Journal of
Agriculture and Biology
ISSN: 3007-1755 (Print), 3007-1763 (Online)

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Research Article

Proximate Analysis and Sensory Evaluation of Chapatti Prepared by the Incorporation of Chia and Cantaloupe Seeds

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ABSTRACT

Chapatti, a staple food in developing countries, is consumed fresh after cooking. Chia seeds are high in fiber, protein, vitamins, essential minerals and antioxidants; also, the omega 3 fatty acids help lower Low Density Lipoprotein (LDL) cholesterol levels, thus promoting melanin production and good heart health. Cantaloupe seed rich in nutrients can perhaps extend the shelf life of chapatti. Ten chapatti treatments were formulated by addition of cantaloupe seed flour (0–20%) and chia seed flour (0–10%). The proximate analysis and sensory evaluation of the chapatti samples were determined to assess their nutritional and sensory properties respectively. Results showed that fortification with chia and cantaloupe seed flours greatly enriched the nutritional nature of chapatti with increased protein, fiber and omega-3 fatty acid composition, without compromising acceptability. The proximate analysis revealed that the moisture content ranged from 21.01% to 33.79%, crude protein from 12.64% to 13.36%, crude fat from 2.36% to 5.92%, crude fiber from 1.71% to 5.89%, and crude ash from 0.50% to 1.03%. Sensory evaluation scores varied across attributes: color (6.33 to 8.83), taste (7.87 to 8.22), texture (6.91 to 8.93), aroma (7.17 to 8.67), flavor (7.47 to 8.93), and overall acceptability (7.53 to 8.83). This study concludes that incorporating chapatti with chia and cantaloupe seed flours improves its physical, sensory and nutritional properties making it a healthier alternative without compromising consumer acceptance.

Keywords: Chapatti, Proximate analysis, Chia seeds, Sensory attributes, Cantaloupe seeds.

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Article History
Received: October 20, 2024
Accepted: January 15, 2025
Published: January 29, 2025

INTRODUCTION

Chapatti is an unleavened flatbread in Pakistan that is a staple food eaten fresh and is made from wheat flour, water, and salt. People are moving towards healthier food today. Chapatti is good for substitution as its fortification and cooking are easy. A study examined the antioxidant potential of chapatti by incorporating barley flour at concentrations of 28, 56, and 84 g. Wheat is the prominent component of many bakery products as wheat flour is produced after milling some nutrients were lost in the bran part. Composite flour is used to overcome nutritional limitations and the application of other flour like maize, yam, cassava, and other seeds flour as substitution proves economically beneficial. Wheat is also limited in essential amino acids like lysine so supplementation pulses, cereals, and seeds may enhance the quality of wheat products.

Various simple food fortifications utilizing chia and cantaloupe seeds, that are easily accessible, can easily be formulated at the household level to improve chapatti's bioactive compounds, vitamins, and mineral content (Younas *et al.*, 2024).

Chia is one of the 3rd most growing crops in Mexico. The nutritional composition of chia seeds is protein (17%), carbohydrates (34%), fat (43%), minerals (6%), moisture (42.1%), crude fiber (6.89%), and ash contents (1.10%). These seeds are the richest source of essential amino acids like lysine (4.9%), valine (5.05%), methionine (3.13%), cysteine (2.18%), and histidine (2.81%), (250-280 g/kg) of oil contents. Dietary fiber, protein, potassium, and calcium are 3, 13, 307, and 41 times more than wheat respectively (Rendon *et al.,* 2019). It also has a large amount of minerals phosphorus (860 mg/g), sodium (16 mg/g), calcium (600 mg/g), potassium (666 mg/g), iron (8 mg/g), manganese (3.34 mg/g), and copper (0.92 mg/g) which are essential for the human body. It has a higher amount of vitamin A and omega-3 fatty acids than wheat (Harisha *et al.,* 2023).

Cantaloupe seeds contain protein (21 to 26%), fiber (26 to 30%), fatty acid (25%), moisture (5%), crude fiber (23%), carbohydrates (20%), and ash content (2.4%). Likewise, cantaloupe seeds are an abundant source of vitamins, phytochemicals, and bioactive compounds and have antioxidant activity (Ali *et al.,* 2022). These seeds have 366 times more vitamin C than wheat flour and also have high antioxidants, vitamin A, and β-carotene (Kulczynski *et al.,* 2019). They are rich sources of potassium, vitamins C, A, and K, and β-carotene. The benefits of these seeds are to lower the cancer risk, hinder the growth of tumor cells in kidneys, and inhibit the spread of tumors by about 20% to 85%. They contain enough essential amino acids like tyrosine, valine, and methionine. The use of these seeds reduces waste and also improves the storage life and food services of the product (Fundo *et al.,* 2018).

MATERIALS AND METHODS

Raw Material

Raw material was purchased from Al-Fatah store Faisalabad and analytical grade chemicals and reagents were used from Merck Germany.

Raw Material Preparation

Chia and cantaloupe seeds were cleaned and milled into fine powder. Chia and cantaloupe seeds were cleaned and milled into fine powder. The powder was sifted through a 150 µm mesh sieve to ensure a uniformly fine texture, allowing only particles smaller than 150 micrometers to pass through. The powder were stored into bags for further analysis.

Product Development

The dough was prepared by mixing chia and cantaloupe seed flour with wheat flour and water. After that, the dough was rounded and shaped before being cooked in a hot pan. Ten preparations were made using RSM software according to Table 1.

Table 1. Preparation of chapatti using various concentrations of chia and cantaloupe seeds.

Treatments	Wheat flour (%)	Chia seed powder (%)	Cantaloupe seed powder (%)
T_0	100	0	0
T_1	90	6	4
T_2	88	4	8
T_3	86	2	12
T_4	82	6	12
T_5	78	10	12
T_6	74	6	20
T_7	84	8	8
T_8	80	4	16
T_9	76	8	16

Proximate analysis of chapatti

Moisture contents (%)

Chapatti moisture contents were determined using the method described (Tongbram et al., 2020). First, retain weight of pre-heated China plates after heating these in hot air oven and take ten grams each of chaptti. Place the China plates in a hot air oven at 105°C for 24 hours. Then, take the sample out of the oven and allow it to cool in a desiccator. After that, the samples had to be weighed, and the moisture contents were calculated using a formula.

https://doi.org/10.55627/agribiol.003.01.0997

$$Moisture\ contents\ (\%) = \frac{Weight\ loss\ of\ sample}{Initial\ weight\ of\ sample} \times 100$$

Crude Fat (%)

Fat contents of chapatti were determined through the Soxhlet apparatus by using the method provided (Tongbram *et al.*, 2020). About 5 g of moisture-free samples are taken at the thimble of the apparatus. Then turn on the mantle and start to heat the solvent at a low boiling point. With the help of a condenser, vapors of solvent condense and fall drop by drop, and fat is extracted from the sample. After a specific level, it went back to the flask after one washing. Took 5 or 6 washing samples for complete removal of fat. After that, the sample was kept in a hot air oven at 105^oC for 1 hour. Fat is determined by using a formula.

$$Crude\ fat\ (\%) = \frac{Initial\ weight\ -\ Final\ weight}{Sample\ weight} \times 100$$

Crude Fiber (%)

The crude fiber of chapatti was determined by using the procedure followed by Tongbram *et al.* (2020). In a 500 ml beaker, 3 g of moisture and fat-free sample (W_1) was taken followed by 200 ml of 1.25% H_2SO_4 added to it and boiled for 30 minutes on a hot plate. By using filter paper, the sample was filtered, and washing was done with distilled water 2-3 times. Again, put the sample in a 500 ml beaker mixed with 1.25% NaOH, and boil for 30 minutes on a hot plate. Then by using filter paper, the sample was filtered, and washing was done with distilled water 2-3 times. Collect the residue in the crucible and place it for 3 hours in a hot air oven at 105^oC followed by weighing the residue in the crucible (W_2). A formula were used to determine crude fiber.

$$Crude\ fiber\ (\%) = \frac{W_2 - W_3}{W_1} \times 100$$

Where;

W_1 = Sample weight (g)

W_2 = Weight of residue before oven drying + crucible

W_3 = Weight of residue after ashing + crucible

Ash contents (%)

Ash contents of the sample were determined by using a muffle furnace (Tongbram *et al.*, 2020). First, the crucibles were weighed, and 5 g of dried sample was placed in crucibles and made smoke-free. The crucibles containing charred samples were kept in the muffle furnace and heated at 550°C for 4-5 hours. Then smoke-free samples were left to cool at room temperature. Ash contents of the sample were determined by using a formula.

$$Ash\ contents\ (\%) = \frac{Weight\ of\ ash\ residues}{Weight\ of\ sample} \times 100$$

Crude Protein (%)

Crude protein was examined by using the Kjeldahl method (Tongbram *et al.*, 2020). Weighed the 0.5 g sample and placed it in a digestive tube. Each digestive tube contained 4 g of mixture. In each tube, 10 ml of H_2SO_4 was added. The tube was placed in the digester and the temperature was increased by about 37^oC. The H_2SO_4 was condensed halfway up the neck, and the solution was clear after 3 hours of heating. Lift the tube racks from the block digester and place them carefully on rack holders. Allow tubes to cool to ambient temperature. At least one blank reagent of 1 ml stock solution is added in each tube for digestion of 10 ml digested samples. In a conical flask, put 4% boric acid. Turn on the equipment by immersing one pipe in distilled water and the other in alkali (40%). Then run the sample on the device for 3 minutes. It took in the needed amount of water and alkali automatically. When the color of ascorbic acid changed from reddish to yellowish, the distillation was stopped for 2-3 minutes until the bubbling stopped and the maximum amount of ammonia was collected. After distillation, the mixture remained in the flask, then titration was done against 0.1 N sulphuric acid. The color changes to pink, and the titration stops. Protein was determined by using a formula.

$$Crude\ protein\ (\%) = \frac{N \times T \times 10ml\ \times 14 \times 100\ \times 6.25}{1000}$$

Where;

N = Normality of HCl, T = Titration volume, Nitrogen equivalent weight (14 g), 10 ml = Volume of the digest used for titration.

6.25: Nitrogen-to-protein conversion factor. This is based on the assumption that proteins on average contain 16% nitrogen (100/16 = 6.25).

Sensory evaluation of chapatti

On the 9-point hedonic scale (from 1 = severely despise to 9 = very like), ten untrained judges (staff and students) from the Food Technology department evaluated the chapatti for color, flavor, texture, taste, and overall acceptability. After testing each sample, panelists washed their lips with water (Miller *et al.,* 2018).

RESULTS

Proximate analysis of chapatti

Moisture Contents

Moisture contents are a critical factor that influences the quality and shelf life of chapatti during storage, impacting its physical, microbial, and sensory properties. The samples were analyzed for crude fat contents, shown in Figure 1. Moisture contents analysis was conducted, and the findings are summarized in Table 2. The values of moisture ratio in T_0 (21.01%), T_1 (28.58%), T_2 (31.61%), T_3 (32.79%), T_4 (28.48%), T_5 (28.53%), T_6 (26.33%), T_7 (25.57%), T_8 (25.56%), and T_9 (24.88%). The results showed that treatment T_3 had the highest moisture contents (32.79%) among all treatments, followed by treatment (T_2) with moisture contents of 31.61%. It has been noted that treatment T_0 contained the lowest moisture contents 21.01%. The investigation showed that an increase in the concentration of chia seed (0 to 10%) led to a decrease in moisture contents 32.61 to 21.01%. Similarly, with the increase of cantaloupe seed concentration (0 to 12%), the moisture contents increased from 21.01 to 32.61%. The combined effect of chia and cantaloupe seeds increased moisture contents by 2.5 times. The incorporation of cantaloupe seeds led to an increase in moisture contents positively.

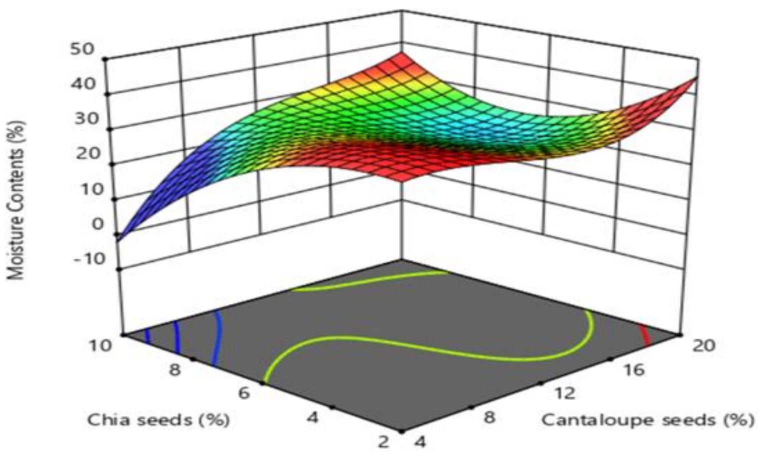

Figure 1. 3D Graphical representation of moisture contents influenced by fortification chia and cantaloupe seeds in chapatti

A quadratic model was applied to predict the moisture obtained through RSM analysis featuring two processing variables i.e. chia and cantaloupe seeds concentrations in chapatti which are expressed below;

$$\text{Moisture Contents} = 28.07 - 8.93\text{A} - 1.63\text{B} + 6.35\text{AB} - 1.15\text{A}^2 + 1.58\text{B}^2$$

This model had a high coefficient of determination (R^2 = 0.944). It indicates that the model can predict the moisture contents as a function of chia and cantaloupe contents. The ANOVA results revealed a low P-value (0.0039) which indicated this model was significant (Table 2).

Table 2. ANOVA for the effect of treatments on moisture contents of chapatti.

Source	Sum of Squares	df	Mean Square	F-value	*p-value*
Model	122.91	8	15.36	15.60	0.0039*
A-Cantaloupe	30.43	1	30.43	30.89	0.0026*
B-Chia seed	8.57	1	8.57	8.70	0.0319*
AB	13.58	1	13.58	13.78	0.0138*

A^2	1.85	1	1.85	1.88	0.2287^{NS}
B^2	5.89	1	5.89	5.98	0.0583^{NS}
Residual	4.93	5	0.9851		
Lack of Fit	4.93	1	4.93		
Pure Error	0.0000	4	0.0000		
Cor Total	127.84	13			
C.V%	3.57				
R^2	0.944				

*Significant
**Highly significant
NSNon-significant

Crude Fat

Crude fat serves as a significant quality factor with favorable sensory attributes, enhancing the softness of chapatti. The samples were analyzed for crude fat contents, and the results are shown in Figure 2. The values of the crude fat ratio in T_0 (2.36%), T_1 (2.81%), T_2 (2.54%), T_3 (2.47%), T_4 (3.06%), T_5 (3.47%), T_6 (5.92%), T_7 (4.19%), T_8 (4.99%), and T_9 (5.71%). Treatment T_6 showed the highest fat contents 5.92% among all treatments, while treatment (T_0) showed minimum fat contents 2.36%. According to the results as the percentage of cantaloupe seeds increased (0 to 20%), there was a corresponding rise in crude fat contents 2.36 to 5.92%. This increase is due to the seeds containing oil. Similarly, an increase in the percentage of chia seeds (0 to 6%) led to an increase in fat contents non-significantly 2.36 to 5.92%. Specifically, cantaloupe seeds exhibited a significant impact on the crude fat percentage.

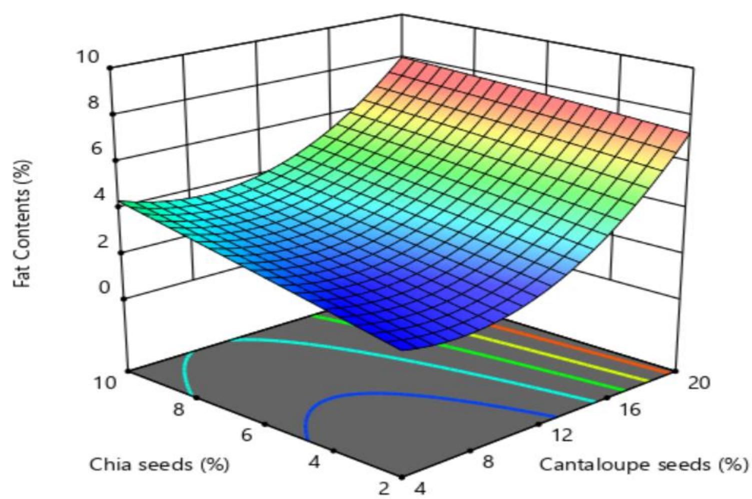

Figure 2: 3D Graphical representation of crude fat contents influenced by fortification chia and cantaloupe seeds in chapatti

It was noted that with the increase in the concentration of chia seeds (0 to 10%) fat contents increased 4 times non-significantly and with the increase of cantaloupe concentration (0 to 20%) fat contents increased 6 times. The combined effect of chia and cantaloupe seeds increased fat contents 7 times. Moreover, a quadratic model for the fat was applied to predict through RSM analysis featuring two processing variables i.e. chia and cantaloupe seeds concentrations in chapatti which are expressed below;

$$\text{Crude Fat} = 2.30305 - 0.226721\text{A} + 0.270307\text{B} - 0.013047\text{AB}$$
$$+0.023072\text{A}^2 + 0.005102\text{B}^2$$

Where A = cantaloupe seeds and B = Chia seeds

The quadratic model had a high coefficient of determination (R^2 = 0.8202). The ANOVA results revealed a low P-value (0.0075) which indicated that the model equation was significant (Table 3). Thus, the statistical evaluation demonstrated that the model equation can be used to predict precisely the maximum values of the crude fat ratio.

Table 3. ANOVA for the effect of treatments on crude fat of chapatti.

Source	Sum of Squares	df	Mean Square	F-value	*p-value*
Model	14.86	5	2.97	7.30	0.0075*
A-Cantaloupe	8.58	1	8.58	21.06	0.0018*
B-Chia seed	1.51	1	1.51	3.70	0.0906^{NS}
AB	0.1328	1	0.1328	0.3261	0.5836^{NS}
A^2	3.70	1	3.70	9.08	0.0167*
B^2	0.0113	1	0.0113	0.0278	0.8718^{NS}
Residual	3.26	8	0.4073		
Lack of Fit	3.26	4	0.8145		
Pure Error	0.0000	4	0.0000		
Cor Total	18.12	13			
C.V%	17.95				
R^2	0.8202				

Crude fiber

Fiber, a non-digestible carbohydrate, is crucial for our health and comprises various components in our body. The samples were analyzed for crude fat contents, and the results are shown in Figure 3. The measured crude fiber contents ranged from 1.71 to 5.89%. The values of the crude fiber ratio in T_0 (1.71%), T_1 (4.36%), T_2 (4.05%), T_3 (3.41%), T_4 (3.06%), T_5 (5.89%), T_6 (4.83%), T_7 (5.31%), T_8 (4.16%), and T_9 (5.41%). Notably, treatment T_5 showed the highest fiber contents (5.89%), surpassing all other treatments. Conversely, treatment (T_0) consisting of 100% wheat flour with no cantaloupe seeds or chia seeds, contained the lowest crude fiber contents 1.71%. As observed, an increase in the concentration of cantaloupe seeds (0 to 12%) resulted in a slight increase in crude fiber contents, ranging from 1.71 to 5.89%. The results demonstrate the significant impact of chia seeds on the crude fiber contents of chapatti. As observed, an increase in the concentration of cantaloupe seeds (0 to 12%) resulted in a slight increase in crude fiber contents, ranging from 1.71 to 5.89%.

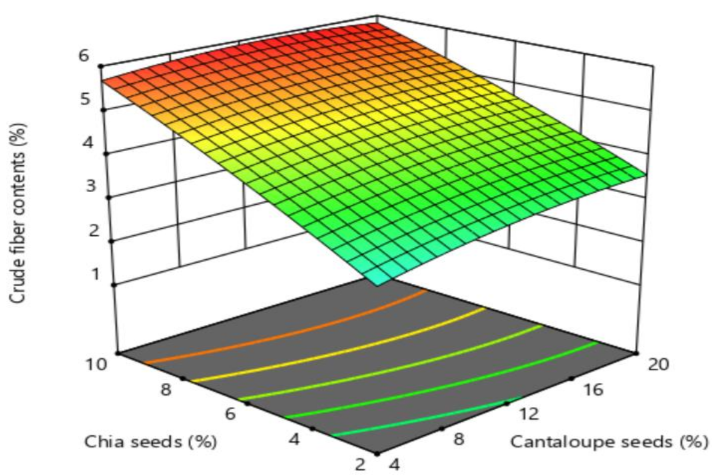

Figure 3. 3D Graphical representation of crude fiber contents influenced by fortification chia and cantaloupe seeds in chapatti

It has been noted that with the increase in chia seeds concentration (0 to 10%) fiber contents increased 5.1 times and with the increase of cantaloupe concentration (0 to 20%) fiber contents increased 3.5 times. Moreover, the combination of chia and cantaloupe seeds contributed to an overall increase in the fiber contents of chapatti up to 6 times. A quadratic model for crude fiber was applied to predict through RSM analysis featuring two processing variables i.e. chia and cantaloupe seeds concentrations in chapatti which are expressed below;

$$\text{Crude Fiber} = 1.72300 + 0.106573A + 0.435230B - 0.003968AB$$
$$-0.002416A^2 - 0.006228B^2$$

Moreover, the quadratic model had a high coefficient of determination ($R^2 = 0.9981$). The ANOVA results revealed a low P-value (<0.0001) which showed that the model equation was significant (Table 4). Thus, the statistical evaluation signified that this model equation can be used to predict precisely the maximum values of the crude fiber ratio.

Table 4. ANOVA for the effect of treatments on crude fiber of chapatti.

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	***p-value***
Model	13.07	5	2.61	828.69	< 0.0001**
A-Cantaloupe	0.1208	1	0.1208	38.30	0.0003*
B-Chia seed	4.82	1	4.82	1527.51	< 0.0001**
AB	0.0123	1	0.0123	3.89	0.0839NS
A^2	0.0406	1	0.0406	12.86	0.0071*
B^2	0.0168	1	0.0168	5.34	0.0496*
Residual	0.0252	8	0.0032		
Lack of Fit	0.0252	4	0.0063		
Pure Error	0.0000	4	0.0000		
Cor Total	13.10	13			
C.V%	1.25				
R2	0.9981				

Ash contents

Ash contents represent the inorganic matter left after the combustion of organic substances. In this study, various concentrations of chia and cantaloupe seeds were incorporated into the preparation of chapatti, and the samples were analyzed to determine their ash contents, as shown in Figure 4. The measured ash contents ranged from 0.50 to 1.03%. The values of the ash ratio in T_0 are (0.50%), T_1 (0.77%), T_2 (0.76%), T_3 (0.75%), T_4 (0.89%), T_5 (1.03%), T_6 (1.01%), T_7 (0.90%), T_8 (0.88%), and T_9 (1.02%). Treatment (T_0) exhibited the minimum ash contents (0.50%), while treatment (T_5) demonstrated the maximum ash contents of 1.03%. The results indicate that an increase in the percentage of chia seeds (0 to 10%) led to a slight increase in ash contents, ranging from 0.50 to 0.89%. Similarly, an increase in the percentage of cantaloupe seeds (0 to 12%) increased ash contents by 0.50 to 0.80%.

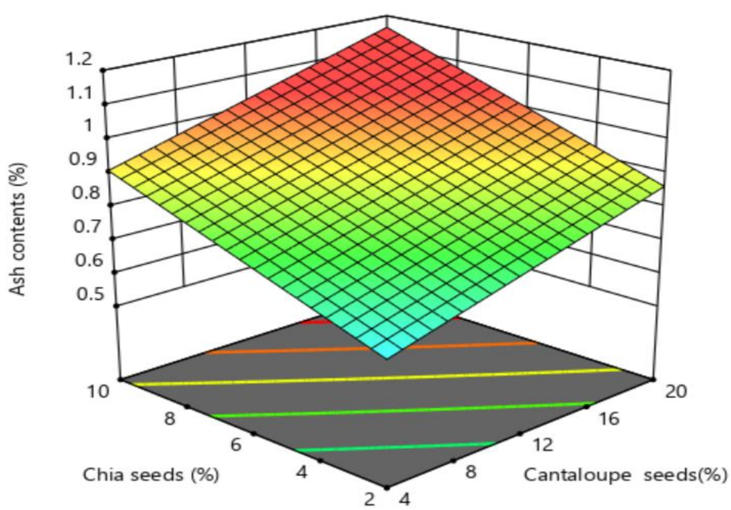

Figure 4. 3D Graphical representation of ash contents influenced by fortification chia and cantaloupe seeds in chapatti

The combination of chia and cantaloupe seeds increased the ash contents of the chapatti. It was determined that the maximum ash contents (1.03 times) were achieved when the concentration of chia seeds reached 10% and cantaloupe seeds were fortified up to 12%. The results obtained from the ANOVA analysis (Table 5) indicated that chia and cantaloupe seeds, either individually or in combination, showed a significant influence on the ash contents of chapatti positively. A quadratic model for the ash was applied to predict through RSM analysis featuring two processing variables i.e. chia and cantaloupe seeds concentrations in chapatti which are expressed below;

$$\text{Ash Contents} = 0.500615 + 0.014410\text{A} + 0.034652\text{B} + 0.000140\text{AB} - 0.00022\text{A}^2 + 0.00026\text{B}^2$$

The quadratic model had a high coefficient of determination (R^2 = 0.989). Thus, the statistical evaluation signified that this model can be used to predict precisely the maximum values of the ash ratio.

Table 5. ANOVA for the effect of treatments on ash contents of chapatti.

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	***p-value***
Model	0.2499	5	0.0500	9783.47	< 0.0001**
A-Cantaloupe	0.0458	1	0.0458	8975.00	< 0.0001**
B-Chia seed	0.0650	1	0.0650	12733.91	< 0.0001**
AB	5.509E-06	1	5.509E-06	1.08	0.0394*
A^2	3.251E-06	1	3.251E-06	0.6365	0.4480NS
B^2	0.0000	1	0.0000	4.34	0.0707NS
Residual	0.0000	8	5.108E-06		
Lack of Fit	0.0000	4	0.0000		
Pure Error	0.0000	4	0.0000		
Cor Total	0.2499	13			
R2	0.989				
C.V%	0.305				

Crude Protein

The crude protein contents are important components to define the nutritional value and quality of food. The samples were analyzed for crude fat contents, and the results are shown in Figure 5. The values of crude protein in T_0 (12.40%), T_1 (12.55%), T_2 (12.64%), T_3 (12.72%), T_4 (12.96%), T_5 (13.20%), T_6 (13.36%), T_7 (12.88%), T_8 (13.04%), and T_9 (13.28%). In T_6 the highest protein contents (13.36%) were observed among all treatments, and (T_0) contained a minimum (12.64%) crude protein. The result indicated that an increase in the concentration of cantaloupe seeds (0 to 20%) caused crude protein to increase gradually up to 12.64-13.36%. Similarly, it was noted that with an increase of chia seed concentration from (0 to 6%) the crude protein increased up to 2.64-13.36%.

It was evaluated that the increase in concentration of chia seeds up to 6% and cantaloupe seeds up to 15% showed maximum protein contents of 13.36%. With the increase in chia seed concentration (0-10%), protein contents increased approximately 1.7 times, and with the increase (0-20%), protein contents increased 1.5 times. The combined effects of chia and cantaloupe seeds increased protein contents 2 times.

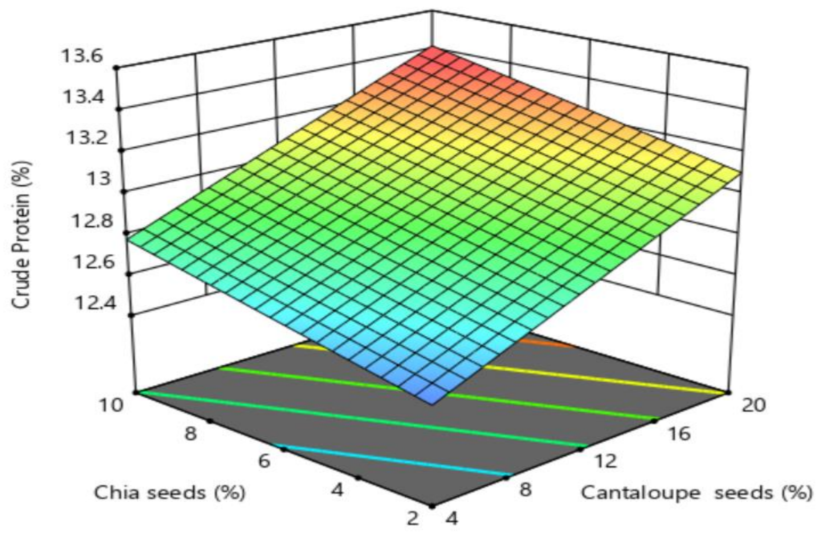

Figure 5. 3D Graphical representation of crude protein contents influenced by fortification chia and cantaloupe seeds in chapatti

A quadratic model for the protein ratio was applied to predict through RSM analysis featuring two processing variables i.e. chia and cantaloupe seeds concentrations in chapatti which are expressed below;

$$\text{Protein Contents} = 12.39 + 0.0125\text{A} - 0.0198\text{B} + 0.00117\text{AB} + 0.0012\text{A}^2 + 0.0054\text{B}^2$$

The quadratic model had a high coefficient of determination (R^2 = 0.8672). The ANOVA results revealed a low P-value (0.0002) which indicated that the model equation was significant (Table 6). Thus, the statistical evaluation indicated that the model equation can be used to predict precisely the maximum values of the protein ratio.

Table 6. ANOVA for the effect of treatments on crude protein of chapatti.

Source	Sum of Squares	df	Mean Square	F-value	*p-value*
Model	0.9341	5	0.1868	10.45	0.0024*
A-Cantaloupe	0.4956	1	0.4956	27.72	0.0008*
B-Chia seed	0.1743	1	0.1743	9.75	0.0142*
AB	0.0010	1	0.0010	0.0544	0.0284*
A^2	0.0117	1	0.0117	0.6530	0.4424NS
B^2	0.0131	1	0.0131	0.7341	0.4165NS
Residual	0.1430	8	0.0179		
Lack of Fit	0.0050	4	0.0012	0.0359	0.9965
Pure Error	0.1381	4	0.0345		
Cor Total	1.08	13			
R2	0.8672				
C.V%	1.04				

Sensory evaluation

With the expansion of the food industry in the twentieth century, the discipline of hedonic response experienced rapid growth. The samples were analyzed for crude fat contents, and the results are shown in Figure 6. This field refers to a set of procedures that are used to precisely quantify human reactions to foods, thereby influencing consumer preferences. According to Food Technologists, it is a scientific approach for generating, analyzing, and measuring product responses as recognized through the senses of sight, hearing, taste, smell, and touch. Sensory evaluation has become an important part of the formation of food products and is now a guideline for setting up, testing, evaluating, and interpreting sensory results.

Color

A combination of senses such as mouthfeel, sight, and hearing are used to experience color. It is the most critical factor of food. It is affected by changing the percentage of chia and cantaloupe-supplemented flour. The mean values of color of chapatti in T_0 (8.3), T_1 (7.3), T_2 (7.4), T_3 (7.7), T_4 (7.5), T_5 (6.3), T_6 (8.8), T_7 (7.8), T_8 (7.1), T_9 (8.6). Chapattis prepared from T_6 showed the highest score (8.8), followed by T_9 (8.6). However, we see that this minimum value of 6.3 was obtained for T_5. A lower value was due to a higher concentration of chia seeds that darkened the chapatti. Neglect of Chapatti color should not be ignored as it has great effect on product rejection and acceptance.

Texture

The texture is to be experienced by means of the senses' combination, including mouth feel, touch, etc. The percentage of chia and cantaloupe supplemented flour change. The mean values of the texture of chapatti in T_0 (8.3), T_1 (6.5), T_2 (6.7), T_3 (8.1), T_4 (7.8), T_5 (8.5), T_6 (8.7), T_7 (6.7), T_8 (7.3), T_9 (8.2). Chapatti prepared from T_6 has observed as the highest score with 8.7 followed by T_5 with 8.5. Results obtained showed that minimum value of T_1 is 6.5. Scores were between 6.5 and 8.7 by the panelist's for the texture of chapattis.

Aroma

A combination of senses such as smell, mouthfeel, and sight are used to experience aroma. The mean values of aroma of chapatti in T_0 (8.2), T_1 (7.3), T_2 (7.8), T_3 (8.2), T_4 (7.5), T_5 (8.6), T_6 (7.4), T_7 (7.7), T_8 (7.2), T_9 (7.7). The results showed that the maximum score (8.6) was found in chapattis made from T_5, followed by treatment T_3 8.2. According to the results, treatment T_8 has a minimum value of 7.2. A good aroma is usually expected by consumers of chapatti. Off-odor is likely to be unaccepted even if the product has good texture and flavor. The aroma of chapatti is important and cannot be ignored, since it influences consumers' decisions to accept or reject the product.

Taste

Taste receptors on the tongue, as well as other areas of the mouth and throat, detect components that have been dissolved in water, saliva, or oil. At different treatments, the score for a taste ranged from 8.8 to 7.1. The mean values of aroma of chapatti in T_0 (8.9), T_1 (8.2), T_2 (8.6), T_3 (7.1), T_4 (7.7), T_5 (8.1), T_6 (8.8), T_7 (8.6), T_8 (7.3), T_9 (8.2). The maximum score (8.8) was present in chapattis prepared from T_6, followed by treatment T_0 (8.6). It has been observed that T_3 has a minimum value of 7.1. Moreover, the highest percentage of chia and cantaloupe seeds 20% did not indicate a good mouthfeel, and an unpleasant taste was observed.

Flavor

The flavor is the combined impressions derived from both taste and aroma. During this evaluation, various aspects of flavor are assessed to determine the overall acceptability and quality of the chapatti. The mean values of the flavor of chapatti in T_0 (8.8), T_1 (8.2), T_2 (7.5), T_3 (8.2), T_4 (7.7), T_5 (8.1), T_6 (7.4), T_7 (7.6), T_8 (8.5), and T_9 (7.8). The maximum score of 8.8 was examined in chapattis made from treatment (T_0), followed by treatment T_8 8. According to the results, treatment T_6 has a minimum value of 7.4.

Overall acceptability

Overall acceptability means to rate the most suitable item in terms of all sensory attributes. Its score is very important to indicate the minimum and maximum validity of treatment. The overall acceptability of the treatments ranged from 7.53 to 8.83. The mean value of the overall acceptability of chapatti in T_0 (8.1), T_1 (8.2), T_2 (7.7), T_3 (8.1), T_4 (8.2), T_5 (8.4), T_6 (8.8), T_7 (7.5), T_8 (8.5), and T_9 (8.1). The maximum score (8.8) was observed in chapattis made from T_6, followed by treatment T_8 8.5. According to the results, treatment T_7 has a minimum value of 7.5. Chapattis prepared from (T_6) had the highest acceptability (8.8) because of their superior texture, color, and taste.

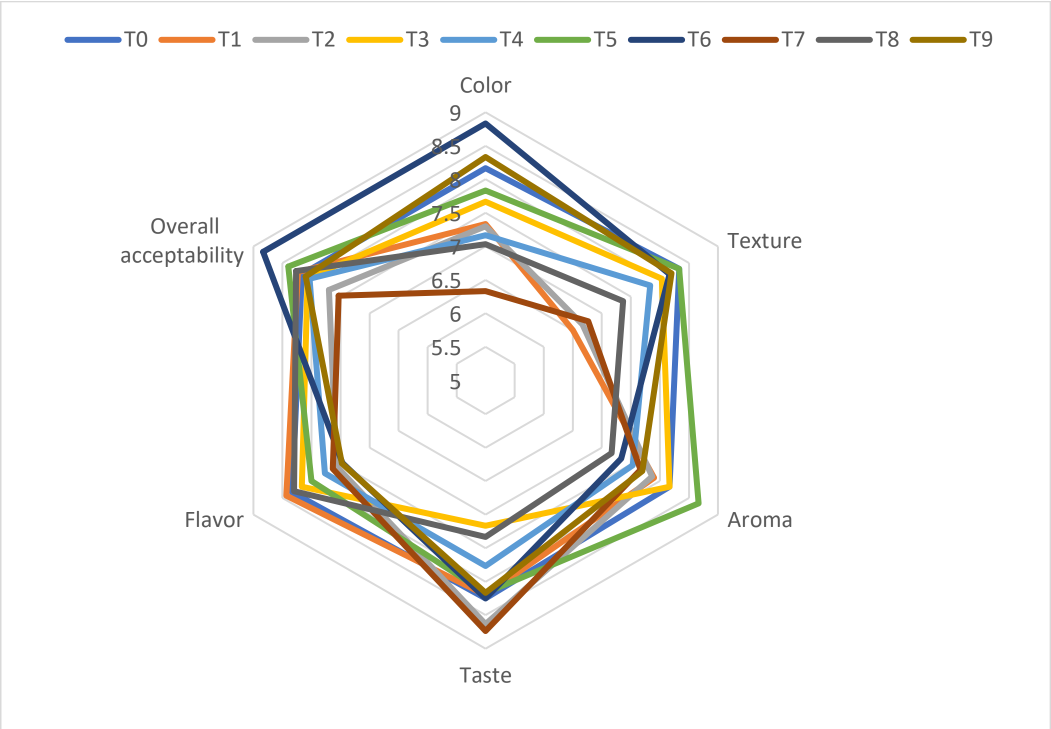

Figure 6. A Graphical representation of sensory evaluation influenced by the fortification of chia and cantaloupe seeds in chapatti

DISCUSSION

Cantaloupe and chia seeds were fortified to enhance the quality and nutritional profile of the chapatti. The results showed that there is a significant increase in moisture, crude fiber, protein, fat, and ash contents. The incorporation of these seeds also effects sensory evaluation of the chapatti (texture, taste, flavor, color). Variation in the moisture contents of chapatti was suspected to be the result of the increase in fiber contents from chia and cantaloupe seeds.

https://doi.org/10.55627/agribiol.003.01.0997

Therefore, the adding of chia seeds only created a negligible and non significant increase in fat contents relative to cantaloupe seeds. According to the literature (Hussain et al., 2019), these conclusions are reported.

Increased in fiber contents come from the development of complexes between polysaccharides and other food ingredients to form complex and indigestible carbohydrates. Hydrogen bonding, cross linking, and gel formation complexes these seeds' polysaccharides with proteins, lipids, and fibers; yielding increased indigestible carbohydrates. The results turn out to be highly correlated with those in the literature (Kumari *et al*., 2020). This rise in ash content can be attributed to the inherently high ash levels in the raw materials used. Both seeds are rich in minerals and get incorporated into the dough and facilitate the bioavailability of minerals. These results are correlated with the previous study (Sharma and Prabhasankar, 2021).

Chia and cantaloupe seeds had higher protein and lipid contents, which may explain the increase in protein. Protein and fat contents of samples increased in tandem with the rise in cantaloupe contents (Tongbram *et al.*, 2020). Chapattis texture was scored between 6.5 and 8.7 on the panelists' scores. However, these findings that bring out the texture of chapattis back to the findings of Netshishivhe (2019), who found out the composite flour score for the texture chapatti. Not only that, it is an indicator of the consumer for food safety, but it is also a food quality indicator (Ajibade and Ijabadeniyi, 2019).

High concentration of chia and cantaloupe seeds was seen to mask the volatile compounds resulting in higher concentration of aroma. By adding this weaker aroma, they reduced the aroma of chapatti (Mamat et al., 2023). The results obtained were closely correlated with the results of previous studies (Aziz et al., 2023). Furthermore, the highest percentage of chia and cantaloupe seeds (20 percent) particularly did not have a good mouthfeel or taste unpleasant (Rekowski et al., 2019). It has been reported similar results were obtained in a chapatti prepared from 16% chickpea and 8% maize flour, for it scored an (8.8) (Kaur *et al.,* 2018). Similar results were reported in a score (8.85) in chapatti prepared from 10% barley flour and 8% oatmeal flour. Even with good flavor or texture, products with dark or off-color are likely to be rejected; on the other hand, food products with high-quality colors have a greater market value (Mamat et al., 2023).

Ejaz (2014) showed similar results for wheat-chickpea composite flour. The highest overall acceptability of chapatti likely results from a harmonious balance of texture and moisture content enhanced nutritional value, and an overall more appealing and satisfying eating experience. Cantaloupe seeds have a fruity flavor and chia seeds have a nutty flavor. These flavors alter the taste and lower the flavor quality of chapatti (Masih et al., 2020). The highest overall acceptability of chapatti likely results from a harmonious balance of texture and moisture content enhanced nutritional value, and an overall more appealing and satisfying eating experience. It has been reported similar results were found (8.85) in chapatti prepared from 18% maize flour and 8% pumpkin seeds (Jayapriya and Parameshwari, 2020).

CONCLUSION

Chapatti is a staple food in developing countries that is consumed just after cooking. The ingredients used for chapatti making are wheat flour and water which are mixed to make dough, followed by sheeting, and then cooking on a hot plate. Chia seeds can help to stabilize blood sugar levels, making them advantageous for individuals with diabetes. Cantaloupe seeds contain vitamins and antioxidants which enhance the immune system and help combat infections. By using the cantaloupe seeds (0-20%) and chia seeds (0-10%) ten treatments were prepared. The results concluded that the proximate composition of fortified chapatti showed that moisture contents increased from 21.01 to 33.79%, fat contents from 2.36 to 5.92%, crude protein from 12.64 to 13.36%, crude fiber from 1.71 to 5.89%, and ash contents from 0.50 to 1.03% positively. Sensory evaluation scores ranged from (8.83 to 6.33), (8.9 to 6.5), (8.667 to 7.167), (8.7 to 6.91), (8.8 to 7.4), and (8.3-7.5) for color, texture, aroma, taste, flavor, and overall acceptability, respectively. This study concludes that incorporating chia and cantaloupe seeds into chapatti significantly enhances its nutritional profile (moisture, fat, protein, fiber, ash content, and antioxidant activity).

ACKNOWLEDGEMENTS

Not applicable.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

There are no known conflicts of interest or personal relationships that could have appeared to influence the results of this study.

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