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FOOD TECHNOLOGY

FORTIFICATION OF CHIA SEEDS IN APPLE JAM TO PREPARE VALUE ADDED PRODUCT

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ABSTRACT

Chia seed is a naturally grown grain and gaining worldwide popularity due to increasing desire for change the healthier lifestyles. They produce gel in water and can be employed as normally thickener, stabilizer or emulsifier in the development of innovative foods. Chia seeds are rich source of fat, fiber and protein contents. On the other hand, adding chia seeds powder to apple jam boosts its nutritious worth.Current study was conducted during 2020 at Department of Food Sciences, GCWU, Faisalabad. The current study on chia apple jam showed results of compositional and sensory analysis. The results of different treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90 % of chia seeds) were observed. The treatment T_3 showed moisture content was 2.86 ± 0.01%. The best ash, fat, fiber and protein contents were 4.07 ± 0.01, 9.74 ± 0.02, 44.06 ± 0.01 and 15.33 ± 0.03%, respectively observed in T_3. The highest nitrogen free extract content was 86.87 ± 0.03% observed in T_0. The results of compositional analysis were best according to T_3. The treatment T_3 showed highest mineral contents than other parameters. The highest 2,2-diphenyl-1-picrylhydrazyl 1.71 ± 0.01 mg/100 g was observed in T_3. The highest total phenolic and total flavonoid contents 0.75 ± 0.01 and 0.58 ± 0.01 mg of GAE/ g were observed in T_3The best results of sensory characteristics of chia apple jam were observed in T_2. The incorporation of chia seed powder at about 60% in apple jam with T_2 was best according to sensorial attributes and acceptable for the preparation and commercialization of product at industrial sector .

KEYWORDS: Chia seeds; apple jam; fortification; antioxidants; minerals; emulsifier

INTRODUCTION

Jam is a form of fruit that is typically created with a variety of fruits, sugar, and pectin and consumed during the off-season. Jams are well-known for their accessibility, organoleptic qualities, and low cost and are typically canned or sealed in sterilized bottles after manufacture. Jam was historically made by boiling seasonal fruits with sugar and pectin to preserve them. Commercial and home-based fruit jam-making operations exist. The jam is made by cutting the fruits, then heating them with sugar and pectin until they reach the desired consistency with the addition of value added ingredients, then packing them in sterilized jars or cans (Bhardwaj *et al.,* 2019).

Apples contain high amounts of vitamins, minerals and fiber all of which beneficial to health. Apple contained fiber 0.8 g, lipid 0.3 g, ash 0.3 g, protein 0.4 g, carbohydrates 13.9 g, water 84.7%, vitamin C 11%, 57 kcal of energy per 100 g of comestible portion. Apples contain a rich source of antioxidants, including; phloridzin, catechin, querecetin and chlorogenic acid. Quercetin has a neuroprotective effect, possibly because it hinders the formation of reactive species. It helps neurons to endure its function. It may therefore help to impedes age-related neuron loss. Maximum dosage of quercetin supplementation may help protect destruction of cells that can cause Alzheimer's disease (Mujkanovic *et al.,* 2019).

However, When an apple is turned into jam, however, the nutritional composition of the apple is drastically reduced, resulting in trace fat and a high concentration of carbohydrates, primarily sugar. Furthermore, due to the heat to which they are exposed during processing, jams typically have lower fibre content than their fresh fruit equivalents. Fortifying the jam with nutrient-dense food products is one solution to the problem of nutrient loss. Fortification allows a processor to restore nutrients lost during processing or to boost a food's nutritional value by adding additional nutrients. As a result, traffic delays can be strengthened and used to deliver a range of items. Beyond fundamental nutritional functions, functional components in food are substances that offer physiological advantages and lessen the risk of chronic disease. Chia seeds (*Salvia hispanica* L.) are one of the foods with beneficial components (Nduko *et al.,* 2018).

Chia seeds are considered as oil and pseudo cereal. They contain up to 68 % omega-3 alpha-linolenic acid and between 25 and 40% fats are amid the plant origin with the immense substance of alpha - linolenic corrosive, compared to flax 57%, perllia 53% and camelina 36%. They likewise contain 20% of omega-6 linoleic corrosive, gives great steadiness between two fundamental unsaturated fats. The protein content in chia seeds is more 19 to 23% than the greater part of the customarily used of cereals, including rice 8.5%, corn 14%, wheat 14%, barley 9.2% and oats 15.3%. It contains all basic amino acids specifically lysine, valine, isoleucine and leucine (2.99, 4.15, 2.42 and 2.85 g/100 g proteins, respectively) (Nduko *et al.,* 2018).

Jams normally have lower fiber contents due to heat in which they are exposed during processing. One approach to solve the problem of nutrient deficiency is the fortification of jam with nutrient dense food. Fortification of jam enhanced antioxidant activity, protein, minerals and fiber content. The value added in the product fullfils the deficiency of nutritents from the food product. The fortified food products not only provides nutritional advantages but also provide physiological advantages (Many and Sarasvathi, 2016).

A typical fruit jam has an even consistency without distinguishable fruit bits, a vivid colour, pleasant fruit flavour, and a semi-jelled texture; it's easy to spread and doesn't have any liquid that flows freely. Jam that has been fortified can so impart colour, taste, texture, spreadability, and overall accaptibility. The aim of this study was to fortify apple jam with chia seeds to check the compositional, nutritional value and sensory attributes of the chia apple jam. The objectives of research work includes, the development and compositional analysis of chia apple jam and antioxidant, physico-sensorial characterization of the prepared jam during storage.

Compositional analysis, mineral profile, physico-chemical analysis, sensory evaluation and statistical analysis of the prepared jam indicated that apple jam could be fortified and demonstrated as a potential application of chia seeds for maximum benefit from its functional properties.

MATERIALS AND METHODS

Current study was conducted during 2020 at Department of Food Sciences, GCWU, Faisalabad.

Materials and reagents

Chia seeds and apples were acquired from Food Technology Section of Ayub Agricultural Research Institute, Faisalabad. All the chemical reagents were purchased from Sigma-Aldrich for analysis. The chia apple jam was kept at refrigeration temperature (4ºC) after packing into jars (Table 1).

Table 1. Formulation of chia apple jam

Ingredients	Treatments (g)			
	T_0	T_1	T_2	T_3
Apple	38.77	28.76	18.78	8.80
Chia powder	0	10	20	30
Water	60	60	60	60
Pectin	0.58	0.58	0.58	0.58
Sugar	0.72	0.72	0.72	0.72
Lemon juice	0.11	0.11	0.11	0.11

Chia-fortified apple jam production

Chia apple jam was prepared with apple, water, sugar, gelatin and lemon juice. The cutted apples were blended and poured them into sterilized container. The mashed apples were put in a broiler to cook (the gelatin and organic product mash together), stirred continuously and then cooked it for 3 hours till the jam accomplished its proper consistency. The jam was evacuated into sterilized jars. Chia seeds at various treatments (10, 20 and 30% w/w) were added in the jam and one jar was left behind with no chia seeds as control tests.

Compositional analysis

Compositional analysis of chia apple jam including; moisture, ash, crude fat, crude fiber, crude protein and nitrogen free extract will be done by following the standard procedures of AOAC (2019).

Mineral profile

The mineral contents from the chia apple jam were determined, by atomic absorption spectroscopy according to the method described by AOAC (2019). The 5 g of chia apple jam was weighed and taken in a crucible and subjected for ashing in a muffle furnace at a temperature of 550 to 600 ºC. The ash was taken in a digestion flask and digested with a mixture of concentrated nitric acid, sulphuric acid and per chloric acid. Then it was cooled at room temperature. The digested material made up to 100 mL with distilled waterm, to determine the amount of potassium, calcium and iron from chia apple jam.

Storage study

Chia apple jam was stored for three months under refrigeration and following analysis were carried out at specific intervals (zero, 30^{th}, 60^{th} and 90^{th} day).

Table 2. Means for moisture, ash, fat, fiber, protein and NFE

Treatments	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	NFE (%)
T_0	3.03 ± 0.01A	3.47 ± 0.01D	0.92 ± 0.02D	4.18 ± 0.01D	0.64 ± 0.02D	86.87 ± 0.03A
T_1	2.98 ± 0.01B	3.67 ± 0.01C	3.19 ± 0.02C	18.66 ± 0.01C	5.63 ± 0.01C	64.97 ± 0.04B
T_2	2.91 ± 0.01C	3.87 ± 0.01B	6.45 ± 0.02B	31.25 ± 0.01B	10.23 ± 0.02B	41.68 ± 0.07C
T_3	2.86 ± 0.01D	4.07 ± 0.01A	9.74 ± 0.02A	44.06 ± 0.01A	15.33 ± 0.03A	18.16 ± 0.02D

Values are mean ± SD for four treatments were analyzed individually in triplicate
Where,
T_0 = Control apple jam, 100% without chia seeds powder, T_1 = 30 % Chia seeds powder + 70 % Apple jam, T_2 = 60% Chia seeds powder + 40% Apple jam, T_3 = 90% Chia seeds powder + 10% Apple jam

Antioxidant potential: The cancer prevention agent potential was resolved by the technique portrayed by Drogoudi *et al.* (2017). The conclusive outcomes were communicated as milimoles of Trolox equivalents (TE) per gram of the jam (m mol TE/ g).

Total phenolic compounds (TPC): The absolute phenolic compounds were inspected by the strategy depicted by Lafarga *et al.* (2018).

Total flavonoids: The complete flavonoids were inspected by the strategy depicted by Nikolic et al. (2018). Absorbance was estimated at 510 nm against the reasonable blank. From calibration bend of rutin, all flavonoids were inspected and the outcomes were estimated in mg rutin equal per gram dry weight extract.

Sensory evaluation: The apple chia jam will be evaluated by different sensory characters i.e., color, taste, mouth feel, spreadability and overall acceptability by using nine-point hedonic scale (Meilgaard *et al.,* 2007).

Statistical analysis: The statistical analysis of the sample was determined according to the method described by Montogomery *et al.* (2013). The collected data were analyzed by using Statistix 8.1 software. Two factor factorials were determined in statistical analysis. One factor factorial includes Proximate and Mineral parameters and two factor factorial include other parameters.

RESULTS AND DISCUSSION

The moisture contents of chia apple jam with different treatments were determined and the obtained results were exposed to statistical analysis. The results showed that there were highly significant difference ($P \leq 0.01$) existed among them. It has been clear from the above results that moisture content considerably varied among chia apple jam with various treatments.

The mean results concerning moisture content are presented in Table 2 showed that, the moisture content 3.03 ± 0.01, 2.98 ± 0.01, 2.91 ± 0.01 and 2.86 ± 0.01 % with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90%), respectively. The results of moisture content were highly significant. Lowest moisture content 2.86 ± 0.01% was observed in T_3. Highest moisture content 3.03 ± 0.01% was observed in T_1. The reduction in moisture content enhanced the shelf life of chia apple jam. Muhammad *et al.* (2019) prepared the apple jam with different concentrations of sweeteners then analyzed at different storage intervals. The apple jam was prepared with saccharin 25 g. The moisture content in apple jam was 68% at 90th day, observed the best. The apple star jam was prepared with different samples of pectin. The lowest moisture content in jam prepared with pectin from purple star apple pulp was 27%, according to (Nwosu *et al.,* 2013).

Ash is an inorganic material, resulted after burning the organic material. The retrieved ash may not have precisely the same structure as the mineral elements in the actual food. The produced ash is homogeneous in hue, gray or white, free of flammable coal fragments or even bonded particles (Bhardwaj *et al.,* 2019). The mean results for ash content of chia apple jam samples are illustrated in Table 2. Mean table for ash contents of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 3.47 ± 0.01, 3.67 ± 0.01, 3.87 ± 0.01 and 4.07 ± 0.01%, respectively. Lowest ash content 3.47 ± 0.01 % was observed in T_0. Highest ash content 4.07 ± 0.01% was observed in T_3. Variation in ash contents were due to variation in inorganic compounds especially calcium ion present in pectin.

Bhardwaj *et al.* (2019) prepared jam with different concentrations of apple, carrot and flaxseed. The ash content in apple jam fortified with carrot and flaxseed was 0.65%, observed in (90:10). The apple star jam was prepared with different samples of pectin. The ash content was 3.9 % in apple star jam prepared with synthetic pectin. Ash indicated the measure of minerals in a food commodity (Nwosu *et al.,* 2013).

Fat is an important constituent that provides us energy, about 9 kcal/ g. It nourishes the body with all the essential fatty acid that can't be synthesized by the body as well as helps to maintain the body. It also helps to retrieve oil in food. Fat content also add flavor and tenderness in food products, apart from possessing a lubricating action and a feeling of moistness in the mouth (Ditrich and Moiseieva, 2017).

In the Table 2, the mean values of chia apple jam have been described. The mean table for crude fat content of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 0.92 ± 0.02, 3.19 ± 0.02, 6.45 ± 0.02 and 9.74 ± 0.02 %, respectively. The lowest crude fat content was 0.92±0.02 % in T_0. The highest crude fat content 9.74 ± 0.02 % was observed in T_3.

Nduko *et al.* (2018) made pineapple jam with various chia seed treatments. The highest fat content in pineapple jam was 30.7% with 50% of chia seeds. The pumpkin jam was fortified with different samples of soybean. The maximum fat content observed in pumpkin jam fortified with sample of aspartame soybean jam was 1.17% (Alsuhaibani and Kuraieef, 2018).

Data regarding the analysis of variance clearly indicated highly significant (P ≤ 0.01) results, which were different from each other. The mean values of chia apple jam are presented in Table 2. The mean table for crude fiber content of chia apple jam with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90%) showed that values were 4.18 ± 0.01, 18.66 ± 0.01, 31.25 ± 0.01 and 44.06 ± 0.01 %, respectively. The lowest crude fiber 4.18 ± 0.01 % was observed in T_0. The highest crude fiber content 44.06 ± 0.01 % was observed in T_3.

These results were assisted by the findings of Nduko *et al.* (2018), who prepared pineapple jam fortified with different treatments of chia seeds. The highest fiber contents in pineapple jam was 21.02 % with 50 % of chia seeds. The pumpkin jam was fortified with different samples of soybean. The maximum fat content in pumpkin jam fortified with sample of stevia soybean was 18.87% (Alsuhaibani and Kuraieef, 2018).

Data regarding the analysis of variance clearly indicated highly significant (P ≤ 0.01) results, which were different from each other. The mean presented in the Table 2 for crude protein contents of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 0.64 ± 0.02, 5.63 ± 0.01, 10.23 ± 0.02 and 15.33 ± 0.03%, respectively. The highest crude protein content 15.33±0.03 % was observed in T_3. The lowest crude protein content 0.64 ± 0.02 % was observed in T_0.

Similar results were compiled by Nduko *et al.* (2018) who studied the proximate analysis of chia pineapple jam. Different concentrations of chia seeds were added in pineapple jam and reported maximum protein content was 8.60 % with 50 % of chia seeds. The pumpkin jam was fortified with different samples of soybean. The maximum protein content in pumpkin jam fortified with sample of stevia soybean was 20.11% (Alsuhaibani and Kuraieef, 2018).

This statistical results showed highly significant differences (P ≤ 0.01). The mean results for NFE are presented in Table 2. Mean table for NFE content of chia apple jam with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90 %) showed that values were 86.87 ± 0.03, 64.97 ± 0.04, 41.68 ± 0.07 and 18.16 ± 0.02 %, respectively. The highest NFE content 86.87±0.03 % was observed in T_0. The lowest NFE content 18.16 ± 0.02 % was observed in T_3.

Minerals play a vital role in various biological functions of the body, especially in the building and regulation processes. Fruits are regarded a great source of dietary minerals. Chia apple jam contain high amount of potassium. The obtained values of the mineral elements; potassium (K), calcium (Ca) and iron (Fe) in chia apple jam are discussed. Chia apple jam is considered a good source of potassium (K), which is important for the regulation of blood pressure and other body functioning (Goyat *et al.,* 2012). The statistical results regarding analysis of variance for K contents of chia apple jam. It was apparent from the statistical results that the treatments showed highly significant differences (P ≤ 0.01). The mean results for K content are presented in Table 3.

The mean table for K content of chia apple jam with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90 %) showed that values were 189.77 ± 0.58, 199.77 ± 0.58, 209.77 ± 0.58 and 219.77 ± 0.58 mg/ 100 g, respectively. The highest K content 219.77 ± 0.58 mg/ 100 g were observed in T_3. The lowest K content 189.77 ± 0.58 mg/100 g were observed in T_0. The K contents were observed from raw and roasted chia seeds. The K content in 0.2 g of raw chia seeds was 8903 mg/ kg.

Table 3. Mean for minerals and antioxidants with treatments

Treatments	Potassium (mg/ 100 g)	Calcium (mg/ 100 g)	Iron (mg/ 100 g)	Antioxidant (mg/ 100 g)	Total flavonoids (mg of QAE/ g)	Total phenolic compounds (mg of GAE/ g)
T_0	189.27 ± 0.58D	160.03 ± 0.01D	1.80 ± 0.01D	1.40 ± 0.02D	0.29 ± 0.01D	0.47 ± 0.01D
T_1	199.77 ± 0.58C	163.04 ± 0.01C	2.10 ± 0.01C	1.50 ± 0.02C	0.35 ± 0.01C	0.53 ± 0.01C
T_2	209.77 ± 0.58B	166.02 ± 0.01B	2.40 ± 0.01B	1.60 ± 0.02B	0.42 ± 0.01B	0.59 ± 0.01B
T_3	219.77 ± 0.58A	169.04 ± 0.01A	2.70 ± 0.01A	1.70 ± 0.02A	0.48 ± 0.01A	0.65 ± 0.01A

Values are mean ± SD for four treatments were analyzed individually in triplicate

Where,

T_0 = Control apple jam, 100 % without chia seeds powder, T_1 = 30 % Chia seeds powder + 70 % Apple jam ,
T_2 = 60 % Chia seeds powder + 40 % Apple jam, T_3 = 90 % Chia seeds powder + 10 % Apple jam

Table 4. Mean for antioxidants, total phenolic compounds and total flavonoids with storage of chia apple jam

Storage	Antioxidants (mg/ 100 g)	Total phenolic compounds (mg of GAE/ g)	Total flavonoids (mg of QAE/ g)
0 Day	1.56 ± 0.12A	0.57 ± 0.17A	0.39 ± 0.17A
30th Day	1.55 ± 0.12AB	0.56 ± 0.17AB	0.38 ± 0.17AB
60th Day	1.55 ± 0.12AB	0.56 ± 0.17AB	0.38 ± 0.17AB
90th Day	1.54 ± 0.12B	0.55 ± 0.17B	0.37 ± 0.17B

Values are mean ± SD for storage were analyzed individually in triplicate

The K content was 8564 mg/kg in 0.2 g of roasted chia seeds (Ghafoor *et al.,* 2018).

Chia apple jam contains calcium (Ca), which is important for bones. The heart, muscles and nerves also need Ca to function properly (Goyat *et al.,* 2012). The statistical results regarding analysis of variance for Ca content of chia apple jam. It was apparent from the statistical results that the treatments showed highly significant differences ($P \leq 0.01$). The mean results for Ca contents are presented in Table 3.

Mean table for Ca content of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 160.03 ± 0.01, 163.04 ± 0.01, 166.02 ± 0.01 and 169.04 ± 0.01 mg/100 g, respectively. The highest Ca content 169.04±0.01 mg/100 g were observed in T_3. The lowest Ca content 160.03 ± 0.01 mg/100 g were observed in T_0.According to Ghafoor et al. (2018), who determined the Ca contents in raw and roasted chia seeds. The Ca contents in 0.2 g of raw chia seeds were 7616.7 mg/ kg. The Ca contents in 0.2 g roasted chia seeds were 7582.0 mg/kg.

Chia apple jam contain an essential mineral of iron (Fe) that's needed for making hemoglobin, a protein found in red blood cells that helps to transport oxygen around the body. It plays a key role in supporting the immunesystem, too. Fe also helps to maintain our energy levels, regulate body temperature and may even improve athletic performance (Goyat *et al.,* 2012). The statistical results regarding analysis of variance for Fe content of chia apple jam. It was apparent from the statistical results that the treatments showed highly significant differences ($P \leq 0.01$). The mean results for Fe content are presented in Table 3.

The mean table for Fe content of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 1.80 ± 0.01, 2.10 ± 0.01, 2.40 ± 0.01 and 2.70 ± 0.01 mg/ 100 g, respectively. The highest Fe content 2.70 ± 0.01 mg/100 g were observed in T_3. The lowest Fe content 1.80 ± 0.01 mg/100 g were observed in T_0.The Fe contents were determined from raw and roasted chia seeds. The Fe content in 0.2 g of raw chia seeds was 11.05 mg/kg and in 0.2 g of roasted chia seeds Fe content was 7.25 mg/kg (Ghafoor *et al.,* 2018).

DPPH is a free radical compound which has been widely used to estimate the free radical scavenging activity of various samples. Mean results for DPPH are presented in Table 3. The mean table for DPPH of chia apple jam with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90 %) showed that values were 1.40 ± 0.02, 1.50 ± 0.02, 1.60 ± 0.02 and 1.70 ± 0.02 mg/100 g, respectively. The highest DPPH 1.70±0.02 mg/ 100 g were observed in T_3. The lowest DPPH 1.40 ± 0.02 mg/100 g were observed in T_0. Table 4 showed that the DPPH of chia apple jam at zero, 30th, 60th and 90th day were 1.56 ± 0.12, 1.55 ± 0.12, 1.55 ± 0.12 and 1.54 ± 0.12 mg/100 g, respectively. The results of DPPH were significant with storage. The highest DPPH 1.56 ± 0.12 mg/100 g was observed at zero day. The lowest DPPH 1.54 ± 0.12 mg/100 g was observed at 90th day.

The current outcomes of antioxidants were in coherence with the conclusions of Drogoudi et al. (2016). The antioxidants were determined from raw and roasted chia seeds. The antioxidant contents in 0.2 g of raw chia seeds were 4.24 mg/ 100. The antioxidant contents in 0.2 g of roasted chia seed were 3.31 mg/ 100 g, according to Ghafoor *et al.* (2018).

The statistically applied data related to the analysis of total phenolic compounds (TPC). Outcomes were highly significant ($P \leq 0.01$). The mean presented in Table 3 for TPC of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 0.47 ± 0.01, 0.53 ± 0.01, 0.59 ± 0.01 and 0.65 ± 0.01 mg of GAE/ g, respectively. The maximum TPC 0.65 ± 0.01 mg of GAE/g was observed in T_3. The minimum TPC 0.47±0.01 mg of GAE/ g was observed in $T_{0.}$Table 4 showed that the TPC of chia apple jam at zero, 30th, 60th and 90th day were 0.57 ± 0.17, 0.56 ± 0.17, 0.56 ± 0.17 and 0.55 ± 0.17 mg of GAE/ g, respectively. The results of TPC were significant with storage. The maximum TPC 0.57 ± 0.17 mg of GAE/ g was observed at zero day. The minimum TPC 0.55±0.17 mg of GAE/ g was observed at 90th day.

The existing consequences of TPC were in harmony with the conclusions of Drogoudi *et al.* (2017). The TPC were determined from raw and roasted chia seeds. The TPC in 0.2 g of raw chia seeds were 3.07 mg of GAE/ g and in 0.2 g of roasted chia seed were 3.43 mg of GAE/ g (Ghafoor *et al.,* 2018).

The analysis of variance of total flavonoids are described that the results were highly significant (P ≤

0.01) and diverse from each other. Mean results for total flavonoids are presented in Table 3. The mean presented in table for total flavonoids of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 0.29 ± 0.01, 0.35 ± 0.01, 0.42 ± 0.01 and 0.48 ± 0.01 mg of QAE/g, respectively. The highest total flavonoids 0.48 ± 0.01 mg of QAE/ g was observed in T_3. The lowest total flavonoids 0.29 ± 0.01 mg of QAE/ g was observed in T_0.

Table 4 showed that the total flavonoids of chia apple jam at zero, 30th, 60th and 90th day were 0.39 ± 0.17, 0.38 ± 0.17, 0.38 ± 0.17 and 0.37 ± 0.17 mg of QAE/ g, respectively. The results for total flavonoids were significant with storage. The maximum total flavonoids 0.39±0.17 mg of QAE/ g was observed at zero day. The minimum total flavonoids 0.37 ± 0.17 mg of QAE/g was observed at 90th day.

The current results of total flavonoids in chia apple jam with different treatments were in the harmony with outcomes of Gazali *et al.* (2014). According to Drogoudi *et al.* (2017) the total flavonoids were determined from raw and roasted chia seeds. The total flavonoids in 0.2 g of raw chia seeds were 2.21 mg of QAE/ g and in 0.2 g of roasted chia seed were 2.51 mg of QAE/ g.

Sensory evaluation is a fundamental characteristic originally performed for quality and excellence evaluation in order to acquire the perspective of the panelists about a developed product. It also acts as a tool for assessing the acceptability of customer. In current investigation, the nine point hedonic scale for chia apple jam was used by a qualified panel of judges. For the objectives, chia apple jam was recorded for color, taste, mouthfeel, spreadability and overall acceptability to measure the influence of treatments and storage on these parameters. The mean squares specified the significant effect of treatments and storage on the sensory aspects of chia apple jam as described in tables.

The color is a vital factor for assessing the manufacturing of chia apple jam, which not only represents the appropriateness of the raw materials but also conveys information about product's development and quality. It is one of the necessary traits for consumers to accept product. The results elucidated that the addition of chia seeds in apple jam considerably decreased the color scores. The statistical observed data relating to the color of chia apple jam prepared from different treatments of chia seeds showed highly significant effect ($P \leq 0.01$).

The mean presented in Fig. 1 for color of chia apple jam with treatments T_0, T_1, T_2 and T_3 (0, 30, 60 and 90%) showed that values were 6.76 ± 0.12, 7.16 ± 0.13, 8.27 ± 0.13 and 6.36 ± 0.12, respectively. The highest value of color 6.36±0.12 was observed in T_3. The lowest value of color 6.76 ± 0.12 was observed in T_0. There was overall trend that color score was proportional to the amount of chia seeds added. Acceptability of color was decreased with increasing chia seeds upto 90% in jam.

Fig. 2 showed that the color of chia apple jam at zero, 30th, 60th and 90th day were 7.38 ± 0.86, 7.27 ± 0.87, 7.16 ± 0.86 and 6.96 ± 0.85, respectively. The results of color were highly significant varied with storage. The maximum value of color 7.38 ± 0.86 was observed at zero day. The minimum value of color 6.96±0.85 was observed at 90th day. The above results are in accordance withthe outcomes of Nduko *et al.* (2018) who found the reduction in color due to absorption of the moisture from atmosphere and oxidation. The pineapple jam was prepared with different treatments of chia seeds. The maximum value of color was 3.91 with 6.25% of chia seeds. The color acts as an indicator for finishing of final processed jam and is linked to differences in taste and smell. Color mark reduction has been tested. The current results of apple jam fortified with chia seeds powder with different treatments were in the harmony with the outcomes of Ozbek *et al.* (2019), who prepared chia strawberry marmalade with different sweeteners. The maximum value of color was 5.7 with isomalt.

Taste is a key for a product's liking or disliking. The perception of taste combines sense of flavor and smell with texture, affected by the appearance. The jam products are quickly stalled, transforming the fresh product's rich aroma and flavor into blend or off flavor. The analysis of variance for taste of prepared chia apple jam with different treatments has been showed in highly significant effect ($P \leq 0.01$). The mean presented in Fig. 1 for taste of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 6.55 ± 0.08, 7.17 ± 0.12, 8.50 ± 0.12 and 6.59 ± 0.14, respectively. The highest value of taste 8.50 ± 0.12 was observed in T_2. The lowest value of taste 6.55 ± 0.08 was observed in T_0.There was overall trend that taste score was proportional to the amount of chia seeds added. Highest taste vlues was observed in T_2 with 60% chia seeds.Taste decreases with increasing chia seeds amount (90%) in jam because it worsen its sensory properties.

Fig. 2 showed that the taste of chia apple jam at zero, 30th, 60th and 90th day were 7.35 ± 0.81, 7.24 ± 0.85, 7.15 ± 0.83 and 7.06 ± 0.80, respectively. The results of analysis of variance for taste were highly significant ($P \leq 0.01$) varied with storage. The maximum value of taste 7.35 ± 0.85 was observed at zero day. The minimum value of taste 7.06 ± 0.80 was observed at 90th day. The taste perspectives were textured composition of flavor and smell strengthened by the presentation. The current results of apple jam fortified with chia seeds powder with different treatments were in the harmony with the outcomes of Ozbek *et al.* (2019). The strawberry marmalade was enriched with 2.5% of chia seeds with different concentrations of sweeteners. The maximum value of taste content was 5.1% in strawberry marmalade with sorbitol.

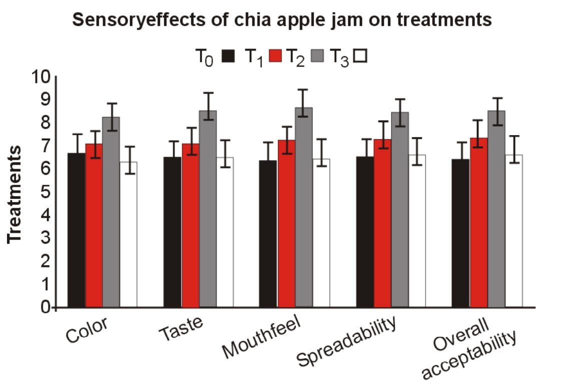

Fig. 1. Levels of sensory characteristics for chia apple jam on treatments

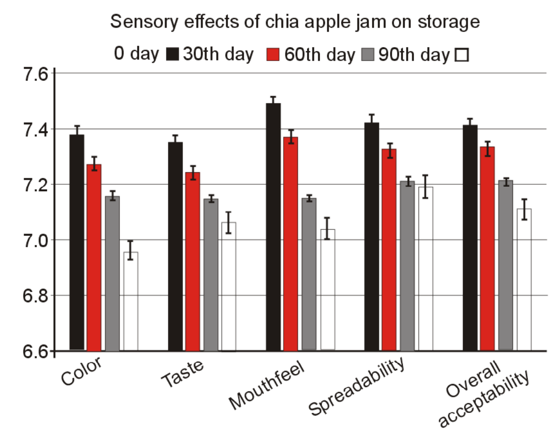

Fig. 2. Levels of sensory characteristics for chia apple jam on storage

The mouthfeel is a vital factor for assessing the manufacturing of chia apple jam, which not only represents the appropriateness of the raw materials but also conveys information about product's development and quality. It is one of the necessary traits for consumers to accept product. The analysis of variance for mouthfeel of chia apple jam with different treatments has been showed in highly significant effect ($P \leq 0.01$). The mean presented in Fig 1 for mouthfeelof chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 6.39 ± 0.14, 7.30 ± 0.11, 8.68 ± 0.14 and 6.48 ± 0.15, respectively. The highest value of mouthfeel 8.68±0.14 was observed in T_2. The lowest value of mouthfeel 6.39±0.14 was observed in T_0. There was overall trend that mouthfeel score was proportional to the amount of chia seeds added.Highest mouthfeel values was observed in T_2 with 60% chia seeds. However, it was observed that addition of 90% chia seeds in apple jam decreases the mouthfeelof the product.

The analysis of variance for mouthfeel of chia apple jam with has been showed in highly significant effect with storage . Fig. 2 showed that the mouthfeel of chia apple jam at zero, 30th, 60th and 90th day were 7.49 ± 0.95, 7.37 ± 0.97, 7.15 ± 0.98 and 7.04 ± 0.96, respectively. The results of mouthfeel were highly significant varied with storage. The maximum value of mouthfeel 7.49 ± 0.95 was observed at zero day. The minimum value of mouthfeel 7.04±0.96 was observed at 90th day.The existing consequences of mouthfeel were in harmony with the conclusions of Nduko *et al.* (2018) in chia pineapple jam. Pineapple jam was prepared with different treatments of chia seeds. The maximum value of mouthfeel in pineapple jam was 8.6 with 50% of chia seeds.

The obtained results refer to the spreadability of the apple jam prepared from chia seeds using different treatments. However, the spreadability was observed highly significantly ($P \leq 0.01$) different among different analyzed treatments. The mean presented in Fig. 1 for spreadability of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 6.58 ± 0.12, 7.29 ± 0.15, 8.47 ± 0.12 and 6.70 ± 0.12, respectively. The highest value of spreadability 8.47 ± 0.12 was observed in T_2 (60 % chia seed). The minimum value of spreadability 6.58 ± 0.12 was observed in T_0.It was observed that 90 % addition of chia seed declines the smoothness and spreadability of the jam. This is because increase in concentration enhance the viscosity of jam and reduce the spreadability ratio of jam on brad slices.

Fig 2 showed that the spreadability of chia apple jam at zero, 30th, 60th and 90th day were 7.42 ± 0.88, 7.32 ± 0.89, 7.21 ± 0.88 and 7.19 ± 0.88, respectively. The results of spreadability were highly significant with storage. The maximum value of spreadability 7.42 ± 0.89 was observed at zero day. The minimum value of spreadability 7.19 ± 0.88 was observed at 90th day.The pineapple jam was prepared with different concentrations of chia seeds. The maximum value of spreadability in pineapple jam was 4.06 with 50 % chia seeds.Spreadability was unaffected, which could be attributable to the presence of a viscous chia seed solution. The existing consequences of spreadability were in harmony with the conclusions of Nduko *et al.*

(2018) in chia pineapple jam.

The obtained results of different treatments for the analysis of variance for overall acceptability of chia apple jam illustrated as highly significant ($P \leq 0.01$) values of chia apple jam. The mean presented in Fig. 1 for overall acceptability of chia apple jam with treatments T_0, T_1, T_2 and T_3 showed that values were 6.45 ± 0.12, 7.38 ± 0.15, 8.54 ± 0.07 and 6.67 ± 0.13, respectively. The highest value of overall acceptability (8.54 ± 0.07) was observed in T_2. The lowest value of overall acceptability (6.45 ± 0.12) was observed in T_0.There was overall trend that acceptability score was proportional to the amount of chia seeds added.

The analysis of variance for overall acceptability of chia apple jam with has been showed in Fig 2, is highly significant effect with storage. The maximum value of overall acceptability 7.41 ± 0.80 was observed at zero day. The minimum value of overall acceptability (7.11 ± 0.97) was observed at 90th day. Overall tendency that acceptability scored was corresponding to the quantity of added chia seeds. It should be observed that chia seed is considered as a novel food with minute details on its nutritional value, hence low acceptability scored. Acceptability was proportional to the amount of chia seeds introduced in the overall trend. It's worth noting that chia seed is regarded as a novel product with limited nutritional data, resulting in a low acceptability score. Product creation from chia seeds in the food sector was extremely wanted with sensitization, and it could be utilised for nutraceutical food products. The pineapple jam was made with various chia seed concentrations.The overall acceptability of pineapple jam was 4.06 with 50% chia seeds (Nduko *et al.,* 2018). The treatment with 60% of chia apple jam and 60th day of storage were the best as in color, taste, mouthfeel, spreadability and overall acceptability.

CONCLUSION

From current research it was concluded that supplementation of apple jam with 60 % chia seeds powder was quite acceptable for sensory evaluation of jam. The 90 % chia apple jam had high nutritional value but not acceptable for sensory characteristics. From the current results, it was concluded that incorporation of chia seeds powder at about 60% is better and acceptable for the preparation and commercialization of product at industrial sector.

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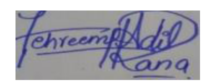
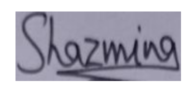
2.	Tehreem Adil Rana	Collected and analysed the data	
3.	Shazmina	Helped in research work and write-up the mansucript	
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