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Effect of pre-treatments on juice recovery and ascorbic acid content of juice extracted from aonla fruits

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Abstract
Attempts were made to analyze the effect of pre-treatments on juice recovery and ascorbic acid content of juice extracted from aonla fruits at College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat. Aonla fruits were given pre-treatment of blanching either by hot water treatment at different temperatures and time intervals (i.e. 85-100 °C and 2-8 min); or steam blanching at different time intervals (2-8 min). The steam blanching of aonla fruits for 2 minutes resulted in more quantity of juice (51%) with higher ascorbic acid content (698 mg/ 100 ml of juice. The maximum juice recovery (76%) was given by screw type juice extractor compared to other juice extraction machines. The screw type juice extractor was operated at four different rotational speeds (90, 180, 270 and 360 rpm). The maximum juice recovery (74%) was at 90 rpm. The optimized conditions obtained for aonla juice extraction were steam blanching for 2 minutes, pulverization of the shreds and juice extraction using screw type juice extractor with the speed of rotation of 90 rpm.

Keywords: Aonla, hot water blanching, steam blanching, screw type juice extractor, ascorbic acid, juice recovery

Introduction
Indian gooseberry (Emblica officinalis Gaertn. Syn. Phyllanthus emblica L.) fruit commonly known as aonla is one of the oldest minor sub-tropical deciduous fruits of India. It belongs to the family Euphorbiaceae and is native of India, Sri Lanka, Malaysia, and China (Jain and Khurdiya, 2004) [10]. In India, aonla is grown in an area of about 50,000 ha with a production of around 2, 00,000 tonnes (Goyal *et al.*, 2008) [8]. The main varieties of aonla grown in India are Banarasi, Chakaiya, Hathijhool, Bansi red, Pinki-tinged, NA7, Anand Aonla – II, Krishna, etc. (Goyal *et al.*, 2007) [7]. The growing popularity for alternate medicines, health foods and herbal products is enhancing the requirements for aonla fruit and its products. The fruit is highly nutritive with a great medicinal value and is the richest source of vitamin C. The vitamin C content in pulp of fresh fruit is 200-900 mg/100 g (Goyal *et al.*, 2008) [8]. The vitamin C content is even greater than that present in guava, citrus fruits and tomato. The fruit juice contains nearly 20 times as much vitamin C as in orange juice. Its other constituents are phenols and tannins containing gallic acid, elegiac acid and glucose which prevent oxidation of vitamin C. It has been observed that ascorbic acid and other polyphenols present in natural extracts of aonla show superior antioxidant activity and counteracting the toxic effects of metal salts in hepatic and renal toxins than equivalent amount of pure ascorbic acid (Roy *et al.*, 1991, Khopde *et al.*, 2001) [18, 13].

Aonla fruits are used in traditional Indian systems of medicines, like ayurvedic and unani, due to their therapeutic values (Agarwal and Chopra, 2004) [1]. The aonla fruits are used to treat common cold, gastric troubles, chronic diarrhoea and dysentery, headache, constipation, enlarged liver, diabetes, bronchitis, jaundice and fever, etc. (Chadha, 2003) [4]. A tablespoon each of fresh aonla juice and honey mixed together forms a very valuable medicine for the treatment of several ailments like tuberculosis of lungs, asthma, bronchitis, scurvy, diabetes, anemia, weakness of memory, cancer, tension, influenza, cold, loss and grayness of hair etc.

Aonla juice helps in enjoying the maximum benefits and natural herbal qualities of aonla. Patients suffering from diabetes with side effects like skin allergy, blood pressure, can get cured by consumption of aonla juice. Aonla juice reduces unwanted fat because it increases total protein levels; this is due to its ability to create a positive nitrogen balance and it also significantly reduces the levels of free fatty acids, reduces cholesterol and cholesterol induced atherosclerosis (obstruction of the arteries), thus making it a useful natural product to fight obesity.

Furthermore, aonla juice has exhibited considerable effect in inhibiting the HIV virus which ultimately results in the disease AIDS (Mathur *et al.,* 1996) [15]. Aonla juice is refreshing and retains characteristic taste and aroma even after few months of its preparation into a beverage.

Aonla juice is either prepared in households or at the cottage level industry. Traditionally, the juice is produced by boiling the aonla fruits in water for about 6–8 min, manually removing of stone using knife, cutting the segments and pressing the segments manually using muslin cloth. The juice extraction process is very vague. The quantity and quality of aonla juice obtained vary widely depending upon the level of processing and the skill of the person. The information available on the scientific technology for production of aonla juice is very limited. For commercial exploitation of this highly nutritious Indian fruit, it is imperative to develop and standardize the technology for the extraction of superior quality aonla juice. Systematic and scientific investigations on different pretreatments for efficient extraction of juice having high content of the ascorbic acid are needed. The study was undertaken with the broad aim of analyzing the effect of pretreatments on juice recovery and ascorbic acid content of juice extracted from aonla fruits.

Materials and Methods

Aonla Fruit

Mature, fresh and good quality Indian gooseberry (aonla) fruits of cultivar Anand Aonla-II were procured from the local market of Anand. The fruits were washed in 5 ppm chlorine water manually in the laboratory to remove the dirt adhering to the fruit and to reduce the microbial load on the fruit.

Juice Extraction

The standardization of technique for juice extraction was carried out after some preliminary tests. Thus, the process was standardized with four different variables; (i) blanching, (ii) pulverization, (iii) juice extraction machine and (iv) operating parameters of the suitable juicing machine. The aonla fruits were given pre-treatment of blanching either by (i) hot water blanching at different temperatures and time intervals; or (ii) steam blanching at different time intervals using a blanching vessel. The treatment was standardized based on juice recovery and ascorbic acid content in the juice. The blanching condition which gave the maximum juice recovery with minimal loss in ascorbic acid content was considered as the best blanching condition. Once the blanching was standardized, the fruits were passed through aonla shredder-cum-destoner machine for shredding and separating the seeds. The shreds were weighed and then pulverized using pulverizer. Some samples were used for juicing without pulverizing. The juicing machines i.e. basket centrifuge, screw type juice extractor, pulper and hydraulic press, were used to extract juice from aonla fruits. The machine which gave the maximum juice recovery was further studied for its machine parameters which were further standardized for the maximum juice recovery.

Experimental plan

Juice extraction process from Aonla fruits

Operations	Treatment	Levels	Observations
Pretreatments	Hot water Blanching	Temperature: 85, 90, 95, 100 Time: 2, 4, 6, 8	Juice recovery (%), Ascorbic acid (mg/100 g),
	Steam blanching	Time: 2, 4, 6, 8	
Fruit shredding and destoning	By power operated continuous flow type machine		
Size reduction	a) With pulverization b) Without pulverization		
Juice extraction	a. Basket centrifuge b. Screw type juice extractor c. Pulper d. Hydraulic press		Percentage increase in juice recovery (%)

Aonla shredder-cum-destoner used for the experiment is a power operated continuous flow type machine for production of aonla shreds developed by Anand Agricultural University (Kapadi *et al.,* 2000) [12]. The pre-determined quantity of whole aonla fruit duly blanched fed through the hopper, moved forward through the reducing clearance between the roller and the sieve with the help of canvas strip fitted with the roller. Thus the gradual scrapping of the pulp from all around the aonla fruit was done till the inner seed is free from pulp. The shreds get discharged from the trapezoidal end just below the sieve and seeds / aonla stones move out through the other end. The shreds were collected separately and were moved immediately either for pulverization or for juicing.

Pulverizer (make: Temp Exchanger, Vadodara) used is a power operated continuous flow type machine for production of pulverized fruits. The machine consists of a hopper, drum consisting of teeths and hammer, 2 mm sieve, discharge chute and power transmission system. The shreds of aonla were fed through the tapered opening, and were gradually crushed by hammer and teeth to smaller pieces in a single pass. The pulverized aonla was then passed through the sieve at the discharge end and gets collected at the bottom. The time taken for pulverization was 2-3 minutes. The speed of rotation was 950 rpm.

Analytical methods

Juice recovery

Percent juice yield was calculated on the basis of weight of juice obtained per unit weight of fruit (Jain and Khurdiya, 2004) [10].

$$\text{Juice recovery (\%)} = \frac{\text{Weight of juice}}{\text{Weight of fruit} - \text{Weight of stone}} \times 100$$

Total ascorbic acid content

Ascorbic acid content of sample was determined according to AOAC (1995) [2] method. Two gram of aonla juice was blended with 20 ml of metaphosphoric-acetic acid solution to extract ascorbic acid. The mixture was filtered using a Whatman filter paper No. 40 and transferred to a volumetric flask. Two milliliter of the filtrate extract with 5 ml metaphosphoric-acetic acid solution was rapidly titrated with 2, 6 dichlorophenol indophenol solution until light distinct rose pink color persisted for more than 5 s.

$$\text{mg ascorbic acid/ml} = (X - B) \times \frac{F}{E} \times \frac{V}{Y}$$

Where,
X = average ml for sample titration
B = average ml for sample blank titration
F = titre of dye
E = ml assayed (=2 ml)
V = volume of initial assay solution (= 7 ml)
Y = volume of sample aliquote titrated (= 7 ml)

$$\text{Titre, F} = \frac{\text{mg ascorbic acid in volume of standard solution titrated} **}{\text{Average ml dye used to titrate standard} - \text{average ml of dye used to titrate blank}}$$

$$** \text{ mg ascorbic acid in volume of standard solution titrated} = \frac{\text{mg of ascorbic acid}}{20 \text{ ml} \times 2 \text{ ml}}$$

Result and Discussion

Aonla fruit juice was extracted using various pre-treatments and different juice extraction machines. The blanching treatments suitable for extraction of juice were evaluated and optimized for the maximum juice recovery and the highest vitamin C content. The necessity of pulverizing the aonla fruit shreds was judged based on the juice recovery. The different juicing machines were also studied and optimized for the maximum juice recovery. The final juice was obtained using the optimized extraction conditions and was analyzed.

Effect of Hot water and Steam Blanching on Juice Recovery from Aonla Fruit

The juice recovery initially increased significantly when the aonla fruits were blanched (hot water) as compared to that from unblanched fruits. As compared to unblanched fruit samples, the juice recovery was more, where fruits were blanched at all the four temperatures from 85 to 100 °C but for the shortest time of 2 and 4 minutes only. At higher temperature combined with prolonged blanching caused softening of the fruit to a level from where the shredding or pulverizing and also the juicing became very difficult. The samples for 8 minutes blanching were discarded due to the above reason, along with the samples at 90, 95 and 100 °C for 6 minutes. However, as the temperature of hot water blanching was increased from 85 to 100 °C, the juice recovery for a particular time interval went on reducing. It is clear that as the hot water blanching temperature increased from 85 to 100 °C, the overall juice recovery reduced from 48 to 37%. As mentioned earlier, the higher temperature (> 90 °C) and longer time (> 6 min) resulted in very soft material unsuitable for juicing. Hence, blanching at all the temperatures for 8 minutes did not produce juice at all and therefore, hot water blanching beyond 6 minutes was not considered. The blanching time more than 2 minutes resulted in reduction in the juice recovery except at the temperature of 85 °C (Table 1). When different samples of aonla fruits were steam blanched, the juice recovery decreased with increase in blanching time i.e. 2, 4, 6 and 8 minutes. However, the recovery of the juice was substantially higher than that from unblanched samples except steaming of the fruits for 8 minutes (Table 1)

Table 1: Effect of hot water and steam blanching on juice recovery and ascorbic acid content of juice extracted from aonla fruits

Blanching Condition	Blanching Temperature (°C)	Blanching Time (min)	Juice recovery (%)	Ascorbic acid content (mg/ 100 ml)	Percentage reduction in Ascorbic acid content (%)
Hot water	85	2	48	696	0.57
		4	43	679	3
		6	41	627	10
		8	-	-	-
	90	2	46	679	3
		4	41	651	7
		6	-	-	-
		8	-	-	-
	95	2	44	668	5
		4	39	637	9
		6	-	-	-
		8	-	-	-
	100	2	43	651	7
		4	37	623	11
		6	-	-	-
		8	-	-	-
Steam		2	51	698	0.29
		4	47	639	9
		6	44	586	16
		8	37	567	19
Control (Unblanched)			42	700	

ANOVA Table						
Source of Variation	**SS**	**df**	**MS**	**F**	**p-value**	**F crit**
Sample	332.13	4	83.03	138.38	2.8311E-14	2.86
Columns	140.83	1	140.83	234.72	1.6282E-12	4.35
Interaction	8.00	4	2.00	3.33	0.030	2.86
Within	12.00	20	0.6			
Total	492.96	29				

The steady decrease in juice recovery from aonla fruit might be due to gelatinization of starch. However, the fruits subjected to steam did not undergo much structural changes and did not become soft initially but as time of steaming was increased, the fruit became softer and the shreds obtained were less reducing juice recovery. Thus, the juice recovery from steam blanched aonla fruit was more compared to hot water blanched aonla fruit and unbranched fruits. Therefore, steam blanching of aonla fruits for 2 minutes resulted in the maximum juice recovery (Table 1).

Table 1: Juice recovery from aonla fruit

Treatment/Time	T1 (2 min.)	T2 (4 Min.)	Mean (W)
W1 (85 Hot Water)	48.0	43.3	45.66
W2 (90 Hot water)	46.3	41.0	43.66
W3 (95 Hot water)	43.0	39.3	41.16
W4 (100 Hot water)	42.6	37.3	40.00
W5 (Steam)	50.6	48.0	49.33
Mean (T)	46.13	41.8	
SEM (W×T)	0.44		
CD(W×T)	1.31		

Mean tables for Blanching treatment

Treatment	Mean Table
W1	45.66
W2	43.66
W3	41.16
W4	40.00
W5	49.33
SEM	0.31
CD	0.93
T1	46.13
T2	41.8
SEM	0.2
CD	0.59
(INT) WxT	S
CV%	1.72

Effect of Hot water and Steam Blanching on Ascorbic acid content of juice extracted from Aonla Fruits

During hot water blanching, as the blanching temperature (85, 90, 95, 100 °C) and time (2, 4, 6, 8 min) was increased, the ascorbic acid content of aonla juice decreased. The minimum ascorbic acid content was 623 mg/100 ml in juice from hot water blanching treatment at 100 °C for 4 minutes, while the maximum ascorbic acid content (696 mg/100 ml) in juice was for treatment of 85 °C for 2 minutes. A steady decrease in ascorbic acid content of the juice with the increase in the temperature of blanching at a particular time was observed during the study. The influence of temperature and duration of hot water blanching on aonla fruit was also studied by Jain and Khurdiya (2002) [9], who established that treatment at 100 °C for 6 minutes lead to 12% reduction of ascorbic acid. The decrease in ascorbic acid might be basically due to heating and also the leaching from the surface of the fruit by water absorption.

On the other hand, when the aonla fruits were exposed to steam and the blanching duration was increased from 2 to 8 minutes, the ascorbic acid content of the juice decreased. The minimum content of ascorbic acid i.e. 567 mg/100 ml in juice was for samples steam blanched for 8 min, while the maximum ascorbic acid content i.e. 698 mg/100 ml in juice was when the fruits were steam blanched for 2 minutes. The minimum percentage reduction (0.29%) of ascorbic acid in aonla juice was observed at steam blanching for 2 minutes and the maximum percentage reduction (19%) of was observed at steam blanching for 8 minutes. The influence of steam blanching on aonla fruit was also studied by Ghorai and Sethi (1998) [6] and they reported a loss of ascorbic acid after steam blanching for 4 to 5 minutes of Banarasi variety of aonla fruits.

Effect of Machine Type with /without Pulverization on Juice Recovery from Aonla Fruit

The influence of different types and mechanism of juice extraction was studied for extraction of juice from aonla fruits. The fruit after steam blanching for 2 minutes were shredded using shredder-cum-destoner. These shreds were then pulverized using pulverizer. The pulverized/unpulverized material then passed through various juice extraction machines such as basket centrifuge, screw type juice extractor, fruit pulper and hydraulic press.

Table 2: Juice recovery from steam blanched fruit with and without pulverization for different juice extraction machines

Machine type	Juice recovery (%)		Percentage increase in juice recovery (%)
	With pulverization	Without pulverization	
Basket Centrifuge	68	43	58
Screw type juice extractor	76	60	27
Pulper	65	36	80
Hydraulic Press	68	45	51

The juice recovery was significantly different for different juicing machines used. The maximum recovery of aonla juice (76%) was obtained when screw type juice extractor was used. The fruit pulper gave the least juice recovery (65%), while the basket centrifuge and hydraulic press resulted in 68% juice recovery. This might be due to the possible application of pressure by the auger/ screw, which might have helped in achieving the compression required to release the juice from the fiber. Similar higher juice recovery of 40-49.6% from kinnow orange (Thakur *et al.*, 2004; Panesar *et al.*, 2000) [20, 17], 66-81% from pomegranate (Kumbhar *et al.*, 2002) [14] and 44.3% from hill lemon (Barwal *et al.*, 2009) [3] using screw type juice extractor, was reported. The maximum juice recovery was given by screw type juice extractor compared to other juice extraction machines. Therefore, the best suitable machine for the extraction of the maximum aonla juice was found to be the screw type juice extractor. Similar recommendation was also given by Barwal *et al.* (2009) [3] (Table 2).

Effect of Speed of Rotation of Screw Type Juice Extractor on Juice Recovery from Aonla Fruits

The screw type juice extractor was adjudged the best for the highest juice recovery from aonla fruit. For further and deeper investigation, it was decided to vary the speed of the extractor and study its effect on juice recovery. The screw type juice extractor was operated at four different rotational speeds (90, 180, 270 and 360 rpm) and the juice recovery was noted for each speed.

When the speed of rotation of the screw type juice extractor was increased from 90 to 360 rpm, then there was steady decrease in the juice recovery from steam blanched aonla fruit. The decrease in juice recovery was almost linear with the increase in rotational speed of the extractor. The maximum juice recovery (74%) was at 90 rpm whereas the

minimum juice recovery (49%) was at 360 rpm of the machine. The juice recovery was noted 61% and 58% at the speed of rotation of screw type juice extractor machine 180 rpm and 270 rpm, respectively. The decrease in juice recovery with the increase in speed of rotation might be because of possible decrease in the residence time for the pulverized material in the machine, resulting in incomplete compression of the material for juice extraction.

Optimization of Juice Extraction Technique

To optimize the whole process of juice extraction, the content of vitamin C and the juice recovery were considered as the deciding factors and hence, all the variables were optimized based on the maximum content of vitamin C and the maximum juice recovery from aonla fruit.

The optimized conditions for juice extraction, obtained from the study:

Blanching condition: Steam blanching for 2 minutes

Requirement of pulverization: Yes

Suitable machine for juice extraction: Screw type juice extractor

Speed of rotation for juice extraction: 90 rpm

Table 3: Biochemical, Microbial and Sensory parameters of fresh aonla juice

S.N.	Attributes	Parameters	Values
1.	Chemical	Vitamin C, mg/ 100 mL	120.95
		Acidity %	2.336
		pH	1.97
		TSS, ºBrix	12.7
		Reducing Sugars,%	7.6
		Total Sugars,%	7.91
		Tannins, % gallotannic acid	1.45
2.	Microbial	Total plate count	1×10^3
		Yeast and molds	nil
		Coliform Counts	nil
3.	Sensory	Color	7.83
		Taste	7.62
		Aftertaste	7.59
		Flavor	7.66
		Overall Acceptability	7.79

The bio-chemical quality parameters of the fresh aonla juice extracted using the optimized processing condition as explained above are given in Table 3. Similar findings have been reported by Mehta and Rathore (1976) [16] Jain and Khurdiya (2002) [9] Jain *et al*., (2003) [4] Jain and Khurdiya (2004) [10], Gajanana *et al.,* (2007) [5] and Shere *et al.,* (2008) [19].

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