↓
Cutting into small pieces (With peel)
↓
Cooking in pressure cooker by adding water
↓
Allowing to cool
↓
Extraction of pulp (cold/hot pulp)

Mixing of sugar and water
↓
Boiling of mixture
↓
Allowing to cool
↓
Addition of citric acid
↓
Straining through muslin cloth
↓
Sugar syrup

Mixing of pulp with strained sugar syrup
↓
Heating (86 °C for 2 min)
↓
Hot filling into pre-sterilized glass bottles
↓
Crown corking
↓
Heat processing (87 °C for 30 min)
↓
Allowing to cool
↓
Labelling and storage at room temperature

Table 7: Treatment combinations for RTS beverage of 10°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H1	10	10	0.3
H2	10	15	0.3
H3	10	20	0.3
H4	10	10	0.4
H5	10	15	0.4
H6	10	20	0.4
H7	10	10	0.5
H8	10	15	0.5
H9	10	20	0.5

Table 8: Treatment combinations for RTS beverage of 12°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H1	12	10	0.3
H2	12	15	0.3
H3	12	20	0.3
H4	12	10	0.4
H5	12	15	0.4
H6	12	20	0.4
H7	12	10	0.5
H8	12	15	0.5
H9	12	20	0.5

Table 9: Treatment combinations for RTS beverage of 15°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H1	15	10	0.3
H2	15	15	0.3
H3	15	20	0.3
H4	15	10	0.4
H5	15	15	0.4
H6	15	20	0.4
H7	15	10	0.5
H8	15	15	0.5
H9	15	20	0.5

4.1.1 Quality evaluation of RTS beverages during storage

The ripe persimmon pulp was extracted as per the procedure discussed above by cold pulping and hot pulping method. The RTS beverages of different combinations were prepared as per procedure described above. The treatment details for preparation of RTS beverages is presented in Table 10 for beverages prepared with pulp of cold pulping method and Table 11 for pulp of hot pulping method. The products were bottled and appropriately labeled and kept for storage under refrigerated and ambient conditions. The evaluation studies for chemical, sensory and microbial parameters were conducted at 0, 3, 6 months of storage.

Table 10: Treatment detail for storage studies of RTS beverage prepared using pulp extracted by cold pulping

Treatments	Description
T1	Best RTS combination of 10°B with pulp of cold pulping method
T2	Best RTS combination of 12°B with pulp of cold pulping method
T3	Best RTS combination of 15°B with pulp of cold pulping method

Table 11: Treatment detail for storage studies of RTS beverage prepared using pulp extracted by hot pulping

Treatments	Description
T1	Best RTS combination of 10°B with pulp of hot pulping method
T2	Best RTS combination of 12°B with pulp of hot pulping method
T3	Best RTS combination of 15°B with pulp of hot pulping method

4.2 Persimmon based flavoured RTS beverage:

The RTS beverages of different combination as selected under section 4.1 (i) for cold and 4.1 (ii) for hot pulping method were prepared and subjected to sensory evaluation. The recipe which got the highest sensory evaluation scores by a panel of judges was selected. This combination was used for preparation of flavoured RTS beverages.

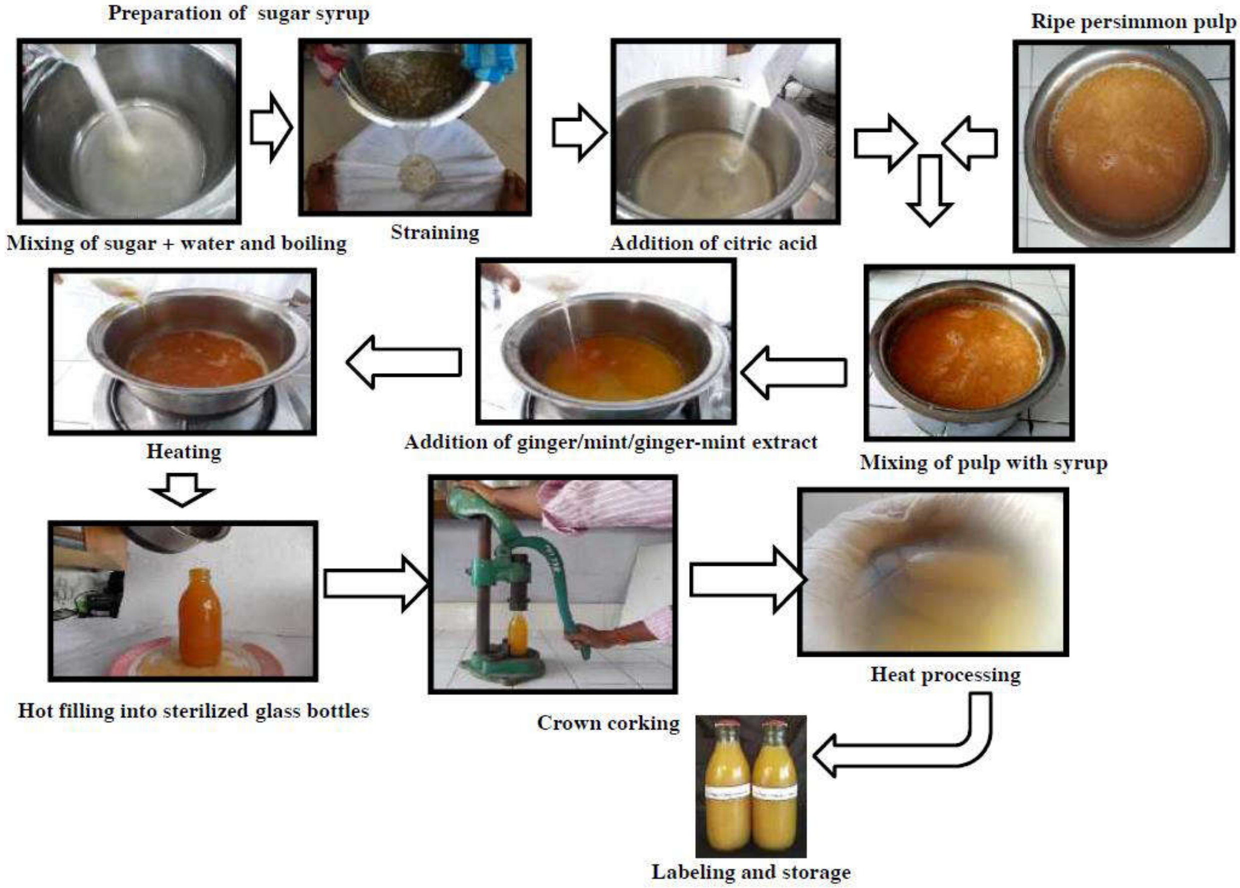
i) Ginger flavoured persimmon RTS beverage

For preparation of ginger flavoured RTS beverage, ginger extract was prepared. The fresh ginger rhizomes were washed and peeled followed by further washing. After grating the ginger manually, the shreds were ground in a mixer and grinder by adding water in the ratio of 1:2. The juice was obtained by squeezing the mixture through double layer cheese cloth. The RTS beverage was prepared by replacing the persimmon pulp with ginger extract in different proportion. The RTS beverages of these combinations were prepared (Table-12) and subjected to sensory evaluation. The best combination was selected on the basis of highest sensory scores.

Table 12 Treatment detail of ginger flavoured persimmon RTS beverage

Treatment (G)	Ginger extract (%)
G1	1
G2	3
G3	6
G4	9

Preparation of flavoured persimmon RTS beverage



ii) Mint flavoured persimmon RTS beverage

The mint extract was prepared by using fresh mint leaves. The leaves were washed and ground in a mixer cum grinder. The juice was extracted by passing the mass through double layered muslin cloth. The pulp was replaced with mint extract for preparation of beverages. The RTS beverages with various concentrations of mint extract were prepared (Table-13) and sensory evaluation was conducted. The best recipe was selected on the basis of highest sensory scores.

Table 13: Treatment detail of mint flavoured persimmon RTS beverage

Treatment (M)	Mint extract (%)
M1	2
M2	4
M3	6
M4	8

Flow sheet for preparation of flavoured persimmon RTS beverage

Ripe Persimmon
↓
Washing
↓
Cutting into halves
↓
Removal of seeds
↓
Cutting into small pieces (With peel)
↓
Cooking in pressure cooker by adding water
↓
Allowing to cool
↓
Extraction of pulp

Mixing of sugar and water
↓
Boiling of mixture
↓
Allowing to cool
↓
Addition of citric acid
↓
Straining through muslin cloth
↓
Sugar syrup

Mixing of pulp with strained sugar syrup
↓
Addition of ginger/mint/
ginger-mint extract
↓
Heating (86 °C for 2 min)
↓
Hot filling into pre-sterilized
glass bottles
↓
Crown corking
↓
Heat processing
(87 °C for 30 min)
↓
Allowing to cool
↓
Labelling and storage at room temperature

iii) Ginger-mint flavoured persimmon RTS beverage

The pulp of base recipe was replaced with different concentrations of ginger-mint extract (Table-14). The RTS beverage prepared by using these combinations was subjected to sensory evaluation by a panel of ten judges. The combination which got the highest overall acceptability score was selected for further studies.

Table 14: Treatment detail of ginger-mint flavoured persimmon RTS beverage

Treatment (GM)	Mint extract (%)	Ginger extract (%)
GM1	6	7
GM2	4	5
GM3	2	3
GM4	1	1

Quality evaluation of flavoured RTS beverage

After selecting the best combination of flavoured RTS beverages {under section 4.2 i), ii) and iii)} by subjecting these to a panel of ten judges, the beverages were prepared and preserved. The products were properly labeled and kept under ambient and refrigerated conditions. The quality evaluation studies were conducted at 0, 3 and 6 months of storage interval.

5. Development and storage of granular powder from wild pomegranate (*Punica granatum L.)*

Step 1: Preparation of Anardana: Wild pomegranate arils were steam blanched for 30 s followed by sulphuring with 0.30 per cent sulphur powder for 60 min in sulphur fumigation chamber before carrying out the drying. The following drying modes were used for the preparation of Anardana.

- **1.1 Sun drying:** The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in the open sun in an inclined position for drying. The material was kept till the sunset before shifting it back in the laboratory for night. Arils were dried in the sun till they attain a constant weight. The mean temperature during these studies was in the range of 18 to 31oC.
- **1.2 Solar tunnel drying:** The pre-treated arils (3 kg) were spread on the perforated aluminium trays and put on the stands inside a solar tunnel drier of dimensions 297 × 204 × 207 cm. This drier has been made of polyethylene sheet of thickness 0.31 mm and the temperature recorded in this drier during these studies was in the range of 21 to 39oC. The pre-treated arils were dried till they attain a constant weight.
- **1.3 Mechanical cabinet drying:** The pre-treated arils (3 kg) were spread on the perforated steel trays of dimension 76 × 56 cm in 0.50 cm layer and dried at constant temperature at 60±2oC inside the mechanical cabinet drier having internal dimensions of 78 × 58 × 128 cm up to a constant weight. The trays were shifted inside the drier by rotation to ensure uniform heat transmission to all the trays.
- **1.4 Solar tunnel drying + Mechanical cabinet drying:** The pre-treated arils (3 kg) were spread on the perforated aluminium trays and put on the stands inside a solar tunnel drier (30oC) until they attain a constant weight. After that these solar tunnel dried arils were further spread on the perforated steel trays and dried at constant temperature at 60±2oC inside a mechanical cabinet drier up to a constant weight.
- **1.5 Sun drying + solar tunnel drying:** The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in open sun (24.5oC) for drying. Arils were dried in the sun till they attain a constant weight. The sun-dried arils were further dried in solar tunnel drier (30oC) up to a constant weight.
- **1.6 Sun drying + solar tunnel drying + Mechanical cabinet drying:** The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in open sun (24.5oC) for drying until they attain a constant weight. These sun-dried arils were Wild pomegranate fruits further dried in solar tunnel drier (30oC) followed by mechanical cabinet drying (60oC). When the arils attain a constant weight in solar tunnel drier then these were shifted to mechanical cabinet drier for further drying up to their constant weight.

Step 2: Preparation of granular powder from dried arils (*Anardana*):

The wild pomegranate arils dried by different drying modes were ground to powdered form in a laboratory scale grinder and then further passed through 22 mesh (710 µm) sieve. The Anardana powder selected on the basis of best physico-chemical and sensory characteristics was used for further storage studies

Step 3: Packaging and storage:

The Anardana granular powder from best selected drying mode was packed in different packaging materials viz Polyethylene pouch (PEP) (T1), Aluminium laminated pouch (ALP) (T2), Aluminium laminated pouch with oxygen scavenger (T3), Aluminium laminated pouch with oxygen scavenger and moisture scavenger (T4) and Aluminium laminated pouch with moisture scavenger (T5). The Anardana granular powder in different packaging treatment was stored under ambient temperature (18-22oC) and refrigerated temperature (4-7oC) for a period of 6 months and was analyzed for changes in various physico-chemical and sensory quality attributes at different intervals (0, 3 and 6 months) of storage.

1. Physicochemical analysis of wild pomegranate and preparation of Anardana

1.1 Composition of raw material (Wild pomegranate): Among various physico-chemical characteristics of wild pomegranate fruits studied, the average length, breadth and weight were found to be 58.40 mm, 52.10 mm and 92.73 g, respectively. The colour of fruits and arils was observed to be yellowish green and red purple (60 A), respectively. The weight of arils per fruit and weight of 100 arils was observed to be 51.80 g and 15.80 g, respectively. Arils were found to contain moisture and total solids as 71.53 per cent and 28.47 per cent, respectively. The titratable acidity of the arils was 3.84 per cent, whereas, the pH was 2.72. Arils also contained 7.39 per cent, 9.15 per cent, 19.79 mg/ 100 g and 9.06 mg/ 100 g of reducing sugars, total sugar, ascorbic acid and anthocyanins, respectively. The total phenols content of arils was 105.40 mg GAE/ 100g and antioxidant activity was observed to be 42.18 per cent.

1.2. Comparison of different drying modes was used for the preparation of Anardana: Before drying, the arils were steam blanched for 30 sec followed by sulphur fumigation (0.3% for 60 min). While comparing different drying modes, mechanical cabinet dried arils possessed maximum TSS (45.20°B), titratable acidity (11.40%), ascorbic acid (11.70 mg/ 100 g), reducing sugars (21.91%), total sugars (25.45%), anthocyanins (33.76 mg/ 100 g), phenols (126.05 mg/ 100 g), crude fibers (35.91%), oil (8.89%) and antioxidant activity (65.22%). It took minimum time (26 h) to dry a given tray load (3 kg), had minimum NEB (0.06 OD), furfural (11.89 ppb) and HMF (0.90 ppm). Mechanical cabinet dried arils were rated best among all drying modes on the basis of highest sensory scores of colour (8.00), texture (8.00), taste (8.56) and overall acceptability (8.55).

Solar tunnel drier

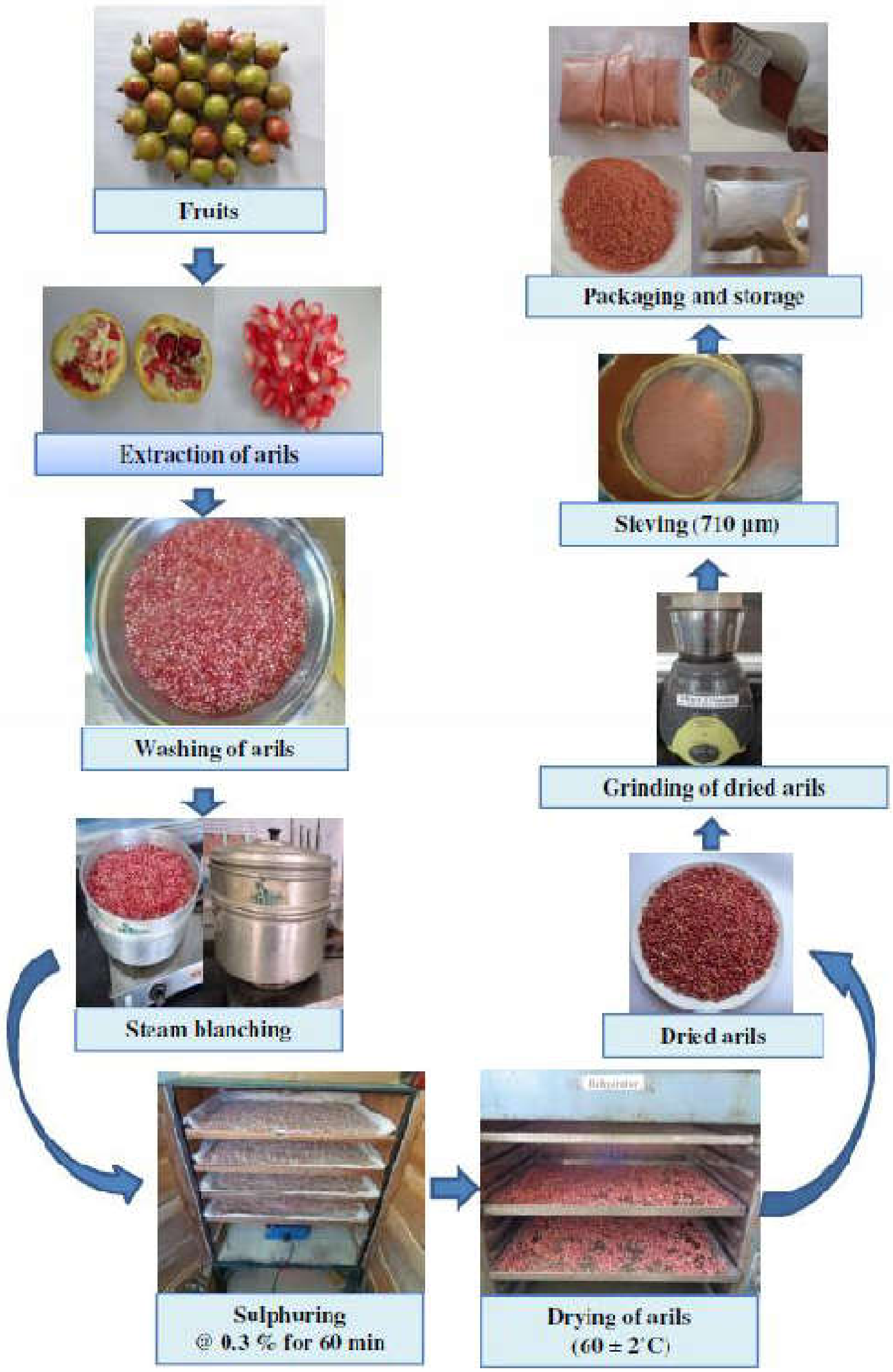
Sun drying

Mechanical cabinet drier

2. Comparison of granular powder prepared from dried arils (Anardana) using different drying methods:

Arils dried in different drying modes were ground to granular powder form in laboratory scale grinder and passed through 22 mesh sieves (710 µm). While comparing the physico-chemical characteristics of granular powder prepared from mechanical cabinet dried arils possessed maximum TSS (44.90°B), titratable acidity (11.25%), ascorbic acid (11.21 mg/ 100 g), reducing sugars (21.36%), total sugars (25.06%), anthocyanins (33.09 mg/ 100 g), phenols (125.61 mg/ 100g), crude fibers (35.85%), oil (8.67%) and antioxidant activity (64.98%) and minimum NEB (0.08 OD), furfural (12.29 ppb) and HMF (0.98 ppm). Powder prepared from mechanical cabinet dried arils were rated best among all drying modes on the basis of highest sensory scores of colour (8.45), texture (8.00), taste (8.50) and overall acceptability (8.55).

Unit operations for the preparation of granular powder from wild pomegranate arils



3. Storage study of granular powder from dried arils (*Anardana*):

Granular powder prepared from mechanical cabinet dried arils was packed in PEP (polyethylene pouches), ALP (Aluminium laminated pouches), ALP with oxygen scavenger, ALP with oxygen and moisture scavenger, ALP with moisture scavenger and stored for 6 months under ambient as well as refrigerated temperature conditions. More or less all physico-chemical characteristics of powder exhibited some changes during storage. However, minimum changes were observed in powder packed in ALP with oxygen and moisture scavenger (T4) with respect to colour properties besides slight increase in moisture from 5.85 to 5.89 per cent, water activity from 0.179 to 0.185, pH from 2.96 to 2.97, reducing sugars from 21.21 to 21.28 per cent, NEB from 0.052 to 0.057 OD, HMF from 0.96 to 1.16 ppm and furfural from 12.12 to 16.97 ppb during storage. Whereas, minimum decrease was observed in titratable acidity from 10.85 to 10.78 per cent, total sugars from 25.01 to 24.96 per cent, TSS from 44.60 to 44.52°B, ascorbic acid 11.10 to 10.91 mg/ 100 g, anthocyanins 34.21 to 33.49 mg/ 100 g, total phenols from 125.14 to 124.13 mg/ 100 g and antioxidant activity 64.48 to 64.03 per cent in the same packaging material ALP with oxygen and moisture scavenger (T4) during storage of six months. Sensory characteristics scores of powder decreased for colour from 8.51 to 8.10, texture from 8.00 to 7.84, taste from 8.50 to 8.30 and overall acceptability from 8.50 to 8.07 during storage. So, granular powder in ALP with oxygen and moisture scavenger (T4) exhibited superior quality in terms of physico-chemical and sensory properties when compared to other packaging treatments. The cost of production of per kg powder in best packaging treatment i.e. ALP with oxygen and moisture scavenger (T4) was recorded as Rs. 343.66, whereas, it was recorded as Rs.342.40 in next best treatment (ALP with moisture scavenger).