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Development of Low Calorie Jam by Replacement of Sugar with Natural Sweetener Stevia

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ABSTRACT

Recently, much attention has been focused on potential health benefits of low calorie foods. This research was conducted for the development of low calorie apple jam by using stevia as a sweetener. The jam samples were stored in pre-sterilized glass jars and were analyzed physico-chemically (moisture, ash, pH, acidity, TSS, total sugars and reducing sugars and ascorbic acid) and organoleptically (colour, taste, appearance, flavour, texture and overall acceptability) during 28 days of storage. Apple jam prepared with sucrose served as control (T1). During storage, a decrease was observed in moisture content (76.99 to 75.33%), ash content (2.01 to 1.36%), pH (3.52 to 3.28) and ascorbic acid content (6.96 to 6.85%) while an increase was recorded in TSS (22.00 to 25.00 °B), titratable acidity (0.49 to 0.66%), total sugars (15.06 to 18.28%) and reducing sugars (5.63 to 8.40%). Statistical analysis of jam samples revealed that storage intervals had a significant ($p<0.05$) influence on physico-chemical and sensory characteristics of low calorie apple jam (T2) prepared with stevia

Key Words: Jam, Stevia, Sugars

INTRODUCTION

The pervasiveness of type 2 diabetes mellitus is growing throughout the world at an alarming rate, resulting in increased premature mortality and healthcare costs (1). It has been predicted that 1 in 10 people worldwide is expected to suffer from this disease by 2030 (2). The primary focus of suitable prevention strategies have been on lifestyle interventions. Modern consumers are now more concerned about the nutritional and caloric value of food they consume and more interested in preferring healthier food products in their diet. The importance of lifestyle prevention makes it necessary to investigate the protective role of healthy nutrients and foods (3). Fruits and vegetables are considered as essential source of nutrients and possess a low content of fats, proteins and calories. The consumption of fruits and vegetables has been related to potential health benefits as they are rich in minerals, vitamins, carbohydrates and fibers (4).

Apple has got the third highest anti-proliferative activity among fruits (5). Apple has high nutritional value and is a good source of vitamin C, Potassium and fiber. It contains 11% sugar, 0.3% proteins, 14% carbohydrates, 4% vitamins and minerals and remaining part of apple contains water (6). Apple peel also contains a large number of nutrients (5). Apple which has good healing power is affective for maintaining health and helps to relief body from many diseases such as diabetes, cardiovascular diseases, arthritis, constipation, cancer, rheumatism, dysentery, Alzheimer and also reduces chances for gallstones formation (7, 8, 9, 10).

Jam is defined as an intermediate moisture food obtained upon boiling fruit pulp with sufficient quantity of sugar (sucrose), pectin, acid, and other ingredients such as preservatives, colouring agents and flavouring materials to a gel like consistency which is firm enough to hold the fruits tissues in position (11). As per FSSAI Standards (12), Jam should contain more than 68.5% total soluble solid (TSS) content and fruit pulp content should be at least 45%. Usually, jams have been prepared with a high amount of sugars, mainly sucrose (13). However, consumption of sucrose in large quantity has been associated with adverse effects on health, such as obesity, diabetes, cardiovascular diseases and hypertension (14). Therefore the use of low calorie sweeteners for replacement

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of sucrosehas been evaluated.

Now-a-days, natural sweeteners are trapping more attention as the replacer of sugar. Stevia has recently gained importance as natural non caloric sweetener and is considered as the main natural substitute of sucrose due to its various modes of action. Stevioside is the main component of stevia that imparts sweetness and is 300 times sweeter than sucrose (15). Stevia exerts several beneficial effects on human health including hypoglycemic, hypotensive due to its blood pressure lowering properties and noncariogenic activities (16, 17, 18). It acts as cardiotonic as it tones, balances and strengthens the heart and also exhibits antimicrobial activities (19). Stevia is also thought to affect glucose metabolism and renel function (20, 21). Keeping in view the above points, the present study was aimed at developing a low calorie apple jam using stevia in place of sucrose.

MATERIALS AND METHODS

Fresh mature apples and sugar were procured from a local market in Rohtak and stevia powder was purchased from Growmore Biotech Ltd, Tamil Nadu, India. All chemical reagents required for analysis of sugar free jam were of analytical grade.

Preparation of apple pulp

Fully ripe, spoilage free apples were washed with clean water. After peeling, apples were cut into pieces and seeds were removed. The fruit pieces were then placed on flame and meshed with a mesher.

Processing of liquid stevia extract

The raw stevia powder was added into boiling water and the mixture was boiled for 2 minutes. After this, the mixture was filtered through a muslin cloth and stored in a jar.

Preparation of jam

Various ingredients for the preparation of low calorie apple jam were weighed according to specifications (1 kg apple pulp, 12 ml stevia extract, 2 g pectin and 500 mg potassium metabisulfite). After pulping, pectin was added and the mixture was cooked until it gave sheet flake test. At this point, TSS of the mixture was noted by hand refractrometer. Then the cooking was stopped and potassium metabisulfite (preservative) was added. The mixture was left for cooling. After cooling, liquid stevia extract was added to it. The finished product was poured into clean, dry sterilized glass jars. Then the product was cooled and capped. The final product was stored in a cool dry place. For the preparation of control jam, sugar was added in place of stevia.

Optimization of levels of stevia in jam

Levels of stevia were evaluated for sensory parameters like colour, appearance, texture, flavour, taste and overall acceptability using 9 point hedonic scale by a panel of 10 judges. 0.6% stevia extract was evaluated as most acceptable for the production of low calorie apple jam because it was as sweet as the control jam. However texture and appearance were lacking in optimized jam because of absence of sugar as sugar gives set and glossiness to jam which was observed in control jam.

Chemical analysis

Moisture content, ash content and titratable acidity were determined by AOAC (Association of Official Analytical Chemists) methods(22). Determination of TSS (Total soluble solids) and ascorbic acid were carried out using Ranganna method (23) while total sugars and reducing sugars were estimated by Lane and Eyon's method given by Ranganna (23). pH was determined as per method given by Ranganna (24).

Microbiological analysis

Total viable count of jam samples was done using the pour plate method given by Harrigan (25). Yeasts and moulds were enumerated by pour plate method described by Harrigan (25).

Sensory analysis

The apple jams were evaluated for sensory parameters like colour, appearance, texture, flavour, taste and overall acceptability using 9 point hedonic scale by a panel of 10 judges.

Statistical analysis

Data were analyzed using one-way analysis of variance (ANOVA) procedures in a randomized complete block design with three replications. Statistical analysis was performed using the OPSTAT software version opstat1.exe (Hisar, India). The values are represented as mean ± SD.

RESULT AND DISCUSSION

Optimization of levels of stevia in jam

Levels of stevia in jam were optimized by sensory analysis using 9 point hedonic scale by a panel of 10 judges (Table 1). Stevia was added in different concentrations (0.15%, 0.3%, 0.45%, 0.6%).Among the samples, jam prepared with 0.6% stevia extract showed highest sensory score for all the parameters. It was as sweet as the control jam. Therefore, 0.6% stevia extract was selected for production of low calorie apple jam.

Table 1: Optimization of levels of stevia in jam

Parameters	Concentration				
	0.15%	0.3%	0.45%	0.6%	Control
Sweetness	6.60±0.02[a]	7.10±0.01[b]	7.40±0.01[c]	7.80±0.02[d]	8.50±0.02[e]
Colour	6.50±0.02[a]	6.90±0.02[b]	7.20±0.01[c]	7.60±0.02[d]	8.00±0.02[e]
Flavour	6.20±0.01[a]	6.50±0.02[b]	6.80±0.01[c]	7.30±0.02[d]	8.30±0.01[e]
Texture	6.60±0.02[a]	7.00±0.01[b]	7.30±0.02[c]	7.60±0.02[d]	8.70±0.01[e]
Appearance	6.50±0.01[a]	6.90±0.02[b]	7.30±0.02[c]	7.60±0.02[d]	8.60±0.02[e]
Overall acceptability	6.62±0.01[a]	6.84±0.02[b]	6.98±0.01[c]	7.68±0.02[d]	8.42±0.01[e]

Values having different alphabetical letters in a row are significantly different ($p<0.05$). The values are expressed as the mean ±SD of three replications.

Effect of storage on physico-chemical characteristics of low calorie apple jam and control jam

Moisture content

Moisture is an important factor which affects the shelf life and freshness of products. Food Products having high moisture content display short shelf life. It was observed that moisture content decreased in all samples during 28 days of storage period (Table 2). For the treatments, maximum mean value was recorded in sample T_2 (76.16%) while minimum value was recorded in sample T_1 (33.17%). The statistical analysis revealed that storage effect on the moisture content of T_1sample was significantly different from T_2 ($p<0.05$). The difference in moisture was expected because preservative added in optimized jam (KMS) acted as a firming agent strengthening the quality of jam and also acted as glazing agent thus providing a waxy coating to prevent water loss. The mean moisture content value significantly ($p<0.05$) decreased from 55.49% to 53.89% during storage. This decrease in moisture content might be due to reopening of the same pack during storage for analysis. The results were in agreement with findings of Anjum et al. (26) who studied diet apricot jam and reported decrease in moisture during 60 days of storage. Similar observations were found by Ashaye and Adeleke (27) in roselle jam.

Ash content

The results obtained regarding ash content of jam samples are presented in Table 2. Ash content gives an indication of minerals composition of food products (27). Ash content represents inorganic matter remaining after destruction of organic matter (24). Among both the treatments, maximum mean value was recorded for sample T_1 (1.72%) while minimum value was recorded for sample T_2 (1.66%). The mean ash content value significantly ($p<0.05$) decreased from 2.03% to 1.38% during storage. This decrease in ash content might be due to increased activities of microorganisms by utilizing the minerals for growth which resulted in reduction of mineral content. Similar observations was found by Ashaye et al. (27) who observed a decrease in ash content of rosella jam during storage.

TSS content

The values of TSS ranged from 22ºB to 68ºB and a significant difference ($p<0.05$) was observed among both the jam samples. The TSS of control jam was noted as 68ºB. The data obtained for TSS revealed that there was slight change occurred during storage at refrigeration temperature. It was observed that TSS increased in both the samples during storage and higher mean value was recorded for sample T_1 (70ºB) as compared to sample T_2 (23.3ºB). This could be attributed to high concentration of sugar that increased TSS of control jam as expected. The mean TSS value increased from 45.00ºB to 48.50ºB during storage. The increase in TSS might be due to hydrolysis of polysaccharide especially pectin into simple sugar in the presence of acid during storage and might also be due to solubilization of jam constituents. These results are in agreement with the results of Muhammad et al. (28) who observed increased in TSS of diet apple jam during storage. In another study, Khan et al. (29) reported an increase in TSS of strawberry jam during storage.

pH content

The pH is an important parameter to obtain optimum gel condition in jam. The statistical analysis revealed that storage effect on the pH of control jam (T_1) was significantly different from optimized jam (T_2) ($p<0.05$). The pH of both the samples was decreased during storage. The initial pH value was recorded 3.48 and 3.52 for T_1 and T_2 respectively which was decreased gradually to 3.23 and 3.28 for $T_1$and T_2 during storage (Table 5). The mean pH values showed considerable decrease from 3.50 to 3.26 during storage. Decrease in pH during storage might be due to increase in acidic content as a result of sugar degradation and might also be due to hydrolysis of pectin. Ehsan et al. (30) also reported a decreasing trend in pH of jam prepared from locust bean fruit pulp during storage. These results are in alignment with the results of Wasif et al. (31) who observed a decrease in pH of apple and olive fruit blended jam during storage.

Titratable acidity

Data pertaining to effect of storage on titratable acidity of jam samples are presented in Table 2. Acidity of control jam and optimized jam was higher than that observed before storage. The initial acidity of sample T_1 and T_2 was observed as 0.54% and 0.49% which was increased steadily to 0.71% and 0.66% respectively during storage. The statistical analysis revealed that storage effect on titratable acidity of both samples was significantly different ($p<0.05$). The mean acidity value noted for T_1 was higher (0.63%) than T_2 (0.57%). The mean acidity value was increased from 0.51% to 0.69% during storage. This increase in acidity might be due to the formation of organic acids due to degradation of polysaccharides and breaking of pectic bodies. These results agree well with the findings of Wasif et al. (31) who observed an increasing trend in acidity of apple and olive blended jam during storage.

Ascorbic acid

Ascorbic acid is the most difficult vitamin to be preserved during storage. As it is the least stable and most heat labile vitamin, it decreases in the product during storage. The results obtained regarding the ascorbic acid content are presented in Table 2. The ascorbic acid content of optimized apple jam and control jam was decreased during storage. The initial ascorbic acid content of sample T_1 and T_2 was noted 13.99% and 6.96% which was gradually decreased to 13.90% and 6.85% respectively during storage. Sample T_1 displayed highest mean value of ascorbic acid content (13.94%) while least mean value was recorded for sample T_2 (6.90%). The statistical analysis revealed that storage effect on the ascorbic acid content of T_1 sample was significantly different from T_2 ($p<0.05$). The mean ascorbic acid content significantly ($p<0.05$) decreased from 10.47% to 10.37% during storage. The reduction in ascorbic content in the samples might be due to the oxidation of the ascorbic acid to dehydroascorbic acid followed by further degradation to 2,3-diketo-l-gulonic acid and finally to furfural compounds. These results are in agreement with the results of Abolila et al. (32) who observed decrease in ascorbic acid content of low calorie orange jam during storage. Muhammad et al. (28) also reported decrease in ascorbic acid content of diet apple jam during storage.

Total sugar

Sugars are the most important constituents of fruit product and an essential factor for the development of flavour of the food product as well as also act as natural preservative. The total sugar content of optimized jam and control jam was increased during storage (Table 2). The initial total sugar content of sample T_1 and T_2 was noted as 62.03% and 15.06% which was gradually increased to 65.60 and 18.28 respectively during storage. Among samples, maximum mean value was noted for sample T_1 (63.78%) while minimum value was recorded for sample T_2 (16.64%). The statistical analysis revealed that storage effect on the ascorbic acid content of T_1 sample was significantly different from T_2 ($p<0.05$). Control jam displayed the maximum mean value for total sugar content as compared to optimized jam which was expected due to addition of sucrose in control sample. The mean total sugar content significantly ($p<0.05$) increased from 38.54% to 41.94% during storage. The increase in total sugar might be due to the conversion of starch and other insoluble carbohydrates into sugars. The increasing trend of total sugar content during present study agrees with the findings of Muhammad et al. (28) who observed an increase in total sugar content of diet apricot jam from during storage. Vidhya and Narain (34) also reported an increase in total sugar content of preserved products using wood apple.

Table 2: Effect of treatments and storage period on physicochemical characteristics of jam

Parameter	Treatment	0	7	14	21	28	Mean
Moisture (%)	T_1	34.00±0.20^a	33.62±0.25^a	33.24±0.26^a	32.85±0.15^a	32.45±0.26^a	33.17^a
	T_2	76.99±0.20^b	76.58±0.25^b	76.17±0.20^b	5.75±0.10^b	75.33±0.20^b	76.16^b
	Mean	55.49^e	55.01^d	54.70^c	54.30^b	53.89^a	
Ash (%)	T_1	2.06±0.01^b	1.91±0.01^b	1.68±0.02^b	1.53±0.01^b	1.41±0.02^b	1.72^b
	T_2	2.01±0.01^a	1.86±0.02^a	1.60±0.02^a	1.49±0.02^a	1.36±0.02^a	1.66^a
	Mean	2.03^e	1.88^d	1.64^c	1.51^b	1.38^a	
TSS (°B)	T_1	68.00±0.00^b	69.00±0.00	70.00±0.00^b	71.00±0.00^b	72.00±0.00^b	70.00^b
	T_2	2.00±0.00^a	22.50±0.00	23.00±0.00^a	24.00±0.00^a	25.00±0.00^a	23.30^a
	Mean	45.00^a	45.50^b	46.50^c	47.50^d	48.50^e	
pH	T_1	3.48±0.02^a	3.42±0.01^a	3.35±0.02^a	3.29±0.01^a	3.23±0.01^a	3.35^a
	T_2	3.52±0.01^b	3.47±0.02^b	3.41±0.02^b	3.35±0.03^b	3.28±0.02^b	3.41^b

	Mean	3.50^{e}	3.44^{d}	3.40^{c}	3.32^{b}	3.26^{e}	
Titratable Acidity	T_1	0.54±0.03^{b}	0.59±0.02^{b}	0.63±0.02^{b}	0.67±0.01^{b}	0.71±0.02^{b}	0.63^{b}
	T_2	0.49±0.03^{a}	0.53±0.02^{a}	0.58±0.01^{a}	0.62±0.02^{a}	0.66±0.01^{a}	0.57^{a}
	Mean	0.51^{a}	0.56^{b}	0.60^{c}	0.64^{d}	0.69^{e}	
Ascorbic acid	T_1	13.99±0.06^{b}	13.97±0.07^{b}	13.95±0.07^{b}	13.93±0.06^{b}	13.90±0.05^{b}	13.94^{b}
	T_2	6.96±0.09^{a}	6.94±0.12^{a}	6.91±0.09^{a}	6.88±0.07^{a}	6.85±0.09^{a}	6.90^{a}
	Mean	10.47^{e}	10.45^{d}	10.43^{c}	10.40^{b}	10.37^{a}	
Total Sugar	T_1	62.03±0.12^{b}	62.86±0.12^{b}	63.76±0.10^{b}	64.68±0.08	65.60±0.10^{b}	63.78^{b}
	T_2	15.06±0.10^{a}	15.83±0.08^{a}	16.63±0.11^{a}	17.43±0.06	18.28±0.11^{a}	16.64^{a}
	Mean	38.54^{a}	39.34^{b}	40.19^{c}	41.05^{d}	41.94^{e}	
Reducing Sugar	T_1	20.85±0.04^{b}	21.59±0.09^{b}	22.33±0.11^{b}	23.13±0.14^{b}	24.03±0.25^{b}	22.38^{b}
	T_2	5.63±0.15^{a}	6.25±0.06^{a}	6.90±0.09^{a}	7.60±0.09^{a}	8.40±0.11^{a}	6.95^{a}
	Mean	13.24^{a}	13.92^{b}	14.61^{c}	15.36^{d}	16.21^{e}	63.78^{b}

Values having different alphabetical letters in a row/column are significantly different ($p<0.05$). The values are expressed as the mean ±SD of three replications.

Reducing sugar

A significant difference ($p<0.05$) was observed in values obtained for reducing sugar content of control jam and optimized jam. The reducing sugar content was increased during storage (Table 2). The reducing sugar content of sample T_1 and T_2 was increased from 20.85 to 24.03 and 5.63 to 8.40 respectively during storage. Maximum mean value was noted for sample T_1 (22.38) while minimum value was noted for sample T_2 (6.95). The high reducing sugar content in control jam can be attributed to inversion of sucrose in acidic environment. The mean reducing sugar significantly ($p<0.05$) increased from 13.24 to 16.21 during storage. The increase in reducing sugar might be due to the inversion of sucrose to reducing sugar (glucose + fructose) due to acidic environment and long storage period. The results are in alignment with the findings of Riaz et al. (34) who observed increasing trend in reducing sugars of strawberry jam during storage. Similar observations for increase in reducing sugar content have been reported by Bhople et al. (35) for beetroot jam during storage.

Effect of storage on the sensory quality characteristics of low calorie apple jam and control jam

The different qualitative characters of prepared low calorie apple jam examined organoleptically by a panel of 9 judges on the basis of 9-points hedonic scale.

Colour

Colour score of freshly prepared jam samples T_1 and T_2 was 8.00and 6.90 which was gradually decreased to 7.50and 6.50 respectively during 28 days of storage (Table 3). The maximum mean value was noted in sample T_1 (7.72) while minimum value was reported in T_2 (6.7). The statistical analysis revealed that storage effect on the colour of T_1sample was significantly different from T_2 ($p<0.05$). Control jam had the maximum colour score value as compared to optimized jam because it contained sugar which gives glossiness to the jam. The mean colour value significantly decreased ($p<0.05$) from 7.45 to 7.00 during storage. Decrease in colour during storage might be due to degradation of ascorbic acid, browning reactions, and polymerization of color pigments with other phenolic compounds. These results were in agreement with Khan et al. (11) who observed decreasing trend in colour of different apple jams during storage. Similar observations were found by Patel and Naik (37) in banana pineapple blended jam.

Taste

Taste score of freshly prepared jam of sample T_1 and T_2 was 8.60 and 7.40 which was gradually decreased to 8.20 and 7.00 respectively during storage (Table 3). The mean taste value significantly ($p<0.05$) decreased from 7.95 to 7.60 during storage. The maximum mean value was noted in sample T_1 (8.38) while minimum value was recorded in sample T_2 (7.20). The statistical analysis revealed that storage effect on the taste of T_1 sample was significantly different from T_2 ($p<0.05$). T_1 (8.38) had maximum taste score as compared to because it contained high amount of sucrose. Decrease in taste score might be due to the change in acidity, pH and sugar content due to degradation of various components during storage. These observations are in alignment with Wasif et al. (31) who observed decreasing trend in taste of apple and olive blended jam during storage. Similar observations were reported by Relekar et al. (32) in sapota jam.

Flavour

Flavour of control jam and optimized jam was decreased during storage (Table 3). The maximum mean value was noted in sample T_1 (8.18) while minimum value was recorded in

sample T_2 (6.50). The statistical analysis revealed that storage effect on the flavour of T_1 sample was significantly different from T_2 ($p<0.05$). Control jam had maximum flavour score because of sucrose which has a pleasant flavour. The mean flavour value significantly ($p<0.05$) decreased from 7.50 to 7.15 during storage. Decrease in flavour during storage might be due to oxidative changes of sugars, enzymatic degradation of phenols and the loss of high volatile aromatic compound at high storage temperature. These results are in agreement with Patel and Naik (37) who observed decreasing trend in flavour of banana pineapple blended jam during storage. Similar observations were found by Priya et al. (38) in mixed fruit jam.

Texture

The texture of low calorie apple jam and control jam was decreased during 28 days of storage period. A decrease in texture of jam samples was observed during storage. Texture of freshly prepared jam of sample T_1 and T_2 was 8.80 and 6.50 which was gradually decreased to 8.40 and 6.00 respectively during storage. The maximum value was noted in sample T_1 (8.58) while minimum value was reported in sample T_2 (6.30). The statistical analysis revealed that storage effect on the texture of T_1 sample was significantly different from T_2 ($p<0.05$). The textual properties of the jam are usually attributed to pectin composition. The role of pectin is to form a network or create thickening effect for jam to set. Pectin forms a gel with sugar and acid. The texture of T_2 was not as good as T_1 because stevia did not form strong gel with pectin. The mean texture value significantly ($p<0.05$) decreased from 7.60 to 7.25 during storage. The statistical analysis revealed that storage effect on the texture of all samples was significant ($p<0.05$). Decrease in texture quality might be due to hydrolysis of pectin during storage. These results are in agreement with Abolila et al. (33) who observed decreasing trend in texture of low calorie orange jam during storage. Similar results were found by Priya et al. (38) in mixed fruit jam.

Table 3: Effect of treatments and storage period on sensory characteristics of jam

Treatment	Storage Days					Mean
	0	7	14	21	28	
Colour T_1	8.00 ± 0.20^{b}	7.80 ± 0.10^{b}	7.70 ± 0.10^{b}	7.60 ± 0.15^{b}	7.50 ± 0.15^{b}	7.72^{b}
T_2	6.90 ± 0.50^{a}	6.80 ± 0.20^{a}	6.70 ± 0.25^{a}	6.60 ± 0.30^{a}	6.50 ± 0.25^{a}	6.70^{a}
Mean	7.45^{e}	7.30^{d}	7.20^{c}	7.10^{b}	7.00^{a}	
Taste T_1	8.60 ± 0.20^{b}	8.50 ± 0.10^{b}	8.40 ± 0.20^{b}	8.30 ± 0.10^{b}	8.20 ± 0.15^{b}	8.38^{b}
T_2	7.40 ± 0.45^{a}	7.30 ± 0.20^{a}	7.20 ± 0.30^{a}	7.10 ± 0.30^{a}	7.00 ± 0.30^{a}	7.20^{a}
Mean	7.95^{e}	7.90^{d}	7.80^{c}	7.70^{b}	7.60^{a}	
Flavour T_1	8.40 ± 0.20^{b}	8.30 ± 0.30^{b}	8.20 ± 0.20^{b}	8.10 ± 0.15^{b}	8.00 ± 0.10^{b}	8.18^{b}
T_2	6.70 ± 0.40^{a}	6.60 ± 0.50^{a}	6.50 ± 0.40^{a}	6.40 ± 0.20^{a}	6.30 ± 0.15^{a}	6.50^{a}
Mean	7.50^{e}	7.45^{d}	7.35^{c}	7.25^{b}	7.15^{a}	
Texture T_1	8.80 ± 0.20^{b}	8.70 ± 0.20^{b}	8.60 ± 0.10^{b}	8.50 ± 0.10^{b}	8.40 ± 0.20^{b}	8.58^{b}
T_2	6.50 ± 0.80^{a}	6.40 ± 0.60^{a}	6.30 ± 0.50^{a}	6.20 ± 0.30^{a}	6.10 ± 0.25^{a}	6.30^{a}
Mean	7.60^{e}	7.55^{d}	7.45^{c}	7.35^{b}	7.25^{a}	
Appearance T_1	8.60 ± 0.20^{b}	8.50 ± 0.15^{b}	8.40 ± 0.20^{b}	8.30 ± 0.15^{b}	8.20 ± 0.10^{b}	8.40^{b}
T_2	6.90 ± 0.70^{a}	6.80 ± 0.50^{a}	6.60 ± 0.60^{a}	6.40 ± 0.40^{a}	6.30 ± 0.30^{a}	6.60^{a}
Mean	7.75^{e}	7.65^{d}	7.50^{c}	7.35^{b}	7.25^{a}	
Overall T_1	8.42 ± 0.20^{b}	8.36 ± 0.48^{b}	8.26 ± 0.16^{b}	8.16 ± 0.13^{b}	8.06 ± 0.32^{b}	8.25^{b}
acceptability T_2	6.88 ± 0.51^{a}	6.78 ± 0.40^{a}	6.66 ± 0.41^{a}	6.54 ± 0.30^{a}	6.42 ± 0.25^{a}	6.65^{a}
Mean	7.65^{e}	7.57^{d}	7.46^{c}	7.35^{b}	7.24^{a}	

Values having different alphabetical letters in a row/column are significantly different (p□o.05). The values are expressed as the mean ±SD of three replications.

Appearance

The appearance of low calorie apple jam was decreased during 28 days of storage period. Appearance of freshly prepared jam of sample T_1 and T_2 was 8.60 and 6.90 which was gradually decreased to 8.2 and 6.3 respectively during storage (Table 3). The maximum value was noted in sample T_1 (8.40) while minimum value was reported in sample T_2 (6.60). The statistical analysis revealed that storage effect on the appearance of T_1 sample was significantly different from T_2 ($p<0.05$). Lack of glossiness was found in sample

T_2 due to the absence of sucrose. The mean value significantly ($p<0.05$) decreased from 7.75 to 6.25 during storage. Decrease in appearance during storage might be due to browning reactions, degradation of ascorbic content and polymerization of colour pigments and phenolic compounds. Similar results have been reported by Bhople et al. (36) who observed decreasing trend in appearance of beetroot jam during storage.

Overall acceptability

The overall acceptability of control jam and optimized jam was decreased during 28 days of storage period. Overall acceptability of freshly prepared jam of sample T_1 and T_2 was 8.42 and 6.88 which gradually decreased to 8.06and 6.42 respectively during storage (Table 3). The mean overall acceptability value significantly ($p<0.05$) decreased from 7.65 to 7.24 during storage. The maximum value was noted in sample T_1 (8.25) while minimum value was recorded in sample T_2 (6.65). Decrease in overall acceptability during the storage period was due to the decrease in colour, texture, flavour, taste and appearance with increasing storage period. These results are in alignment with the Khan et al. (30) who observed decreasing trend in overall acceptability of strawberry jam from during storage. Similar observations were found by Muhammad et al. (29) in diet apple jam.

Effect of storage on the microbiological quality characteristics of low calorie apple jam

Total viable count

The results regarding the total viable count of different jam samples during storage effect are presented in Table 4. The total viable count ranged from 1×10^3 to 22×10^3. This implied that the jam was made under hygienic conditions and was safe for consumption (38). T_1 had minimum viable count because of preservative effect of sucrose as it binds the water molecules and make it unavailable to microorganisms. The total viable count increased during storage but no spoilage of products was noticed. The acceptable limit of total plate count in jam is not more than 40 % of the field examination (12). Similar results were found by Vidya and Narain (34) in wood apple jam.

Table 4: Effect of storage periods and treatments on total viable count (cfu/gm) of jam

Treatment	Storage Days				
	0	7	14	21	28
T_1	1×10^3	2×10^3	4×10^3	7×10^3	11×10^3
T_2	1×10^3	2×10^3	6×10^3	11×10^3	18×10^3

Where, T_1 = control sample (apple jam); T_2 = optimized jam (apple jam with stevia)

Yeast and mould count

The results regarding the yeast and mould count of both jam samples during storage are presented in Table 5. A slight increase in yeast and mold count was observed in jam samples during the storage. The yeast and mould count ranged from 0 to 16×10^3. However, the increase in yeast and mould growth was within the permissible limit. The acceptable limit of yeast and mould count in jam is not more than 125 per 1/60 c.m.m (12). Similar results were found by Vidya and Narain (34) in wood apple jam.

Table 5: Effect of storage periods treatments on yeast and mould count (cfu/gm) of jam

Treatment	Storage Days				
	0	7	14	21	28
T_1	0	1×10^3	2×10^3	5×10^3	8×10^3
T_2	0	1×10^3	5×10^3	8×10^3	13×10^3

Where, T_1 = control sample (apple jam); T_2 = optimized jam (apple jam with stevia)

CONCLUSION

The use of natural sweetener stevia in the manufacture of apple jam was shown to be satisfactory, resulting in a product with jam characteristics and with taste and flavour similar to conventional jam with low calorie value. Low-calorie values could be satisfaction for diabetics or people with restricted diet even for weight maintaining person. The appearance of undesirable attributes such as appearance and texture of low calorie jam is a constant problem with high intensity sweeteners if sugar is completely substituted with sweeteners. These attributes are collaborated to the fewer acceptances of samples with more intensity of them. Thus, more studies are required aimed at improving texture and appearance attributes in low calorie jam.

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