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Inulin and Fructooligosaccharides Incorporated Functional Fruit Bars

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***Abstract*—**Papaya and banana bars were developed incorporating inulin (IN) and fructooligosaccharides (FOS) (Liquid and Powder form) in various proportions. The control bars were standardized using 70% fruit pulp, 30% sugar, 0.3% citric acid while the treated bars were standardized with 70% fruit pulp, 15% sugar, 15% of IN and FOS and 0.3% citric acid. Among the various proportions tested, papaya bars with 90% FOS (Powder) + 10% IN and banana bars with 90% FOS (liquid) + 10% IN were sensorially best accepted. The study revealed that addition of IN and FOS improved the sensory scores. The Physico-chemical and proximatecomposition analysis revealed slight changes in brix°, total sugars, reducing sugars, non-reducing sugars, moisture, protein, fat, vitamin C, ash, iron, zinc, calcium and crude fibre between control and treated fruit bars. Further the glycemic index of papaya bar was reduced from 65 to 54 when treated with FOS and IN.

***Keywords*—**Banana, fructooligosaccharides, functional fruit bars, inulin, papaya

I. Introduction

TODAY, foods are not only intended to satisfy hunger and provide necessary nutrients for humans but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumers [7]. In this regard, functional foods play an outstanding role. In the last decades,consumer demands in the field of food production have changed considerably. Consumers more and more believe that foods contribute directly to their health. Papaya (Carica papaya L) is an important fruit of India. Papaya fruits are called protective foods because of their nutritive contributions such as vitamins, minerals, bulk cellulose and protopectin. Banana *(Musa paradisiaca)* is a good source of potassium, vitamins and minerals. Manufacturing of fruit bars exists in food industries from many years. This is one of the preservation technologies to preserve the fruits. Fruit bars principally made from fruit pulp retain most of the nutrients, minerals and flavour constituents thus forming a good nutritional supplement besides being a much sought after confectionery product. Fruit bars offer tremendous advantage owing to simplicity and lower inherent cost in production with better consumer appeal [5]. In the present study, incorporation of IN and FOS were carried out in different proportions to standardize the Papaya and Banana bars. The consumption of foods containing functional prebiotics and probiotics is the current global consumer trend.

Consumers prefer functional foods to others which decrease the risk of some diseases. The average daily consumption of IN and FOS has been estimated to be 1–4 g in the United States and 3–11 g in Europe [8]. IN and FOS can be incorporated in food products to replace sugar and to cut down calories. Experimental studies have shown the uses of IN and FOSsuch as acting as bifidogenic agents, stimulating the immune system, decreasing the levels of pathogenic bacterias in the intestine, relieving constipation, decreasing the risk of osteoporosis by increasing mineral absorption especially of calcium, reducing the risk of atherosclerosis etc., IN and FOS modulate the hormonal level of insulin and glucagon, thereby regulating carbohydrate and lipid metabolism by lowering the blood glucose levels [3]. IN and FOS have wide applications in various types of foods like confectionery, milk desserts, yogurt, fresh cheese, baked goods, chocolate, ice cream and sauces. There are plenty of studies on glycemic index of common foods, but no study on prebiotics incorporated fruit bars. Therefore, the present study was undertaken to standardize papaya and banana bars incorporating IN and FOS and to study the sensory properties, physico-chemical and proximate composition and glycemic index.

II. Materials And Methods

A. Formulation

The control Papaya bar was prepared as per the method described by [13] and the control banana bar was prepared according to [14]. In the treated bars, keeping the proportion of pulp and citric acid constant, various formulations were tried changing the proportions of sugar, IN and FOS (powder and liquid form) as detailed in Table I.

B. Preparation of Pulp Mixture

The papaya fruit was cleaned with water followed by 1% potassium permanganate solution. The pulp was made using stainless steel pulper(Powder king Industries, Gujarat, India)and passed through a 30mm mesh stainless sieve to obtain a homogenous pulp. Bananas were washed, peeled and cut into thin slices and were immersed in one per cent potassium metabisulphite solution and pulp was prepared same as papaya pulp. Only, the papaya pulp was concentrated by boiling for 15 minutes, but not the banana pulp. Then, the pulp was blended with other ingredients *viz.,* sugar, citric acid, IN and FOS and mixed thoroughly.

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TABLE I
VARIOUS FORMULATIONS OF IN ANDFOS FOR DEVELOPMENT OF FUNCTIONAL FRUIT BARS

Treatments	Fruit pulp	Sugar	IN and FOS	Citric acid
PT_0	70% (Papaya)	30%	-	0.3%
PT_1	70% (Papaya)	15%	15% (90%liquid FOS + 10% IN)	0.3%
PT_2	70% (Papaya)	15%	15% (80%liquid FOS + 20% IN)	0.3%
PT_3	70% (Papaya)	15%	15% (70%liquid FOS + 30% IN)	0.3%
PT_4	70% (Papaya)	15%	15% (90% powder FOS + 10% IN)	0.3%
PT_5	70% (Papaya)	15%	15% (80% powder FOS + 20% IN)	0.3%
PT_6	70% (Papaya)	15%	15% (70% powder FOS + 30% IN)	0.3%
BT_0	70% (Banana)	30%	-	0.3%
BT_1	70% (Banana)	15%	15% (90%liquid FOS + 10% IN)	0.3%
BT_2	70% (Banana)	15%	15% (80%liquid FOS + 20% IN)	0.3%
BT_3	70% (Banana)	15%	15% (70%liquid FOS + 30% IN)	0.3%
BT_4	70% (Banana)	15%	15% (90% powder FOS + 10% IN)	0.3%
BT_5	70% (Banana)	15%	15% (80% powder FOS + 20% IN)	0.3%
BT_6	70% (Banana)	15%	15% (70% powder FOS + 30% IN)	0.3%

C. Dehydration

The pulp mixture was spread on a greased trays with a tray load of 250gm/ 1sq ft and dried in preheated cabinet drier (Pioneer instruments, India) at 60- 65°C for 4-5 hours or till the mixture turns to non-sticky and to the moisture content of 15-20%. The dried bar was removed from the tray in layer form and such 6 layers were piled and cut in to 3 × 9 cm bars and packed in Biaxially Oriented Polypropylene (BOPP) covers and stored in an air tight container at ambient temperature for further analysis.

D. Evaluation of Sensory Characteristics

Sensory attributes such as color, odor, taste, texture and overall acceptability of the fruit bars were evaluated using Hedonic rating test as recommended by [15]. A trained panel consisting of 15 expert judges was selected for sensory evaluation. The panelists were selected from the staffs and students of Department of Foods and nutrition, Post Graduate and Research Centre, ANGRAU. The requirement for panel membership are (i) good health (ii) average sensitivity (iii) high degree of personnel integrity (iv) intellectual curiosity and interest in sensory evaluation (v) ability to concentrate and learn and (vi) availability and willingness to spend time in evaluation and submission to periodic test for acuity and consistency. Candidates possessing these qualities were indexed with details of age, sex, specific likes and dislikes etc. Samples were served to the panelists and they were asked to rate the acceptability of the product through sensory methods. Different attributes viz., color, odor, taste, texture and overall acceptability were rated on the basis of the 5 points of the hedonic scale.

E. Analysisof Physicochemical and Proximate Composition

All the nutrients were analysed using standard methods and the results obtained wereused for comparison among various fruit bars. Moisture, protein, fat, total sugars, reducing sugars, non-reducing sugars, ash, crude fibre, iron, zinc and calcium were analysed by using AOAC [16] methods. Carbohydrate content of the product was calculated by difference i.e. hundred minus sum of the percentage of moisture, protein, fat, crude fibre and ash. FOSwere estimated in the best accepted IN and FOS incorporated papaya and banana bars by HPLC (Varian, Model 350, RI detector) method [22]. Mobile phase consisting of acetonitrile and methanol was used in the ratio of 70:30 for HPLC analysis. The sample extracts were filtered through ordinary filter paper, what man filter paper No. 42 and 0.25μmillipore membrane. Prior to analysis, the analytical column was thoroughly washed with methanol. The flow rate of this mobile phase was maintained at 1 mL/ min. Concentration of FOS was calculated by the following formula.

FOS concentration

$$= \frac{\text{Sample peak area}}{\text{Standard peak area}} \times \frac{\text{Standard weight}}{\text{Sample}} \times \text{purity of standard}$$

(Purity of the standard is 100%)

F. Glycemic Index of Fruit Bars

1. Selection of Subjects

Initially fifteen members were selected from VasanthaNilayam Ladies hostel at ANGRAU campus with the age group of 19-22 years. Subjects were excluded if they, reported a history of gastrointestinal disorders, suffered from diabetes, were taking medication for any chronic disease conditions or intolerant or allergic to any of the foods. Finally eight healthy subjects were selected from those 15 members. Before starting the glycemic index trial, subjects were given instructions about the study.

2. Method for Glycemic Index

The method used for measuring and calculating the glycemic index of the fruit bars was in accordance with WHO/FAO recommendations [20]. Subjects attended each testing session after 10hours overnight fast but not exceeding 16 hours and had been instructed not to consume unusually large meals and not to exercise vigorously on the previous day. On the first three occasions, the subjects were given the standard reference food (Glucose). The 50g of glucose was made up with 250ml of water and served for the subjects. On the next three occasions, the subjects consumed sixty four gram of control papaya bar (made without IN and FOS) which provided 50g of carbohydrate. Again on the next three occasions, 65 g of treated papaya bar (made with IN and FOS) was given to provide 50 g of carbohydrates for each subject. The subjects were given 250 ml of water to drink with the fruit bars.

Blood glucose levels were measured by using Horizon one touch Glucometer in capillary whole blood obtained by finger prick in the fasting state and at 15, 30, 45, 60, 90 and 120 minutes after the consumption of fruit bars. Capillary blood samples may be preferable to venous blood samples for reliable glycemic index testing. After the consumption of food, glucose concentrations change to a greater degree in capillary blood samples than in venous blood samples. Therefore, capillary blood may be a more relevant indicator of the physiologic consequences of high-glycemic index foods [21].

3. Determination of Glycemic Index and Glycemic Load of Fruit Bars

The incremental area under two hour glucose response curve (IAUC) was calculated according to the formula used by [10]. Glycemic index of the fruit bars were calculated by applying the following formula.

Glycemic index

$$= \frac{\text{IAUC of test food}}{\text{IAUC of reference food}} \times 100$$

Glycemic loads of control and treated papaya bar were calculated by using the following formula

Glycemic load = Glycemic index/100 ×dietary carbohydrate content of serving

G. Statistical Analysis

The results of the study were subjected to statistical analysis with the following statistical tests. Means and Standard deviation were used for sensory evaluation scores and blood glucose levels of the subjects. Analysis of variance (ANOVA) was used to know the significant difference of sensory scores and significant difference between the mean values of IAUC of glucose, control papaya bar and treated papaya bar.

III. Results And Discussion

A. Development of Fruit Bars

The proportions of IN and FOS were incorporated in fruit bars as described in Table I. The fruit pulp was dried in cabinet drier at 60- 65°C for 4- 5 hours. The drying behavior of the fruit bars was also observed and it was found that the fruit bars incorporated with IN and FOS were easily removed from the tray when compared to those of without IN/FOS.

TABLE II
DRYING CHARACTERISTICS OF THE FRUIT BARS

Treatments	Moisture Content (%)	Characteristics
PT_0	16	Not sticky and less pliable
PT_1	18	Sticky and not easy to remove from the tray
PT_2	18	Not easy to remove from the tray
PT_3	19	More Sticky and not easy to remove from the tray
PT_4	17	Less Sticky and More pliable, easy to remove from the tray
PT_5	19	Sticky and not easy to remove from the tray
PT_6	18	Sticky and not easy to remove from the tray
BT_0	15	Not sticky and less pliable
BT_1	16	Less Sticky and More pliable, easy to remove from the tray
BT_2	17	Sticky and not pliable
BT_3	19	More Sticky and not easy to remove from the tray
BT_4	17	Sticky and not pliable
BT_5	17	Sticky and not easy to remove from the tray
BT_6	17	More Sticky and not easy to remove from the tray

B. Organoleptic Characteristics of Papaya Bar

The scores for colour of the papaya bars ranged from 3.3 to 4.6 and texture from 3.3 to 4.5 on hedonic scales. The scores for flavour, taste and over all acceptability ranged from 3.4 to 4.1, 3.1 to 4.4 and 3.4 to 4.4 respectively (Table III).

Among the liquid FOS treatments,PT_2 i.e. the papaya bar incorporated with 80% liquid FOS + 20% IN received highest total mean scores (20.2) and was best accepted followed by PT_1 (19.4) and PT_3 (18.1).

Among the powder FOS treatments, PT_4 was preferred with highest total mean scores (22) and accepted well in terms of colour, texture, flavor, taste and over all acceptability followed by PT_5 (20) and PT_6 (19.9). It was found that, among all the treatments, PT_4 was best accepted with highest total mean scores (22)

It was found that PT_4 had significantly higher score for colour, compared to PT_0, PT_1 and PT_3 (P= 0.05) and it had higher score for texture compared to PT_0, PT_3 and PT_6. PT_4 also hadbetter flavor than PT_0, PT_1, PT_3 and PT_5. With regardto taste among the various treatments, PT4had higher scores compared to PT_0, PT_1, PT_3 and PT_6. The overall acceptability of PT_4 had significant higher scorethan PT_0 andPT_3 (P=0.05). Though statistically not significant, the scores of other treatments were lower than those of PT_4.

TABLE III
SENSORY EVALUATION SCORES FOR FRUIT BARS (VALUES ARE MEAN ± STANDARD DEVIATION)

Treatments	Colour	Texture	Flavor	Taste	Over all acceptability
PT0	3.3±0.99	3.3±0.86	3.4±0.71	3.1±0.99	3.4±0.71
PT1	4.0±0.74	4.0±0.70	3.6±0.60	3.8±0.60	4.0±0.70
PT2	4.1±0.69	4.1±0.69	4.0±0.42	3.9±0.55	4.1±0.48
PT3	3.8±0.72	3.8±0.69	3.5±0.50	3.2±0.77	3.8±0.52
PT4	4.6±0.60	4.5±0.61	4.1±0.48	4.4±0.71	4.4±0.62
PT5	4.3±0.93	4.0±0.74	3.5±0.50	4.0±0.74	4.2±0.58
PT6	4.5±0.87	3.8±0.78	3.9±0.55	3.7±1.09	4.0±0.89
BT0	3.2±0.91	3.2±0.58	3.2±0.81	3.7±0.66	3.7±0.58
BT1	4.2±0.90	4.0±0.74	3.8±0.80	4.1±0.88	4.2±0.66
BT2	3.5±0.79	3.5±0.62	3.5±0.65	3.8±0.87	3.8±0.60
BT3	3.7±0.83	3.3±0.49	3.3±0.62	3.4±0.62	3.5±0.51
BT4	3.4±1.0	3.4±0.71	3.4±0.47	3.4±0.79	3.6±0.60
BT5	3.6±0.86	3.5±0.93	3.2±0.73	3.7±0.84	3.7±0.75
BT6	3.9±0.42	3.7±0.66	3.7±0.44	3.9±0.42	4.0±0.42

C. Organoleptic Characteristics of Banana bar

The scores for colour and texture of banana bars ranged from 3.2 to 4.2 and 3.2 to 4.0. The scores for flavour, taste and over all acceptability ranged from 3.2 to 3.8, 3.4 to 4.1 and 3.6 to 4.2.

Among liquid FOS incorporated bars, the bar developed using 90% liquid FOS and 10% IN (BT_1) was accepted with overall sensory score of 20.3 followed by BT_2(18.1)and BT_3 (17.2).Similarly, when the banana bars were prepared using powder FOS, BT_6 was preferred with highest total mean scores (19.2) followed by BT_5(17.7) and BT_4 (17.2). It was found that, irrespective of powder or liquid FOS treatments, BT_1 was best accepted with highest total mean scores (20.3). The highly accepted BT_1 got significantly higher score for colourthan BT_0 and BT_3 (P= 0.05) and it got higher score for texture than BT_0, BT_3 andBT_4. The taste of BT_1 scored high compared to BT_3 and BT_5.The score for flavor of BT1 was high compared to all other treatments but it was not statistically significant. There was significantdifference in overall acceptability of BT_1 comparedto BT_0, BT_3, BT_4 andBT_5.

The results indicated that the addition of IN and FOS improved the sensory properties of the papaya and banana fruit bars when compared to their respective controls. In all parameters, incorporation of FOS exerted beneficial effects on the quality of the bars. The fruit bar with 90%FOS +10% IN in both papaya and banana bars were best accepted compared to other proportions. Due to the incorporation of IN and FOS, the fruit bars developed were pliable and the texture was improved over the control bars. IN and FOS allowed the development of fruit bars without compromising on taste and texture. The increase in acceptability with the decrease of IN might be due to increase in hardness of the bars. Though the firmness is desirable quality in fruit bars, too much of firmness may not be acceptable.

D.Physico-Chemical and Proximate Composition of Papaya and Banana Fruit bars

Physico- chemical and proximate composition was analysed for control and best accepted papaya and banana bars (Table IV and V). The moisture content of all bars ranged between 15 to 17%. PT_0andPT_4contained 16 and 17 and BT_0 andBT_1 contained 15 and 16 respectively. Due to the water holding capacity of IN and FOS, the moisture content of PT_4 and BT_1 were increased slightly compared to their respective control (PT_0 and BT_0). Reference [6] reported that the freshly prepared jamun and banana fruit bar contained 13.1 and 13.4 percent moisture respectively. Reference [1] reported the moisture content of the fruit bar (prepared from blend of papaya and tomato) as 27.1- 28%. Reference [19] reported that Jack fruit leather had moisture content of 16.48. In the present study the values obtained are more or less similar to the values reported by [6] and [19].It can be observed from the Table IV that the papaya pulp of $PT_0$and PT_4 contained the same pH (3.9) and acidity (0.65%), whereas the pulp of $BT_0$and BT_1 also had the samepH (3.8) and acidity (0.6%) respectively. The brix° was estimated in PT_0, PT_4, $BT_0$and BT_1 as36°, 34° , 39.2° and 38° respectively. Reference [1] reported that the pH, acidity and total soluble sugars (TSS) content of the mixed pulp (Papaya and Tomato, 70: 30 on weight basis) as 4.76, 0.0243% and 11.6° respectively.

TABLE IV
PHYSICO-CHEMICAL COMPOSITION OF SELECTED FRUIT BARS

Parameters	Treatments			
	PT_0	PT_4	BT_0	BT_1
Moisture%	16	17	15	16
pH	3.9	3.9	3.8	3.8
Acidity (%)	0.65	0.65	0.60	0.60
Brix º	36	34	39.2	38.0
Total sugars (g/100g)	37.50	36.0	52.60	55.45
Reducing sugars (g/100g)	15.38	14.56	14.0	16.25
Non reducing sugars (g/100g)	22.12	21.44	38.60	39.2

The total, reducing and non-reducing sugars content in papaya bar of PT_0 were 37.5g, 15.38g and 22.12g respectively and the values were decreased to 36g, 14.56g and 21.44g respectively in the papaya bar of PT_4due to the lower amount of sugars in powder FOS. Reference [9] reported the total and reducing sugars of fruit bar (prepared from blend of guava and papaya) as 55.97g and 7.74 respectively. Since only the papaya fruit was used in the present study, the values of total and reducing sugars in the present study may be less compared to the study reported by [9].

Similarly, total, reducing and non-reducing sugars content in the banana bar of BT_0were estimated as 52.60g, 14.0g and 38.60g respectively whereas in the BT_1 treatment, the total, reducing and non- reducing sugars were increased to 55.45g, 16.25g and 39.20g respectively. The slight increase was noticed after addition of liquid FOS in banana bar.

TABLE V
PROXIMATE COMPOSITION OF SELECTED FRUIT BARS

Nutrients (%)	PT_0	PT_4	BT_0	BT_1
Protein(g)	1.6	1.6	1.2	1.2
Fat(g)	1.4	1.8	1.6	1.8
Carbohydrate (%)	77.8	76.0	80.3	78.6
Vitamin C(mg)	15.1	16.0	51.0	52.0
Ash(g)	1.8	2.0	0.6	0.9
Iron(mg)	1.2	1.3	1.0	1.0
Zinc(mg)	1.7	1.7	1.5	1.6
Calcium(mg)	25.0	31.2	31.0	31.5
Crude fiber(g)	1.4	1.6	1.3	1.5
Calories (Kcal)	330.2	326.6	340.4	335.4

The protein content in PT_4 andBT_1 were found same as PT_0 andBT_0 (control). The carbohydrate content was calculated as per difference method. The carbohydrate content of the PT_4 andBT_1 was low when compared to PT_0 andBT_0respectively due to the addition of low caloric IN and FOS. The ash and crude fibre content was also increased slightly in treated papaya (PT_4) and banana bar (BT_1) when compared to control bars (PT_0 andBT_0).

Reference [18] reported the protein and fat values of Mango fruit bar as 1.82% and 0.95% respectively. Reference [1] found that the protein, fat and carbohydrate content in the mixed pulp of papaya and tomato(70: 30) as 0.69%, 0.13% and 6% respectively. The protein and fat values were high in the present study when compared to these values. But it was more or less similar to study reported by [18]. There were slight differences in other nutrients between control and treated bars.

E. Concentration of FOS in Best Accepted Papaya (PT_4)and Banana bar(BT_1)

HPLC results showed that the papaya bar (PT_4) contained 5.7 g of FOS /100 g of bar where as banana bar (BT_1) had only 0.4g of FOS/ 100 g of bar. The initial content of 13.5 g /100g of FOS in the pulp mixture was reduced to 5.7 g in papaya bar and 0.4g in banana bar after dehydration of the pulp for 4-5 hours. The reduction in the quantity might be the result of the degradation of FOS. More degradation was seen in case of banana bar.ThepH and temperature influence the degradation of FOS. Reference [12]reported that FOS are degraded at 60°-100°C temperature and 2.7- 3.3 pH.In the present study though the fruit pulp was dehydrated at 60°C and the pH was 3.8 and 3.9, still there was substantial reduction in the quantity of FOS in fruit bars, this might be due to the longer duration of heating (4-5 hours).

F. Determination of Glycemic Index and Glycemic Load of Papaya bars

The average blood glucose levels of the subjects on three occasions at different intervals after consumption of glucose, control papaya bar and treated bar were measured. The IAUC values for the papaya bars and glucose are given in Table VI.

TABLE VI
MEAN IAUC OF THE PAPAYA FRUIT BARS

Product	Mean IAUC (mg/dl)
Glucose	2230.95
Control papaya bar	1460.25
Treated papaya bar	1214.85

There was a difference between the IAUC values of glucose, control and treated papaya bar. The glycemic index of the control papaya bar and treated papaya bar were calculated as 65 and 54 respectively. It was found that statistically there was no significant difference between the mean values of glucose, control and treated bar at 5% level. The control papaya bar was found to have high glycemic index and treated papaya bar comes under low glycemic index. Similarly the study conducted in thirteen type 2 diabetic subject's reports that equi-carbohydrate amount of papaya and mango produced higher glycemic response as compared to bread (reference food). The similar glycemic responses of Papaya and Mango were reflected in their glycemic index values [2]. There is evidence that IN and FOS can lower the glycemic index. Reference [17] reported that invitro digestion of IN enriched pasta lowered glycemic index. IN containing food products may be beneficial because of reducing glucose uptake in the body and thereby reducing post prandial hyperglycemia [4]. In diabetic subjects also, taking 8 g of FOS/ day for 14 days led to a decrease in fasting blood glucose [11]. In this study, 3.25g of FOS present in the 65 g of papaya fruit bar resulted in lowering the glycemic index. The FOS added could have high beneficial effects if it have not been damaged or modified during processing. The glycemic index can be further reduced by increasing the amount of incorporation of FOS and IN in the food products. However care should be taken while consuming the amount of IN/ FOS i.e. it should not be more than 20g/day. The 20g of papaya bar can be taken in one serving i.e. one papaya bar. The glycemic load of the control and treated papaya bar were calculated as 10.15 and 8.262 for 20g of papaya bar/ one serving.

IV. Conclusion

There is no doubt that functional foods generate one of the most promising and dynamically developing segments of food industry. Functional foods have been developed virtually in all food categories, so this new type of incorporation of prebiotics in Fruit bars can be a good idea for enterprises to bring out potential functional product. The developed papaya and banana bars can supply nutritional requirements as well as health benefits from IN and FOS and it can be served as good functional fruit bar for people of all age groups. Incorporation of prebiotic compounds viz., IN and FOS can be recommended for the development of other fruit bars also. Therefore, functional components can be imparted to the public and the potential of functional foods and constituents can be realized.

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