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Standardization of technology for extraction of wild apricot kernel oil at semi-pilot scale

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ABSTRACT

The suitability of wild apricot stones for extraction of kernel oil for its use for both edible and pharmaceutical purposes was evaluated at semi-pilot scale. The pits/stones of wild apricot otherwise considered as waste and are thrown away by the farmers. Mean fruit weight in bitter and sweet kernelled apricots ranged between 8.0-15.1g and 16.0-18.3g with the stone recovery of 12.7-22.2% and 11.7-13.3% respectively. The use of mechanical decorticator was found most appropriate for crushing of stones/pits with respect to ease of handling, efficiency and economy of the operation. Dipping of crushed shells and kernels in 25% salt solution was found optimum for separation of kernels. Dipping of kernels in 25% salt solution prior to oil extraction also brought about complete removal of bittering component-HCN in oils. The use of table oil expeller was optimized for extraction of oil from separated kernels with an oil yield of 38-40% in wild apricot fruit kernels. The oil possessed good nutritional and pharmaceutical significance and can be utilized in different pharmaceutical preparations. The method of oil extraction was found quite cost effective and can be adopted at semi commercial scale.

Keywords: Wild apricot, stones/pits, kernels, mechanical decorticator, specific gravity, HCN

INTRODUCTION

Wild apricot (*Prunus armeniaca L.*) commonly known as chulli, chulu, Zardalu or sahare are extensively grown as wild in Jammu & Kashmir, Himachal Pradesh., Uttranchal, and in many parts of North-eastern states. Availability of apricot stones and kernels in India and Himachal Pradesh are given in Table-1. Owing to their short harvest season and poor shelf life, these fruits are mostly used for making local liquor (Ghanti), open sun drying and extraction of pulp to prepare some home made products. The stone/pits left after these operations usually possess no commercial value and are treated as waste, which otherwise is a good source of edible oil containing high amount of unsaturated fatty acids. Generally, apricot fruits comprise of 11.7-22.2% stones, which yield 30.7-33.7 % kernels, which may be both sweet as well as bitter in taste. Both types of kernels can be utilized for extraction of oil. Locally, the kernel oil from apricot (*chulli),wild peach* (*behmi*) and hard shelled walnut is already being used to a limited extent by the local tribal in some parts of the country for food, massaging and for other home made remedies. Owing to the availability of these fruits in large quantity, there exists a good scope for its utilization for extraction of oil. According to Shah (1985) the apricot fruits comprising of 6-11% of the stones constitute about 22-38% of kernels, which possess good potential for extraction of oil.

However, this potential remained unexploited due to lack of appropriate technology for crushing of stones to separate kernels, removal of bittering components from the kernels and oil extraction for its adoption at semi-commercial scale. Thus, these studies were undertaken to develop a suitable method for mechanical decortication of stones, kernel separation, oil extraction and its quality characterization for its use at semi-pilot scale.

MATERIALS AND METHODS

The stone/pits of wild apricot fruits left after utilization of edible portion in the preparation of pulp were collected from Mandi, Kinnaur and Shimla areas of Himachal Pradesh. Decortication of stone/pits was carried out manually and by using mechanical decorticator, which was got fabricated from the Division of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi (India). The mechanical decorticator is a type of roller crusher consisting of two rollers moving in inward opposite directions with the help of 3 HP motor and is provided with a hopper and feeder assembly. The clearance between two rollers was adjusted according to the respective size of stones. The efficiency of the mechanical decorticator was compared with that of manual breaking of stones (yield of decorticated stones per hour). The method for kernel separation from the decorticated/crushed mass was standardized by using different concentrations of salt (15, 20 and 25%) having specific gravities of 1.115, 1.158 and 1.188 respectively and compared against traditionally used manual method. The efficiency of kernel separation was calculated by measuring the quantity of separated kernels from the crushed mass in a given time interval. The oil from separated kernels was extracted by solvent extraction method using petroleum ether as the solvent and by the use of table oil expeller. Table oil expeller (M/S Sardar Engineering Company, Kanpur, India) is a 24 patti screw type oil expeller driven by 7HP motor, in which the kernels are fed into the moving hopper at predetermined flow rate, which are pressed in between rollers (worm) and side walls of the expeller. The kernels were passed through expeller 3-4 times until a thin slice of press cake is obtained. The oil after coarse filtration through a filter press was packed in pre-sterilized glass/PET bottles and kept in a cool dry place. The oil yield was compared with the apricot oil extracted through the traditionally used oil press (portable power ghani) and baby oil expeller as well as after solvent extraction through Soxtec oil extraction apparatus (M/S Velp Scientifica, Italy).

Analyses

Standard analytical procedures were followed for estimation of iodine value, saponification value, acid value and peroxide value in the extracted oils (AOAC, 1995). The specific gravity and refractive index was determined as per methods detailed by Ranganna (1997), while colour of the oils was determined by using Lovibond Colour Tintometer (Model E, AF-900) using one inch cell (Ranganna, 1986). The hydrocyanic acid was determined by using Alkaline-titration method (AOAC, 1995). The fatty acid composition of the apricot kernel oil was determined according to the method of Metcalfe *et al.* (1966) by converting oil in to respective fatty acid methyl esters and by using gas liquid chromatography (GLC). Vitamin E in the oil was estimated using method as detailed by Pearson, (1976).

Statistical analysis: Triplicate determinations were made for each attribute and the data pertaining to physico-chemical characteristics were statistically analysed using logarithmic transformation and Factorial Completely Randomized Design (Cochran and Cox, 1967 and Gomez and Gomez, 1984). The cost of production of apricot oil was worked out after taking in to consideration all the input parameters and adding 20% profit margin.

RESULTS AND DISCUSSION

Physico-chemical characteristics of apricot fruits, stones and kernels: Broadly, mean fruit and stone weight ranged between 8.0-15.1g and 1.8-1.9g respectively. The highest stone recovery was recorded in wild apricots collected from Mandi area. The shell thickness was found maximum (1.2-1.4mm) in bitter kernelled apricot stones. The kernel recovery (%) was however higher in wild apricot stones (33.7%) grown in Karsog area of Mandi district and minimum in stones collected from Shimla district (30.7%). In conformation to our results, the kernel recoveries in apricot stones of different regions was reported as 30% (Aggarwal *et al.,* 1974); 34% (Hallabo *et al.,* 1975) and 22-38% in sweet and bitter apricots (Anonymous, 2005). Further oil yield obtained through solvent extraction ranged between 45.6-46.3% found in wild bitter apricot kernels. The apricot oil yield reported by earlier workers was 35-45% (Dang *et al.,* 1964); 48% (Parmar and Sharma, 1992) and 48.6% by Hallabo *et al* (1975). Qualitatively, the bitter apricot kernels showed the presence of HCN- a bittering component, whereas the sweet apricot kernels were completely free of this component. Further, on the basis of 13,280 metric tonnes of cultivated and wild apricots grown in India , about 1791 metric tonnes of stones can be collected, which can yield about 572 metric tonnes of kernels (Table-2). Thus, utilization of kernels for the extraction of oil can add up to 268 metric tonnes of oil in the national oil pool.

Decortication/Crushing of Stones: Breaking of stones/pits of wild apricots followed by separation of kernels is the most time-consuming and difficult unit operation. Data in Table-3 reveal that only 3.2-4.4 kg of stones could be broken manually within one hour as against 120 kg decortication obtained by using mechanical decorticator within the given time interval. Further it was also observed that kernels were not crushed by using mechanical decortication while through manual crushing, sometimes kernels also got crushed, thus making the separation most difficult. Minor variation in decortication within stones of different wild apricots was due to the variation in size and hardness of the stones. Further, manual breaking of stones yielded 95.1-95.5% of crushed stones against the efficiency of 85.4-86.5% obtained by using mechanical decortication. The stones which remained uncrushed/ undecorticated were either very small in size or they passed through the sidewalls of the roller. These findings thus suggest the need for grading of stones prior to their decortication and some modification in adjustment of the rollers. Mechanical decorticator was also found very cost effective as compared to manual breaking. Thus, keeping in view the ease of handling, cost of decortication and better yield of crushed mass per unit time, and decortication of stones has been optimised.

Kernel separation: From the crushed mass of stones/pits, the kernels are separated manually, which is most time consuming and laborious unit operation. In order to improve the efficiency of operation, different methods of kernel separation were attempted viz. floatation in water, specific gravity separation and manual separation. Data in Table-4 reveal that dipping crushed mass in 25% salt solution brought about complete separation of kernels which floated on the top of salt solution due to difference in density of kernels while shells settled at the bottom. Using salt solution of lower concentration i.e. 5, 10, 15% did not yield optimum separation of kernels. Similarly, dipping crushed mass in simple tap water (floatation in water) was found altogether unsuitable. Comparatively low kernel separation obtained manually was probably due to the presence of excessively crushed/pressed kernels, which were difficult to separate manually. Further, it was observed that by using specific gravity separation, 6.3-7.3 kg kernels were got separated within one hour against the manual separation of only 610-620 g kernels. Besides, the specific gravity separation has also drastically reduced the cost of kernel separation. Thus, the use of specific gravity separation method by using 25% salt solution has been optimised for kernel separation.

Detection and Removal of bittering component from wild apricot kernels: The kernels from apricot stones showed the presence of hydro cyanic acid (HCN) — a bittering/toxic component, which is known to be produced due to the hydrolysis of amygdalins. The HCN contents in Bitter apricot kernels ranged between 148-173 mg/100g, however its presence was not detected in sweet kernels of wild apricot stones. The oil extracted through solvent oil extractor (Soxtec) did not contain any HCN. While oil obtained through Oil expeller did show the presence of HCN. Besides, the cake left after oil extraction through solvent extraction contained about 75% of total HCN found in the kernels. Thus the commercial method of oil extraction needs some modification in oil extraction process to minimize the presence of HCN in the oil.

The effectiveness of different methods was evaluated for removal of HCN from the apricot kernels (Table 5). With the increase in duration of the treatment, the extent of removal of HCN from the kernels increased however soaking the kernels in water to activate the inherent enzyme β-glucosidase (emulsin) did not exert any appreciable effect on removal of HCN from the kernels as immersion of kernels in water up to 60 minutes could reduce the HCN only up to 12.36-15.03 % in apricot kernels. However, dipping of kernels in 5ppm β-glucosidase for 40-50 minutes resulted in complete detoxification of apricot kernels but this method is so costly.

Further, blanching of kernels did help in almost complete detoxification of apricot kernels from the HCN contents. Among different methods of detoxification the use of 10 % sodium thiosulphate for different intervals was found to be most effective for complete detoxification depending upon the initial HCN levels in kernels from different locations. Earlier, the dipping of kernels in 20 % salt solution of 1.158 specific gravity for 5 minutes was standardized for complete removal of HCN (Sharma *et al*. 2004). Further, it is reported that the apricot kernel oil free of hydro-cyanic acid, which might be attributed to the type of apricot kernels used for extraction, as kernels from sweet kernelled apricots are known to be free of hydro-cyanic acid (Hallabo *et al*, 1975).

However, dipping of kernels in 10 % sodium thiosulphate solution was found most effective as sulphur containing compounds like sodium thiosulphate is often used as a part of antidotal treatment to ensure that there is ample sulphur available to detoxify all the cyanide. The detoxification was probably achieved due to reaction of sodium thiosulphate with the cyanide to form sodium thiocyanate, which could get solubilized in water. The extents of HCN present in the oil and press cake after each treatment is presented in Table 6. The oil and press cake obtained from kernels after blanching for 20 minutes and immersion in 10% sodium thiosulphate solution for 30-40 minutes did not show any presence of HCN, while, the oil and press cake obtained after immersion in water at different intervals showed the presence of HCN in both oil and press cake.

Kernel oil extraction: The mean oil yield from apricot kernels extracted by using table oil expeller was 37.5-38.5 % against the oil recovery of 31.5-32.0% and 28.5-29.0% obtained through baby oil expeller and oil press (power ghani) respectively (Table-7). Comparatively low oil yield through oil press was probably due to the exertion of less pressure for oil extraction and the use of wooden contact parts, which are known to absorb some oil during extraction processes. The oil recovery through solvent extraction was however 45.6-47.0%. Comparatively low oil yield through oil press was probably due to the exertion of less pressure for oil extraction and the use of wooden contact parts, which are known to absorb some oil during the extraction process. Thus, the use of table oil expeller was found most appropriate with appreciably higher oil yield with minimum HCN and has been optimized for its use at commercial scale. It also involved minimal exposure of kernels to heat thus preserving the natural flavour of oil.

Quality characteristics of apricot kernel oil: The wild apricot kernel oil extracted through different methods was evaluated for physico-chemical characteristics and the visual appearance of extracted oil was observed to be light to deep yellow in colour. Further, the oil obtained through solvent extraction and oil press had the iodine value of 100.2-100.4 g I_2/100g as against the value of 100.2-100.8g I_2/100g obtained in oil extracted through table oil expeller (Table-8). The effect of oil extraction method however was found to be non- significant. The saponification value (mgKOH/g oil) representing the average molecular weight of the oil was recorded as 189.5 – 191.1 in the oil extracted through solvent extraction method, 190.9 – 191.9 in the oil extracted through oil press and 191.5-192.7 in oil obtained from table oil expeller. Similarly, the peroxide value (meq/kg oil) was recorded lowest in oils extracted through solvent extraction (5.1-5.4) while, the oil extracted through oil press showed highest peroxide value of 6.6-6.7 followed by the oil extracted by using baby oil expeller (6.5–6.7). Further, the apricot kernel oil extracted by using either methods of extraction did not show much variation in its quality characteristics except for peroxide value which was slightly higher under both the method of oil extraction i.e. oil press and table oil expeller.

*Fatty acid composition of apricot kernel oil***:** The fatty acids in the apricot kernel oil were identified as palmitic (7.79%), palmitoleic (0.48%), stearic (0.93%), oleic (62.07%), linoleic (27.76%) and linolenic acid (1.42%). It was found that apricot oil possessed an appreciable proportion of unsaturated fatty acids which comprised of 62.55 per cent monounsaturates and 29.18 per cent polyunsaturates. While the saturates were only 8.72 per cent thus the ratio between unsaturates and saturates (U/S) was recorded as 10.51. Among the unsaturated fatty acids, oleic acid ($C_{18:1}$) and linoleic acid ($C_{18:2}$) were the predominant acids in apricot kernel oil (Table-9).

Earlier, Sherin *et al*. (1993) recorded a value of 68.88% oleic acid and 15.77 % linoleic acid in kernel oil of NJA-13 apricot cultivar grown in Pakistan. Beyer and Melton (1990) also reported the presence of 69% and 26% of oleic and linoleic acid respectively in apricot kernel oil. According to Kapoor *et al*., (1987) the oleic and linoleic acid content of different cultivars of apricot grown in Ladakh region ranged between 50.95 to 83.33% and 9.62 to 45.90% respectively. The oils rich in polyunsaturated fatty acids have been shown to reduce the risk of cardio vascular diseases (Agar *et al*.1995). Linoleic and linolenic acids are essential fatty acids and are important for maintenance of skin, hair growth, regulation of cholesterol metabolism and maintenance of cell membrane integrity (Sardesai, 1997). Thus, apricot oil possesses special dietary importance and can be used for both edible and pharmaceutical purposes.

Cost of production: The cost of production of apricot oil has been calculated assuming processing of 1000kg apricot stones to extract oil within one month. Data in Table-10 reveals that from 1000kg stones, about 320kg kernels are obtained to extract 121.6kg oil. For establishment of oil extraction unit a sum of Rs. 1,31,000/- is required for procurement of machinery excluding the cost of land and building. Total recurring cost including depreciation cost and interest on the capital works out to Rs. 29,070/- for extraction of 121.6kg oil. While total cost of production including 20% profit margin has been calculated to be Rs. 287/- per kg against the prevalent sale price of Rs. 300/- per kg. It is further revealed that cottage scale unit can generate employment for atleast one person per unit to process apricot stones with profit margins of 20-25%.

Thus utilization of apricot kernels for extraction of oils seems to be a profitable proposition for the efficient utilization of stones/pits which otherwise is thrown as a waste. Preparation of such oils may also open an avenue for their utilization in various purposes viz., pharmaceuticals, and cosmetics and in the food industry. Establishment of oil extraction unit adjoining fruit processing unit would not only supplement processor's income but also help in checking environment pollution.

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Table 1. Physico-chemical characteristics of apricot fruits, stones and their kernels collected from different locations in Himachal Pradesh.

Parameters	**Mandi**	**Shimla**	**Kinnaur**	**Mean**	**$CD_{0.05}$**
Fruit kernel type	Bitter	Bitter	Bitter	Bitter	
Weight of fruit, g	8.0	15.1	12.8	12.0	0.24
Size of fruits					
(i) Horizontal dia, mm	24.0	26.7	25.3	25.3	0.14
(ii) Vertical dia, mm	22.4	25.0	23.7	23.7	0.16
Fruit density, g/cc	1.3	1.3	1.2	1.3	0.01
Pulp weight, g	6.2	13.2	10.9	10.1	0.24
Pulp, %	77.8	87.3	85.6	84.3	-
Stone weight, g	1.8	1.9	1.9	1.9	0.03
Stone recovery, %	22.2	12.7	14.4	15.6	0.23
Pulp/stone ratio	3.5	6.9	5.5	5.3	-
Size of stones/pits					
(i) Horizontal dia, mm	16.8	19.7	16.8	17.8	0.16
(ii) Vertical dia, mm	15.8	16.4	15.8	16.0	0.09
(iii) Thickness, mm	11.0	11.1	11.0	11.0	0.10
Shell weight, g	1.18	1.33	1.27	1.26	0.02
Shell thickness, mm	1.4	1.3	1.2	1.3	0.01
Kernel weight, g	0.60	0.59	0.58	0.59	0.01
Kernel recovery, % (on stone basis)	33.7	30.7	31.4	31.9	0.32
Stone/kernel ratio	3.0	3.2	3.1	3.1	-
Size of kernel					
(i) Horizontal dia, mm	12.9	16.1	12.7	13.9	0.10
(ii) Vertical dia, mm	10.6	10.1	10.3	10.3	0.11
(iii) Thickness, mm	8.5	7.2	8.4	8.0	0.16
Kernel density , g/cc	1.0	1.0	1.0	1.0	-
Kernel moisture, %	4.1	4.0	4.1	4.1	-
Oil recovery, %	45.6	46.3	46.3	46.1	0.57
Moisture in oil, %	0.25	0.26	0.26	0.26	-
HCN in kernels	+	+	+	+	-

(+)= HCN present; Karsog, Mandi (930-935 m amsl.); Jubbal, Shimla (1850-2000 m amsl); Kalpa, Kinnaur, (2190-2250 m amsl)

Table 2. Availability of apricot fruits, stones/pits, kernels and expected oil yield in India and Himachal Pradesh

Cultivated apricot	Fruits, MT	Stone, %	Availability of stones, MT	Kernel, %	Availability of kernels, MT	Oil yield, %	Expected oil yield, MT
India *	10,000	12.5	1,250.0	31.9	398.8	47.2	188.2
HP**	1,450	12.5	181.3	31.9	57.8	47.2	27.3
Wild apricot							
H.P. ***	3,280	16.5	541.2	32.1	173.7	46.1	80.1
Total in H.P. (wild + cultivated)	4,730		722.5		231.5		107.4
Total in India (wild + cultivated)	13,280		1,791.2		572.5		268.3

* FAO, 2005; ** Anonymous, 2006; *** Approximate Yield; MT= Metric tonnes

Table 3. Standardization of a method for decortication of apricot stones/pits obtained from different locations in Himachal Pradesh

Location	Decorticated stones (yield kg/hour		Grand Mean	(%) Decortications		Grand Mean
	Manual	Mechanical		Manual	Mechanical	
Mandi	3.2	120.0	61.6	95.1	86.5	90.8
Shimla	3.8	120.0	61.9	95.2	85.5	92.4
Kinnaur	4.4	120.0	62.2	95.5	85.4	90.4
MEAN	3.8	120.0		95.3	85.8	

Karsog, Mandi (930-935 m amsl.); Jubbal, Shimla (1850-2000 m amsl); Kalpa, Kinnaur, (2190-2250 m amsl)

Table 4. Efficiency of kernels separation (Kg/hour) from decorticated mass of stones/pits of apricots.

Location	Kernel yield (Kg/hour)				
	Manual separation	**Mechanical Separation**	**Water**	**Specific gravity separation (25% salt)**	**Mean**
Mandi	0.620	3.7	0.0	7.0	2.8
Shimla	0.610	3.7	0.0	6.3	2.7
Kinnaur,	0.610	3.9	0.0	7.3	2.9
Mean (M)	0.613	3.8	0.0	6.9	

Karsog, Mandi (930-935 m amsl.); Jubbal, Shimla (1850-2000 m amsl); Kalpa, Kinnaur, (2190-2250 m amsl)

Table 5. Standardization of method for removal of hydro-cyanic acid (HCN) from bitter apricot kernels.

Location	Treatment duration, min.	ResiduaL HCN, mg/100 g kernels				
		Immersion in water	**Immersion in 5 ppm β-glucosidase solution**	**Immersion in 25% salt solution**	**Blanching**	**Immersion in 10 % sodium thiosulphate solution**
	Initial (0)	148.00 (0.00)	148.00 (0.00)	148.00 (0.00)	148.00 (0.00)	148.00 (0.00)
Karsog, Mandi (930-935 m amsl)	10	148.00 (0.00)	118.00 (20.27)	130.00 (12.16)	135.00 (8.78)	92.50 (37.50)
	20	148.00 (0.00)	68.00 (54.05)	121.00 (18.24)	98.33 (33.56)	21.00 (85.81)
	30	141.90 (4.12)	41.66 (71.85)	74.03 (49.98)	42.66 (71.18)	0.00 (100.00)
	40	140.10 (5.34)	0.00 (100.00)	26.44 (82.13)	0.00 (100.00)	0.00 (100.00)
	50	134.86 (8.88)	0.00 (100.00)	10.05 (93.21)	0.00 (100.00)	0.00 (100.00)
	60	129.70 (12.36)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)
	Initial (0)	173.00 (0.00)	173.00 (0.00)	173.00 (0.00)	173.00 (0.00)	173.00 (0.00)

Jubbal, Shimla (1850-2000 m amsl)	10	173.00 (0.00)	142.00 (17.91)	160.00 (7.51)	161.50 (6.64)	129.00 (25.43)
	20	170.83 (1.25)	96.49 (44.22)	140.00 (19.08)	118.46 (31.52)	76.75 (55.63)
	30	167.76 (3.03)	61.90 (64.22)	110.45 (36.16)	82.47 (52.33)	42.51 (75.42)
	40	162.03 (6.34)	31.76 (81.64)	82.47 (52.33)	48.50 (71.97)	19.96 (88.46)
	50	153.96 (11.00)	0.00 (100.00)	32.00 (81.50)	0.00 (100.00)	0.00 (100.00)
	60	147.00 (15.03)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)
	Initial (0)	154.00 (0.00)	154.00 (0.00)	154.00 (0.00)	154.00 (0.00)	154.00 (0.00)
Kalpa, Kinnaur (2190-2250 m amsl)	10	154.00 (0.00)	129.50 (15.91)	132.20 (14.15)	140.5 (8.76)	126.50 (17.85)
	20	154.00 (0.00)	96.49 (37.34)	108.30 (29.68)	110.03 (28.55)	82.47 (46.45)
	30	150.00 (2.60)	62.10 (59.68)	84.24 (45.30)	74.20 (51.82)	40.13 (73.94)
	40	147.00 (4.54)	20.16 (86.91)	42.00 (72.72)	46.80 (69.61)	0.00 (100.00)
	50	142.00 (7.79)	0.00 (100.00)	12.50 (91.88)	0.00 (100.00)	0.00 (100.00)
	60	134.00 (12.98)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)	0.00 (100.00)

* Figures in parenthesis represent % HCN removal/detoxification

Table 6. Effect of apricot kernels treatment on residual hydrocyanic acid (mg HCN/100g) in extracted kernel oil and press cake fro table oil expeller.

Treatments	**Duration, min**							
	0		**20**		**40**		**60**	
	Press cake	**oil**	**Press cake**	**oil**	**Press cake**	**oil**	**Press cake**	**oil**
Immersion in water	90.0 (0.0)	42.0 (0.0)	78.0 (13.3)	34.0 (19.0)	55.0 (38.8)	28.0 (33.3)	40.0 (55.5)	22 (47.6)
Immersion in 5 ppm β glucosidase solution	90.0 (0.0)	42.0 (0.0)	20.0 (77.7)	13.0 (69.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)
Immersion in 25% salt	90.0 (0.0)	42.0 (0.0)	30.0 (66.6)	10.0 (76.1)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)

solution								
Blanching	90.0 (0.0)	42.0 (0.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)
Immersion in 10% sodium thiosulphate solution	90.0 (0.0)	42.0) (0.0)	20.0 (77.7)	6.8 (83.8)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)	0.0 (100.0)

*Figures in parenthesis represent % HCN removal/detoxification

Table 7. Standardization of a method for extraction of kernel oil from apricot stones

Location	**Oil yield, %**				**Grand mean**
	Solvent extraction	**Oil press (Power ghani)**	**Baby oil expeller (4 bolts)**	**Table oil expeller (Y2K)**	
Mandi	45.6	28.5	32.0	38.0	36.0
Shimla	46.6	29.0	31.5	37.5	36.1
Kinnaur	47.0	29.0	32.0	38.5	36.6
Mean (M)	**46.7**	**29.4**	**32.0**	**38.2**	**-**

Karsog, Mandi (930-935 m amsl.); Jubbal, Shimla (1850-2000 m amsl); Kalpa, Kinnaur, (2190-2250 m amsl)

Table 8. Effect of different oil extraction methods on the quality characteristics of apricot kernel oil

Location	**Type of kernel**	**Iodine value,g I_2/100g oil**				**Saponification value, mg KOH/g oil**				**Acid value, mg KOH/g oil**				**Peroxide value, meq/kg oil**			
		SE	**OP**	**TOE**	**Grand Mean**	**SE**	**OP**	**TOE**	**Grand Mean**	**SE**	**OP**	**TOE**	**Grand Mean**	**SE**	**OP**	**TOE**	**Grand Mean**
Mandi	Bitter	100.4	100.2	100.3	100.3	191.1	191.9	192.7	191.9	2.3	2.9	3.0	2.7	5.3	6.6	6.5	6.1
Shimla	Bitter	100.2	100.4	100.2	100.3	189.5	190.9	191.5	190.6	2.8	2.8	2.8	2.8	5.4	6.6	6.5	6.2
Kinnaur	Bitter	100.2	100.3	100.8	100.4	191.0	191.1	192.1	191.4	2.7	2.7	2.9	2.8	5.1	6.7	6.7	6.2
Mean (M)		100.3	100.3	100.4	100.3	190.5	191.3	192.1	191.3	2.6	2.8	2.9	2.8	5.3	6.6	6.6	6.2
Mean (L)		100.3				191.9				2.7				6.1			
$CD_{0.05}$	Location (L)				2.75				NS				0.84				NS
	Method (M)				0.20				0.90				0.09				0.99
	L×M				2.08				NS				0.50				0.90

Mandi, Karsog (930-935 m amsl), Shimla, Jubbal (1850-2000 m amsl), Kinnaur, Kalpa (2190-2250 m amsl)
SE = Solvent extraction, OP =Oil Press, TOE = Table oil expeller, NS=Non significant, Bitter= bitter kernels oil, Sweet=sweet kernels oil

Table 9. Fatty acid composition of apricot kernel oil

Fatty acid	**Per cent composition (% w/w)**
Palmitic $C_{16:0}$	7.79
Palmitoleic $C_{16:1}$	0.48
Stearic $C_{18:0}$	0.93
Oleic $C_{18:1}$	62.07
Linoleic $C_{18:2}$	27.76
Linolenic $C_{18:3}$	1.42
Σ SFA	8.72
Σ MUFA	62.55
Σ PUFA	29.18
Σ UFA	91.73
U : S ratio	10.51:1

Σ SFA - Saturated fatty acid; Σ MUFA - Mono unsaturated fatty acid;
Σ PUFA - Poly unsaturated fatty acid; Σ UFA -Unsaturated fatty acid
U : S ratio - Unsaturate: saturate ratio

Table 10. Cost of production of apricot oil at cottage scale

I. Machinery and equipment

S.N.	**Particulars**	**Quantity**	**Unit cost (Rs)**	**Total Amount, Rs**
1.	Mechanical decorticator (breaking/crushing of stones/pits)	1	44,000	44,000.00
2.	Kernel oil expeller (Y2K) (oil extraction)	1	45,000	45,000.00
3.	Oil filter press (oil filtration)	1	25,000	25,000.00
4.	PP cap sealing machine	1	10,000	10,000.00
5.	Miscellaneous articles: Water tubs, Sieves, Buckets ,Trays		5,000	5,000.00
6.	Unforeseen expenditure			2,000.00
	TOTAL FIXED COST			**1,31,000.00**
II	**Recurring cost**			
1	Apricot stones, kg	1000	20	20,000.00
2	Decortication, kg	1000	0.13	130.00
4	Kernel separation, kg	320	1.75	560.00
5	Kernel drying cost, electricity units	50	3.50	175.00
7	Extraction and filtration cost,	50	3.50	175.00

	electricity units			
8	Bottles (250 ml capacity), (121.6 kg, yield)	490 No,s	4.35	2128.00
9	Antioxidant TBHQ, g	2.43	2600	6.30
10	Labels, No's	490	1.00	490.00
11	Labour, man days	30	100	3,000.00
	TOTAL RECURRING COST			**26,664.30**
III	**Interest and depreciation cost**			
1	Depreciation on machinery and equipment @ 10% on 1,31,000 for one month			1,091.67
2	Interest on capital (fixed & recurring) @ 10% pa for one month			1313.87
IV	**Cost of production (**recurring cost + interest and depreciation cost)			**29,069.84**
1	Total quantity of oil, kg			121.60
2	Unit cost of production, Rs/kg			239.06
3	Profit @ 20%			47.81
4	Total production cost per kg			286.87
5	Sale price per 250 ml bottle			71.72

TBHQ= tertiary butyl hydroquinone