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Integrated protocol for value-addition in strawberry *(Fragaria x ananassa)*

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Abstract

An integrated protocol was standardized for production of diversified products from strawberry (*Fragaria x ananassa*). The fresh fruits were subjected to lactic acid fermentation using *Lactobacillus* sp. The prepared probiotic drink was collected and left over fruits were utilized for preparation of other products, viz. candy, squash, jelly and wine. Candy was prepared by incubating whole fruits in subsequently increasing concentrations of sugar syrup and then drying at 60 °C temperature in electric dehydrator to an intermediate moisture level of around 12%. The sugar syrup thus left had attractive red color due to anthocyanins extracted from the fruits. It was used for preparation of squash, jelly and wine. The strawberry probiotic drink contained 2.2 °B TSS, 0.17% acidity, 2.1 mg/100ml vitamin-C, 37.1 mg/100ml phenolics and 2.36 mg/100ml anthocyanins. During ambient storage of probiotic drink up to 30 days, vitamin-C, phenolics and anthocyanin contents decreased while reducing sugars increased. Quality analysis of strawberry products revealed that candy contained highest amounts of phenolics and anthocyanins followed by jam, jellly and squash and least in wine. The vitamin-C content ranged between 1.6 to 14.8 mg/100 g or ml, being highest in jelly while least in wine. The ethanol content in wine was found to be 11.7 per cent. All the strawberry products were highly acceptable during sensory evaluation scoring above 7.0 out of total 9.0. It may be concluded that a variety of processed products could be prepared from same raw material by using the integrated protocol for strawberry products.

Key words: Strawberry, Probiotic, Fermentation, *Lactobacillus,* Anthocyanins

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Strawberry (*Fragaria x ananassa*) is one of the richest sources of natural antioxidants among fruits (Wang *et al.,* 1996, Wang and Zheng, 2001). In addition to usual nutrients, such as vitamins and minerals, strawberries are also rich in anthocyanins, flavonoids and phenolic compounds (Heinonen *et al.*, 1998). The fruit contains ellagic acid, ellagitannins, gallotannins, proanthocyanidins, quercetin, catechin, ascorbic acid, folic acid and minerals (Karaaslana and Yamanb, 2017). A number of strawberry products like juice, jam, jelly, squash, etc. were prepared by many workers (Ayub *et al*., 2010; Khan *et al*, 2012; Islam *et al*, 2012; Kefayatullah *et al*., 2019) but their studies were limited only to preparation of single product from single raw material. A concept of multiple product development from single source with complete utilization of left over materials has been worked out. An integrated protocol has been developed for production of diversified products, viz. probiotic drink, sqaush, jam, jelly, candy and wine.

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Materials and Methods

Healthy, mature, ripe fruits of strawberry were brought from Institute's orchard and washed thoroughly with tap water. The probiotic drink was prepared as per the method developed by Garg *et al.* (2015) for cucumber probiotic drink. The fruits were subjected to lactic acid fermentation in brine solution using *Lactobacillus plantarum* culture maintained in Microbiology Laboratory. After achieving desired level of lactic acid content in solution, it was collected as probiotic drink after separating the fruits (Fig. 1). The drink was filled in bottles and stored under ambient conditions. It was analyzed for biochemical, sensory and microbial parameters enlisted in next paragraph.

The fruits obtained were divided into two batches. One batch of fruits was subjected to jam preparation by pulping and heating of pulp with required amount of sugar and acid using protocol described by Srivastava and Kumar (2002). The second batch of strawberries was utilized for preparation of candy as per the method Tandon *et al.*

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(2004) for making aonla candy. The strawberries were incubated for two successive overnights in increasing concentrations of sugar syrup at 50 and 60 °Brix. The fruits were then separated, rinsed with warm water and dried in electric dehydrator at 60° C to an intermediate moisture level of around 12 percent. The prepared candy was packed in small jars. The attractive red colored left-over sugar syrup was then utilized for three kinds of products. Two non-fermented products, viz. squash and jelly were prepared by mixing sugar and other additives using methods of Srivastava and Kumar (2002). The fermented product, strawberry wine was prepared through alcoholic fermentation applying lab culture of *Saccharomyce cerevisiaes* as per the protocol developed by Garg *et al.* (2014) for bael wine.

The prepared strawberry products were analyzed for physico-chemical attributes. The TSS was recorded by using hand refractometer (Erma, Japan). Titratable acidity, ascorbic acid, and total phenolics were determined as per the methods described by Ranganna (2000). The acidity of products was estimated by titrating the samples against 0.1 N sodium hydroxide solution using phenolphthalein as indicator. The acidity of probiotic drink was calculated in terms of lactic acid while it was in terms of citric acid in case other products. Ascorbic acid content of beverage was measured by titrating samples against 2, 6-dichloro phenol indophenol dye solution, while phenolic content was estimated by using Folin and Ciocalteu's reagent. Total anthocyanins were determined by the ethanol extraction method developed by Fuleki and Francis (1968). The concentration of ethanol in strawberry wine was measured spectrophotometrically using potassium dichromate-sulphuric acid mixture as per the method of Caputi *et al.* (1968).

The sensory evaluation of products was carried out by a panel of semi-skilled judges on composite scoring (Amerine *et al.*, 1965) based on colour, aroma and taste of samples. The microbial counts for bacteria, yeast and mould were observed as per Speck (1984) method. The samples were analyzed in three replicates and data was presented in tabular form. It was analyzed statistically for mean value and standard deviation using microsoft excel.

Results and Discussion

The prepared probiotic drink was subjected to total microbial count and was found to have more than 10^6 counts of *Lactobacillus* bacteria. The total soluble solid of the drink was 2.2 °B at zero day which remained almost unchanged during storage up to one month (Table 1). The acidity of drink was observed to be 0.17

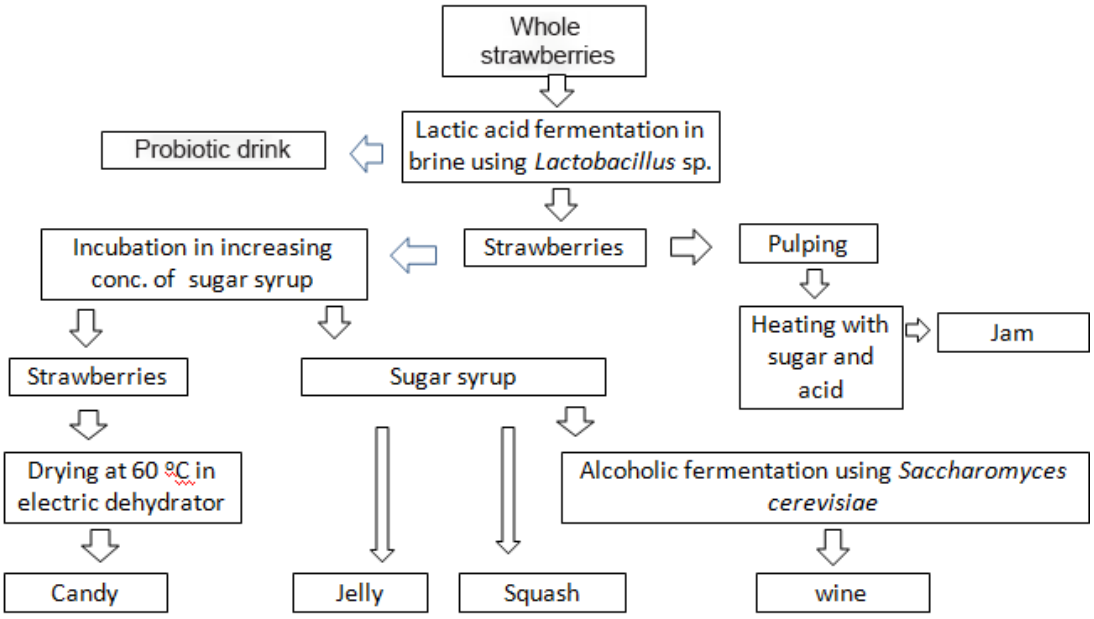


Fig. 1: Flow diagram of integrated protocol for strawberry value-addition.

per cent as lactic acid. It remained unchanged up to 20 days of storage but decreased thereafter to 0.12 per cent at 30 days (Table 1). The product had little amount of vitamin C (2.1 mg/100 ml) which further declined to negligible amount (0.8 mg/100 ml) after one month (Table 1).

This reduction might be due to oxidation of ascorbic acid into dehydroascorbic acid by oxygen (Sethi *et al.,* 1980). The probiotic drink contained good amount of phenolic compounds (37.1 mg/100ml) initially which decreased continuously with the storage period (Table 1). After 30 days, the total phenolic content was found to be 25.1 mg/100ml. The decrease in phenolic compounds may be attributed to break down of these compounds during storage. Raj *et al.* (2011) also reported gradual decline in polyphenol contents in sand pear and pear-apple juice beverage during storage.

The product had attractive purple colour due to presence of anthocyanins. The level of anthocyanin pigment was 2.36 mg/100ml initially which fell to a final level of 1.33 mg/100ml after one month, showing regular decrease throughout storage (Table 1). The fall in anthocyanins during storage might be due to oxidation of pigment. Muche *et al* (2018) also reported reduction in anthocyanin content during storage. Reducing sugars content depicted increasing trend during storage. It increased from an initial value of 0.48 per cent to 1.03 per cent at the end of storage.

The increase is attributable to the hydrolysis of sucrose in glucose and fructose by the acid present in the beverages or gradual inversion of non-reducing sugars into reducing sugars in acidic medium (Malav *et al.*, 2014). During sensory evaluation on the basis of appearance, aroma and taste, the probiotic drink obtained high organoleptic score (8.1 out of 9.0) at zero day which though declined but retained within good acceptable range till the end of storage (Table 1).

The prepared products, viz. squash, jelly, jam, candy and wine were also evaluated for different biochemical parameters (Table 2). The vitamin-C content in squash, jelly, jam and candy ranged from a lowest of 11.6 mg/100 g in squash to a highest of 14.8 mg/100 g in jelly. Candy was found to contain maximum phenolic (198.0 mg/100 g) and anthocyanin contents (20.4 mg/100 g), followed by jam, jelly and squash. The strawberry wine was found to contain 11.7 per cent ethanol apart from 1.6 mg/100 ml vitamin-C, 22.5 mg/100 ml phenolics and 3.7 mg/100 ml anthocyanin content after 45 days of ageing under refrigerated condition. All the products had good acceptable sensory qualities.

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Table 1: Changes in chemical attributes of strawberry probiotic drink during storage

Parameters	Period of storage (Days)			
	0	10	20	30
Total soluble solids (^{O}B)	2.2±0.11	2.2±0.11	2.2±0.11	2.0±0.11
Acidity as lactic acid (%)	0.17±0.01	0.17±0.01	0.17±0.01	0.12±0.01
Vitamin-C (mg/100ml)	2.1±0.05	1.9±0.05	1.1±0.05	0.8±0.05
Total phenolics (mg/100ml)	37.1±0.11	34.9±0.89	28.4±0.25	25.1±0.90
Total anthocyanins (mg/100ml)	2.36±0.05	1.97±0.03	1.60±0.04	1.33±0.01
Reducing sugars (%)	0.48±0.01	0.51±0.01	0.58±0.01	1.03±0.01
Sensory scores (out of 9)	8.1±0.26	7.7±0.68	7.5±0.52	7.0±0.29

Mean Value ± Standard Deviation

Table 2: Biochemical characteristics of strawberry products

Product	Total soluble solids (OB)	Acidity (%)	Vitamin C (mg/100 g or ml)	Total phenolics (mg/100 g or ml)	Total anthocyanins (mg/100 g or ml)
Squash	55.0±0.11	0.69±0.05	11.6±0.06	30.6±0.75	4.7±0.06
Jelly	78.0±0.11	1.15±0.06	14.8±0.35	130.5±2.25	8.6±0.05
Jam	72.0±0.11	0.77±0.05	13.1±0.35	167.1±16.4	12.4±0.20
Candy	68.0±0.11	0.97±0.05	13.1±0.35	198.0±6.7	20.4±0.11
Wine	8.6±0.11	0.49±0.01	1.6±0.06	22.5±2.3	3.7±0.11

Mean Value ± Standard Deviation

Conclusion

The protocol followed for strawberry value addition resulted in obtaining multiple diversified products (main product and co-products) from a single starting raw material. After obtaining probiotic drink, fruits separated were used for preparation of candy or jam while byproduct, i.e. sugar syrup was used for squash, jelly or wine. Thus, depending upon the resources available, the processing economics can be improved to a significant extent. The technology leaves no waste and hence highly viable economically as well as ecologically.

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