Production of Bael fruit (*Aegle marmelos)* pulp based intermediate moisture product

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Abstract

The study was carried out to develop fibre enriched Bael fruit pulp based intermediate moisture food using potato, sugar and salt as ingredients, with the aim of improving the palatability and increasing the utilization of the fruit, to develop moisture sorption isotherms at 5°C, 30°C and 35°C temperatures, and to increase the popularity of Bael fruit among people. Three treatments included the ratios of Bael: Potato: Sugar; 3:2:1, 2:3:1 and 1:1:0 respectively. Sensory evaluation was done using 30 semi trained panelists. According to their preference they selected 2:3:1 (Bael: Potato: Sugar) ratio as the best ingredients combination. This product was coded as 578 and it was superior in almost all the sensory attributes. The superior product recorded 14% fibre content and 15.5% moisture content. Microbial testing was conducted for the superior product at 2 week intervals at the ambient temperature condition. The Escherichia coli *count was nil on all occasions. Total bacterial count and mould count has increased gradually.*

The sorption study and microbial testing results show that the product need to be packed in moisture proof packaging material at ambient temperature and application of food grade preservatives to extend the shelf-life of the product. Hence the study shows that this product has high nutritional and utilizable value, and there is a possibility of the production of Bael fruit pulp based intermediate moisture product incorporating potato, sugar and salt as additional ingredients.

Key Words: Bael fruit (*Aegle marmelos*), intermediate moisture food, dietary fibre, sensory evaluation, moisture sorption isotherms

Introduction

Processing and storage techniques for most underutilized fruit crops are weakly developed or neglected. Therefore, the quality of the final products cannot be maintained up to required standards. As a result, underutilized fruit trees are not very popular. Improving the processing and storage techniques of underutilized fruits is one of the important aspects in increasing popularity and benefits of underutilized fruit trees.

The term underutilized is specified for crops that are not presently cultivated in a particular region or a country, but whose value has been proven elsewhere under similar climatic conditions, and those that are harvested from the wild. However, what is considered underutilized in one area may not be in another area. These fruits may not meet the table values of mango, banana, apple, etc., but they are very popular for their nutritional and medicinal qualities, and can become processed products enhancing their quality and value. Many of these species can tolerate various kinds of abiotic stresses and can be exploited under different situations (Chundawat and Sen, 2002).

The Recommended Daily Allowances (RDAs) for energy is regularly exceeded in all developed countries; a major consequence being an increased incidence in obesity, diabetes and associated circulatory problems. Nutritionists have warned against the adverse effects of high intakes of fat, salt, and diets high in sugar and low in dietary fibre (Booth, 1997). Bael fruit is very rich in vitamins, amino acids and minerals when compared to other fruits (Amilasithyapa, 1998), and it can contribute significantly to the daily nutrient needs of the individual. In addition, it can be used advantageously to supplement deficiencies of other foods (Wills *et al.*, 1984). People have a preference for value added products than for consuming it as a completely edible fruit. Preparation of a

Bael product with the combination of potatoes, sugar and salt was a new concept. Using a number of ingredients and chemicals appeared unnecessary. The simplicity of the procedure for making such a product will lead to reduced cost of production and increased involvement of small-scale holders in this sector. Products which involve Bael fruit have high medicinal value and can be a better choice for consumers. In other words, this will promote the utilization of Bael fruit in every season.

This study was conducted to develop a value added product of Bael and to determine the shelf life of the product.

Method

After a number of preliminary trials using different ingredients (pectin, glucose syrup, maltodextrin, gelatin) in different treatment combinations, three experimental studies were eventually carried out (Table 1). Bael and potato percentages were considered as the main variables and salt percentage was considered as fixed.

Table 1. Treatment combinations for three products of "Crispy Bael" confection

Treatment	Code No.	Bael %	Potato %	Sugar %	Salt %
1	246	49. 92	33.28	16.64	0.16
2	578	33.28	49.92	16.64	0.16
3	750	49.92	49.92	-	0.16

Bael fruits (*Aegle marmelos*) were taken at fully ripened stage. Fruits were opened, all the seeds and some of the long fibre parts were discarded from the squeezed Bael pulp, and the required weight of the pulp was taken. Boiled and weighed potato was blended well to get a uniform texture. Sugar and salt were also blended as in the potato blending. Finally all these three ingredients (potato, sugar, and salt) were blended together. The final mass was mixed with Bael pulp. The mixture was cooked on a gas cooker for 35- 45 minutes, at a temperature of 95^0 C until it was concentrated.

The cooked mixture was spread on metal trays and kept inside the forced air circulation oven for a period of four hours at a temperature of 80 ^{0}C. The dried mixture was made into the shape of balls using a block. Shaped balls were placed on the trays and heated again in the same oven under the same conditions for one hour. Each of the Bael balls was coated with a special dough mixture (Table 2) and kept inside the baking oven at a temperature of 180^0C for a period of 20 minutes. After cooling to room temperature, crispy Bael balls were packed in polypropylene bags and sealed well. The best ingredient ratio was selected through the sensory panel testing using 30 semi-trained panelists. The best product was subjected to develop moisture sorption isotherms (5^0C, 30^0C and 35^0C temperatures), proximate analysis and microbial testing.

Production and application of processing techniques of "Crispy Bael" confection

Food processing is a means of providing good nutrition by creating attractive food shapes and textures and using novel ingredients. In the production of Bael product, the sugar, potato and salt were the compatible novel ingredients, and there were no unpleasant organoleptic properties in the product (Plate 1).

Table 2. Formula for the dough mixture

Ingredient	Amount (g)
Wheat flour	64
Sugar	18
Vegetable oil	10
Skim milk powder	1
Baking powder	0.5
Vanilla	0.25
Water	As required

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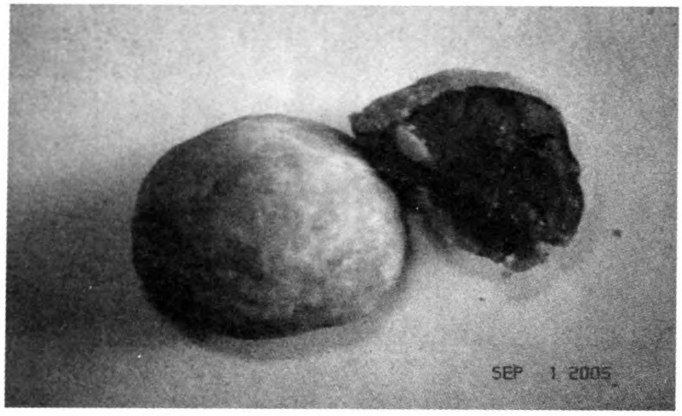

Plate 1. "Crispy Bael" confection

The pulp of the ripe Bael fruit contains bittersweet aromatic flesh which has a high demand in the food processing industry. It has a high pectin content and can be used to prepare an excellent jelly but the recovery is low. Therefore, to improve the texture of the product, the addition of potato as an ingredient was important. The addition of sugar improved the taste reducing bitterness, and an additional preservative effect was contributed by salt and other specific solutes (Potter and Hotchkiss, 1996). A food preserved solely by high salt content may not be palatable, but a lower salt concentration combined with less acid may be acceptable (Lund *et al.,* 2000).

In the production of "Crispy Bael", the two processing methods, heating and drying, could be applied more successfully. At cooking, the pulp of the Bael fruit did not settle and it was concentrated during the drying process, further reducing the water activity. The combination of heat treatment and low water activity preserves the product.Reactions occurring during drying can result in quality losses, particularly nutrient losses and other deteriorative changes caused by enzymatic browning. In air dehydration, it is usually possible to assume that the temperature gradient within the food is negligible (Fennema *et al.,* 1975).

Sensory evaluation

The panelists were given all three samples, and they assessed the sensory attributes of appearance, smell, texture, taste, aroma, and overall acceptability of each of the products, by scoring each of them according to their degree of liking. The scale ranged from like highly-05 to dislike highly-01. The mean scores for each of the sensory attributes of each of the products, which were coded as 578, 246 and 750, are shown in Fig. 1.

According to the results, the product coded as 578 could be regarded as the best combination of ingredients. This was prepared with 33.28% Bael fruit pulp, 49.92% potato, 16.64% sugar and 0.16% salt, and it was superior in almost all the sensory attributes (appearance, smell, texture, taste, aroma and overall acceptability). In this product, fruit pulp: potato ratio was 1:1.5. In the products 246 and 750, the amount of fruit pulp was 49.92%. According to the panelists' comments, these products gave a slightly bitter, more prominent Bael taste with a high astringency and a darker colour than that of product 578. Product 750 did not include sugar at all. The addition of potato to improve the texture and to suppress the astringency could be the reason for the selection of 578 as the best product in all sensory attributes.

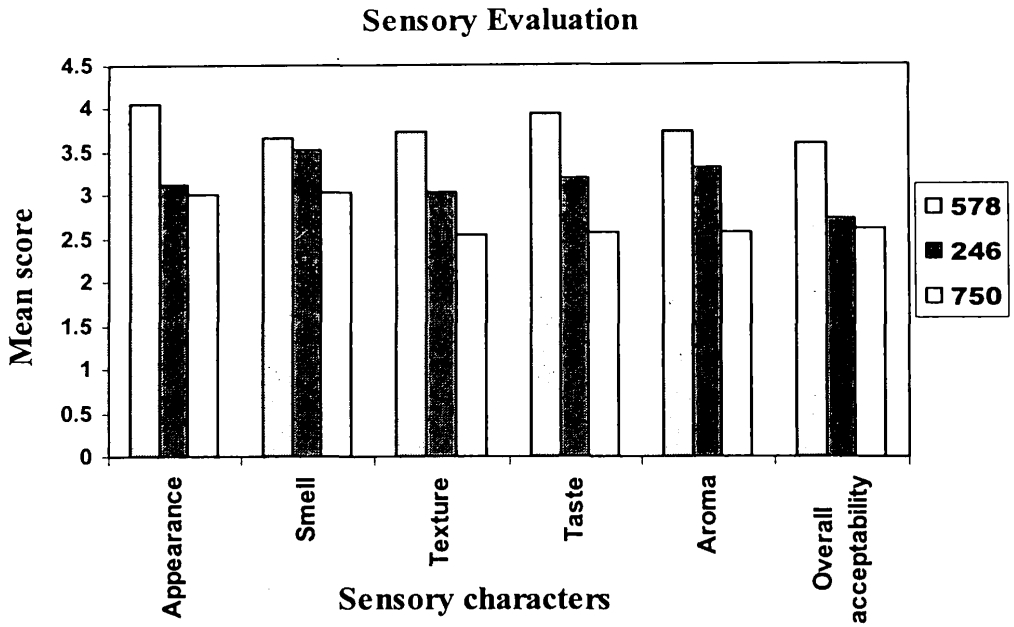

Fig.1 Sensory variation among the products.

Kruskal-Wallis statistical analysis of scores for sensory evaluation of "Crispy Bael" showed that there was a highly significant difference among appearance, texture, taste, and aroma of the product which was coded as 578, from the other products, whereas the smell and overall acceptability of the same product were significantly different ($P<0.05$) from other two products (Table 3).

Table 3. Probability values and Kruskal-Wallis statistical (Kw) values for each of the sensory characters.

Sensory attributes	P value	Kw
Appearance	0.0001	18.69**
Odour	0.0154	8.34*
Texture	0.0000	23.52**
Taste	0.0000	21.14**
Aroma	0.0001	18.73**
Overall acceptability	0.0037	11.21*

* Significant, ** highly significant

Development of moisture adsorption isotherms

The sorption isotherms are commonly used in the prediction of possible changes in food stability and packaging selection. With increasing temperature, a decrease in equilibrium moisture content was shown (Fig. 2). This indicates that water sorption is not favored at high temperatures. At temperatures below freezing point of a food, water activity depends only on temperature (Lund *et al.*, 2000).

The shape of isotherms especially below the water activity of 0.5 is produced by the water adsorption of various polymers such as protein, starch, cellulose etc. and the latter part by sugars for various starch containing foods (Sarvacos *et al.*, 1986).

Increase in sorption energy at low water contents is due to low moisture levels. Water is much less mobile and it takes more energy to release these water molecules, than when water content is higher (Gogus and Kaya, 1998). At high water activity values in ranges above 0.3, even the slightest growth of microorganisms was found to be detrimental to the commodity. There were no microbial attacks at the temperature of 5°C. However, there could be structural changes of the food sample by swelling.

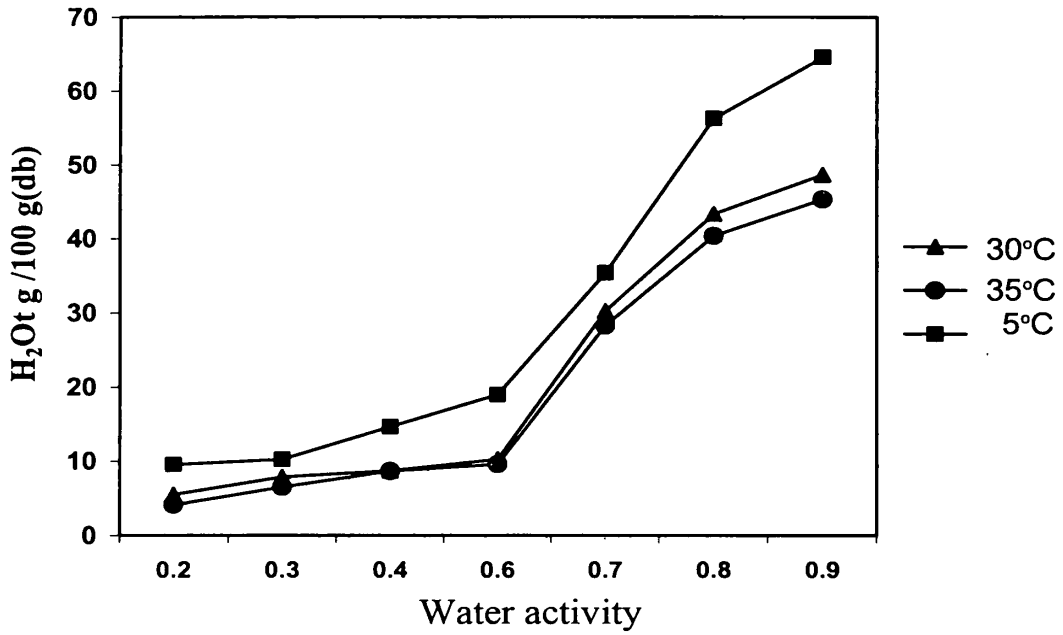

Fig. 2 Moisture adsorption isotherms for the "Crispy Bael" at the temperatures of 5°CF

Proximate analysis of "Crispy Bael" (coded as 578)

Physico chemical qualities of the product which was selected as best, are given in the table below (Table 4). Moisture content of the product was 15.5%. It is in the intermediate moisture food range. This product contains high mineral content, because the Bael fruit has a high mineral content. When considering the nutritional quality of the product, there is not much loss in dietary fibre and minerals.

Table 4. Physico-chemical qualities of selected "Crispy Bael" confection

Parameter	Value
pH	5.5
Total soluble solids (Brix)	54%
Moisture	15.5%
Mineral content	0.195%
Crude fat	7.33%*
Crude protein	3.64%
Crude fibre	14%

*Vegetable oil is the source of fat.

Microbiological stability

The product gave positive results on bacterial growth, and yeast and mould growth. The product showed nil results on *Escherichia coli* contamination (Table 5). The yeast and mould growth is more prominent than the bacterial growth (Fig. 3). This indicated that the reduction of water activity may not be the sole contributor to suppress growth of microorganisms.

Poor packaging material and crispy cover around the product could increase moisture migration into the product and deteriorate the product qualities. The absence of any preservatives in the product could enhance the deterioration further.

Table 5. Microbiological quality of the product

Parameter (Count/ g)	Interval		
	2 weeks	1 month	$1^1/_2$ months
TPC	$3*10^2$	$3.5*10^1$	$4*10^2$
Coliform (*E. coli*)	Nil	Nil	Nil
Yeast & mould	$3*10^2$	$4*10^2$	$5.5*10^1$

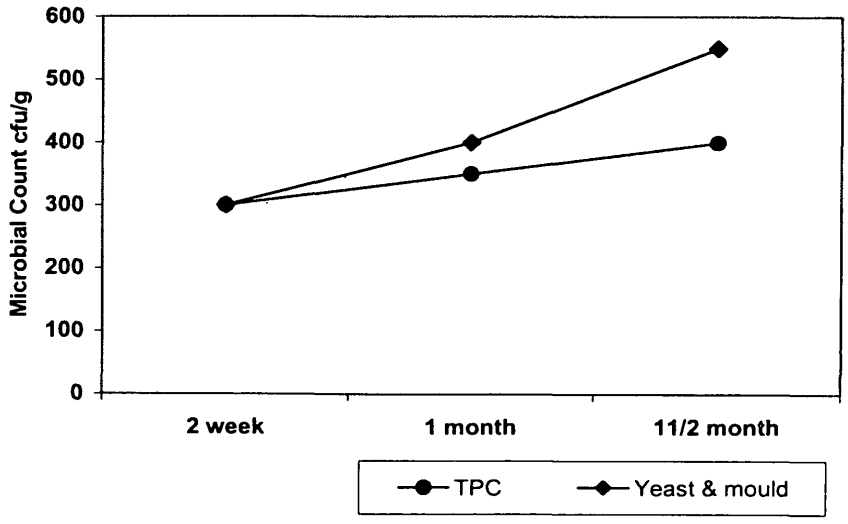

Fig. 3. Microbial stability of the product at ambient temperature conditions

Conclusions

The results of the study indicate the possibility of production of a Bael fruit pulp based confection with standard quality. It was observed that there was satisfactory consumer acceptability for "Crispy Bael" confection. From the point of fibre content, this product can be considered as a functional food for healthy life. According to the moisture adsorption properties, this product should be packed in moisture proof packaging materials at ambient temperature conditions which will help to extend the product's shelf life to more than one and half months. Whatever the packaging used, there should be addition of food grade preservatives to prevent the growth of yeast and mould.

Modifications should be carried out to improve the crispiness of the product and to improve the nutritional quality of the product further.

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