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# Development and characterization of wheat rusks supplemented with Chia (*Salvia hispanica* L.) flour with respect to physicochemical, rheological and sensory characteristics

Muhammad Asif KHAN[1*], Kashif AMEER[2], Sadaf SHAKOOR[3], Muhammad Rizwan ASHRAF[3], Madiha BUTT[4], Muhammad Shafique KHALID[5], Allah RAKHA[6*], Madiha ROHI[7*], Muhammad NADEEM[5], Anees Ahmed KHALIL[8], Neelam CHAUDHARY[9], Muhammad SAFEER[3], Muhammad RAFEH[10]

**Abstract**

Highly nutritional and functional properties of chia seeds would make it unique than other grains. Considering its known properties chia can be used as an important food ingredient. These are rich in fiber, ash, protein, polyunsaturated fatty acids (PUFA) and antioxidants. Higher proportion of protein having greater biological value with essential amino acids and high dietary fiber content prevents several metabolic disorders and obesity. It is also consist of PUFA helpful in lowering cardiovascular diseases. Rusks were supplemented with chia flour at a rate ranging 5 to 20% with the goal to modify the fiber content, nutritional contents and physicochemical properties. The obtained results were highly significant and showed increasing trend in dietary fiber and PUFA values. Texture values decreased significantly. Sensory evaluation showed significant ($p<0.05$) differences in color, flavor, texture and overall acceptability. Most acceptable treatment was with 5% chia flour supplementation with a mean score of 8.10. Hence, Chia flour-supplemented rusks up to 5% addition level could be utilized as a convenience food and vehicle of improved nutritional status with health beneficial bioactive compounds. Moreover, supplementation of chia flour led to improvement of functional properties of wheat rusks as a valuable source of dietary fiber and bioactive compounds.

**Keywords:** wheat; physicochemical; rheology; sensory; chia flour.

**Practical Application:** Chia-flour supplemented wheat products including rusks can be used as a valuable source of essential nutrients for various consumer groups.

## 1 Introduction

The concept of functional foods has been trending nowadays. Researchers and common people are also taking keen interest in foods of the plant origin. Chia as a novel food ingredient gained very much high popularity among researchers because of considerable functional properties. Chia (*Salvia hispanica* L.) is a member of the mint family (belonging to family *Lamoaceae,* which produce flowering annually) and has uniqueness due to its nutritional and therapeutic profile (Kulczyński et al., 2019). Word "chia" comes from the Nahuati word "chian" or chien meaning "oily". It was among the elementary foods of several Central American civilizations and was less vital than corn and beans and more imperative than amaranth. Chia seeds were used in Mexico, Argentina and other South-Western States of America. Since 2009, whole seed and flour are used as an important food stuff in variety of products in the European communities (Turck et al., 2019).

Proximate composition of chia is highly valuable. Chia seeds approximately yields 25-40% of oil upon extraction and of total composition of Chia oil, linolenic and linoleic acid may be present up to 60% and 20%, respectively (Ali et al., 2012) with ratio of about 1:3 (Baker et al., 2016). Chia reported to have a high protein, ash, dietary fiber and fat contents ranged 15-25%, 4-5%, 18-30%, 30-33%, respectively. Chia contains 26-41% carbohydrates and antioxidants (Ixtaina et al., 2008). Moreover, higher proportion of protein of Chia exhibits greater biological value with essential amino acids (Vázquez-Ovando et al., 2010). Cereals lack essential amino acids, such as lysine and Chia can

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[1] *Department of Food Science and Technology, Islamia University of Bahawalpur, Bahawalpur, Pakistan*
[2] *Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan*
[3] *University of Agriculture Faisalabad, Subcampus Burewala, Burewala, Pakistan*
[4] *College of Agriculture Bahauddin Zakariya, University Bahadur, Subcampus Layyah, Pakistan*
[5] *Department of Environmental Sciences, COMSATS University Islamabad, Vehari Campus, Pakistan*
[6] *National Institute of Food Science and Technology, University of Agriculture Faisalabad, Faisalabad, Pakistan*
[7] *Department of Food Science and Technology, Government College Women University, Faisalabad, Pakistan*
[8] *University Institute of Diet and Nutritional Sciences, Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan*
[9] *Department of Continuing Education, University of Agriculture, Faisalabad, Pakistan*
[10] *Department of Forestry, Range and Wildlife Management, Islamia University of Bahawalpur, Bahawalpur, Pakistan*
*Corresponding authors: arrehman_ft@uaf.edu.pk; asifkhan.muhammad@gmail.com; madiharohi2009@yahoo.com

be used and added as counterpart of cereal protein in many cereal products. Chia being a plant source has a huge potential to be used as an important stuff in several food items (Iglesias-Puig & Haros, 2013).

In the era of modernization, a thrill by consumer towards healthy life style regarding nutritional aspects would challenge the researchers for nutritious and healthier products to meet the consumers demand. Dietary fiber is an important constituent in our diet but due to several processing reasons, it would not be a part of recipes in products. Most of the people eat processed foods that contain no or minute quantities of dietary fiber and recently consumers' awareness about dietary fiber benefits has escalated (Raju et al., 2014; Ayerza & Coates, 2004). The main stuff used for bakery products production is white flour, which is refined and bran has been removed by milling which impart a lot of benefits to host. Although the products made from all-purpose flour confer good taste and physical properties but harmful to human beings owing to being deficient in essential components (Sahoo & Divakar, 2018). So, it has become the dire need of the current situation for replacement or supplementation of wheat flour with health beneficial components of plant-origin to make composite for development of healthy and nutritious products. By knowing that chia seed contains excellent amount of fiber and contains several other nutritional and bioactive compounds, this study was aimed at supplementation of wheat rusks with chia flour and evaluation of the nutritional and physicochemical properties of supplemented rusks as well as total phenolic content and radical scavenging activities.

## 2 Materials and methods

### *2.1 Formulating the composite flour*

Different composite flour formulations were formulated using the various levels of chia seed flour and wheat flour. Four treatments were made as $T_0$ (100% wheat flour), $T_1$ (95% wheat flour and 5% chia flour), $T_2$ (90% wheat flour and 10% chia flour), $T_3$ (85% wheat flour and 15% chia flour), $T_4$ (80% wheat flour and 20% chia flour).

### *2.2 Proximate analysis of composite flour*

The compositional analysis of flour blends along with the control sample were performed for proximate estimation of composition. These analyses include moisture, protein, fat, ash, NFE and fiber following the guidelines mentioned in American Association of Cereal Chemists (2000).

*Moisture analysis*

Wheat and chia flour blends were analyzed for moisture content by using hot air oven according to AACC Method No. 44-15A (American Association of Cereal Chemists, 2000). 5 g of sample from each treatment was weighed. Empty china dish along with sample were weighed and placed at 105˚C in an air forced draft oven till the constant weight. Moisture contents were calculated using the formula (Equation 1):

$$\text{Moisture content }(\%) = \frac{\text{initial weight of sample}(g) \text{- weight of dried sample}(g)}{\text{initial weight of sample}} \times 100 \quad (1)$$

*Ash analysis*

The ash of the blends was determined by incinerating the samples in muffle furnace according to the guidelines mentioned in AACC Method No. 08-01 (American Association of Cereal Chemists, 2000). Heated the weighed sample in a crucible on flame until it is smokeless, then crucible was placed at 550˚C in a muffle furnace till greyish white ash is obtained. After that sample containing crucible was cooled by placing in desiccator. Finally, ash content calculated as (Equation 2):

$$\text{Ash }(\%) = \frac{\text{weight of sample after ashing}}{\text{weight of fresh sample}} \times 100 \quad (2)$$

*Crude fat analysis*

Determination of crude fat in flour blends and control was done using Soxhlet apparatus according to the guidelines mentioned in AACC Method No. 30-25 (American Association of Cereal Chemists, 2000). 3g moisture free sample from each treatment was taken in thimble of Soxhlet apparatus. Solvent used was n-hexane at the condensation rate of 2-3 drops/s for 16 h to extract the fat content by giving 3-4 washings and then boiling the contents of the flask containing fat to remove hexane and get the fat (Equation 3).

$$\text{Crude fat }(\%) = \frac{\text{wt.of fresh sample-wt. of defatted sample}}{\text{wt. of fresh sample}} \times 100 \quad (3)$$

*Crude fiber analysis*

Samples after the extraction of fat was subjected to crude fiber analysis by using Fiber tech following the guidelines of AACC Method No. 32-10 (American Association of Cereal Chemists, 2000). Crude fiber content estimated by digesting defatted sample. In a beaker 2 g of fat free sample taken and 200 mL 1.25% sulphuric acid was added to it up to the mark and boiled for 30 min. After that of filtering the beaker contents to make the sample acid free 2-3 washings were done with hot water. The sample residues were transferred into beaker and now the addition of 200 mL of 1.25% NaOH solution was done and the whole procedure was repeated again. Now the residues were carefully transferred to china dish and placed in oven for drying for 3-4 h at 100 ˚C until the constant sample weight. After that sample charring was done. Then placed the sample at 550˚C in a muffle furnace till greyish residue left. The fiber was calculated as (Equation 4):

$$\text{Crude fiber \%} = \frac{\text{weight loss on ignition}(g)}{\text{Initial weight of sample}(g)} \times 100 \quad (4)$$

*Crude protein analysis*

Nitrogen content of the wheat and chia flour blends and control were measured by Kjeldhal apparatus by AACC Method No. 46-10 (American Association of Cereal Chemists, 2000). 2 g of moisture free sample, 5 g of digestion mixture ($K_2SO_4$, $CuSO_4$ and $FeSO_4$) and 30 mL of conc. $H_2SO_4$ was taken in Kjeldhal's flask. The whole mixture was heated at 60 °C until the greenish mixture obtained. This content was diluted with 250 mL distilled water after attaining temperature equilibrium. In distillation assembly, 10 mL of dilution, 10 mL of 40% NaOH was distilled against 4% solution of boric acid containing methyl red indicator. Color changed from pink to golden yellow when ammonia was collected in boric acid solution. Volume of sulphuric acid was then measured by titration of mixture against 0.1N sulphuric acid after distillation. Using the formula crude protein was estimated (Equation 5 and 6).

$$\text{Nitrogen}\ (\%) = \frac{0.0014 \times \text{volume of sulphuric acid used} \times \text{volume of digested samples}}{\text{wt.of sample} \times \text{volume of sample taken for distillation}} \times 100 \quad (5)$$

$$\text{Protein} = \%\ \text{Nitrogen} \times 6.25 \quad (6)$$

*Nitrogen Free Extract (NFE)*

The NFE was calculated as (Equation 7):

$$\text{NFE}\ (\%) = 100 - (\%\ \text{fat} + \%\ \text{crude fiber} + \%\ \text{protein} + \%\ \text{ash} + \%\ \text{moisture}) \quad (7)$$

### *2.3 Rusk dough preparation*

Composite flour containing chia flour and control sample were used to make dough with all other ingredients. The amount of chia flour and wheat flour varies according to the treatment plan for each treatment, dough was made with the following recipe;

### *2.4 Rheological analysis*

Dough containing wheat flour and chia flour was assayed to study the rheological properties. Farinograph and Mixograph studies were performed for dough rheology determination according to the procedures mentioned in AACC Method No. 54-21 and 54-40 A, respectively (American Association of Cereal Chemists, 2000).

*Farinograph analysis*

The dough rheology of blends and treatment was determined by Barbender Farinograph by method described in AACC Method No. 54-21 (American Association of Cereal Chemists, 2000). 50 g sample was taken in bowl of instrument, dry mixing for 1 min was continued, and then addition of water was done till the graph touched 500 BU line. The instrument running time was 20 min at 30 °C, properties of dough like water absorption, mixing tolerance index, dough development and dough stability time were recorded.

*Mixograph analysis*

Rheological behavior of dough with control was evaluated through Mixograph according to AACC Method (American Association of Cereal Chemists, 2000). Peak time and mixing tolerance were determined.

### *2.5 Rusk preparation*

Rusk was prepared by considering the formulations described in Table 1, by the standard AACC Method (American Association of Cereal Chemists, 2000). By using a mixer ingredients mixing was done for dough preparation. Then dough was molded, panned and proofing was done at 30 °C and 85% RH for 45 min for optimum dough development. Then baked for 15-20 min at 225 °C. After that the cooling of the bread was done, again proofed sliced and final baking (150 °C/15 min) was done to obtain the crispy rusk.

**Table 1**. Recipe with ingredients for formulation of rusk dough preparation.

| Ingredients | Quantity |
|---|---|
| Flour | 300 g |
| Sugar | 18 g |
| Oil | 18 mL |
| Salt | 4.5 g |
| Yeast | 6 g |
| Water | 170-180 mL |

### *2.6 Dietary fiber analysis*

The total, soluble and insoluble dietary fiber content of the rusk supplemented with chia flour was determined.

*Insoluble dietary fiber*

Insoluble dietary fiber contents were determined according to AACC Method No. 32-07 (American Association of Cereal Chemists, 2000). IDF was analyzed by gelatinizing duplicate sample with heat stable α- amylase, for removal of protein and starch contents protease and amyloglucosidase were used for sample digestion. Filter enzyme mixture into the filtration flask. Preheated (at 70 °C) 10 mL of distilled water was used for residues washing and twice with 10 mL of 95% EtOH and acetone. Samples were then dried and weighed. One of the duplicate sample was used to analyze the protein contents while others used for determination ash contents.

*Soluble dietary fiber*

Dietary fiber contents were analyzed according to AACC Method No. 32-07 (American Association of Cereal Chemists, 2000). SDF was analyzed by gelatinizing duplicate samples with stable heat α- amylase. After that protease and amyloglucosidase were used to digest the samples for removal of starch and protein contents through crucible filter enzyme mixture into filtration flask. Preheated (at 70 °C) 10 mL of distilled water was used for residues washing, filter and water washing was saved for SDF determination. In a beaker weigh combine solution of filtrate and water washings. After this 320 mL of preheated 95% EtOH was added and allowed it to precipitate for 60 min at room temperature. After that filtrated residues were washed with 120 mL portion of EtOH (78% and 95%) and acetone then dried them and weighed. One of the duplicate sample was used to analyse the protein contents while others used for determination ash contents.

*Total dietary fiber*

TDF was also analyzed using the method of AACC Method No, 32-07 (American Association of Cereal Chemists, 2000).

TDF was analyzed by gelatinizing duplicate sample with heat stable α- amylase, for removal of protein and starch contents protease and amyloglucosidase were used for sample digestion. To precipitate soluble fiber, 4 volumes of preheated (60 °C) 95% ethanol were added. Residues were filtered, washed by using ethanol (95 and 78%) and acetone then dried as well as weighed. One of the duplicate sample was used to analyse the protein contents while others used for determination ash contents. Sample was also run with blank through entire procedure. It was calculated as Equation 8:

$$Dietary\ fiber\ (\%) = \frac{R1 + R2\ /2 - P - A - B}{m1 + m2\ /2} \times 100 \tag{8}$$

Whereas,

R1 = residue weight from m1, R2 = Residue weight 2 from m2, m1 = sample weight 1, m2 = sample weight 2, A = ash weight from R1, P = protein weight from R2, B = blank

BR1+ BR2/2-BP-BA

Whereas,

BR = blank residue, BP = blank protein from BR, BA = blank ash from BR2

### *2.7 Fatty acid profile*

FA profile was determined following the guidelines described by the method of Association of Official Analytical Chemists (2005). First, lipid extraction was done and through methylation transformed into methyl esters. After that FA profile of prepared samples investigated by using gas chromatograph (GC) with a FID detector. Column temperature for 4 min was kept 100 °C and increased at 3 °C/min to 240 °C. 225 °C and 285 °C was injector's and detector's temperature respectively. An SP2560 100 m × 0.25 mm capillary column and Helium as carrier gas were used. Results were noted in g of FA's/100 g of lipids.

### *2.8 Physicochemical evaluation of rusk*

The prepared rusk samples were analyzed for their organoleptic properties to determine different qualitative and quantitative parameters of the rusk like color and texture.

### *2.9 TPC and antioxidant activities determination*

All samples including control and chia-flour supplemented rusks were analyzed for their total phenolic content (TPC) and antioxidant activities. All control and supplemented rusks samples were subjected to TPC analysis through Folin-Ciocalteau reagent method as per the reported method of Ameer et al. (2017). Spectrophotometer (UV-1800, Shimadzu Inst. Co., Ltd, Kyoto, Japan) was employed and all measurement were recorded spectrophotometrically at 765 nm detection wavelength and results were reported in terms of mg gallic acid equivalent (mg GAE/100 g on dry weight (DW) basis.

All samples including control and chia-flour supplemented rusks were analyzed for their radical scavenging activities and 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) antioxidant assays were used according to reported method of Jiang et al. (2021). In case of both DPPH and ABTS-RSA's, the spectrophotometric absorbance values were recorded using spectrophotometer at 515 and 734, respectively. Furthermore, the results obtained from both DPPH and ABTS assays were documented in terms of micromole Trolox equivalents (µmol TE/g DW).

### *2.10 Sensory evaluation*

Rusk supplemented with chia flour was analyzed for its sensory parameters. Sensory evaluation was carried on a 9-Points Hedonic Scale (Meilgaard et al., 2007).

### *2.11 Statistical analysis*

All measurements were recorded in triplicate manner (n = 3). The obtained data from experiments was subjected to statistical analysis to find out the level of significance (analysis of variance) in a complete randomized design. Means were further compared through Tukey-HSD for significance differences at $p < 0.05$.

## 3 Results and discussion

### *3.1 Proximate analysis of the composite flour*

Table 2 represents the calculated proximate values of the composite flour. Statistical analysis showed a highly significant results among the treatments. It was observed that moisture contents and NFE showed decrease in numerical values and rest of the statistical values of crude fat, crude protein, crude fiber and ash showed increasing trend by the increase in supplemented flour. Increasing values is a confirmation of their high nutritional profile. Statistical analysis in Table 2 described that the observed moisture contents were significant among the treatments. Table 2 highlighted the various observed moisture contents values and showed decrease in numerical values by the increase in supplemented flour. 12.73% was the highest value for moisture content by $T_0$ among treatments containing no supplementation flour. Moisture value of 11.93% was recorded as the lowest value among treatments by $T_4$ having highest supplemented flour percentage of 20%.The fat contents increased significantly between the treatments as the chia seeds powder has a high fat content in its composition. Mean values for the crude fat contents are shown in Table 2, which depicted that the crude fat values among the treatments varies between 1.77% to 4.41%. Highest value was observed in $T_4$ (4.42%) which contains 80% wheat flour and 20% chia seeds flour.

### *3.2 Rheological analysis*

The study of flow and deformities in the substances is known as rheology. The rheology study provide various characteristics of dough which further helps in suitable materials selection and their proportions into a number of substances.

*Frinographhic parameters*

Water absorption is the amount of water absorbed under specific interval of time.The increasing water absorption trend in treatments can be explained by increasing proportion of dietary fiber that contains larger number of hydroxyl groups that results into the formation of stronger bonds with water contents. ANOVA for the water absorption data revealed that the water absorption values of the composite flour are highly significant among treatments, as shown in Table 3. Mean values of water absorption are shown in Table 3 that predicts an increasing trend in the water absorption ranging from 59% to 71%. Maximum water absorption (71%) was observed in $T_4$ that contains 80% wheat flour with 20% chia seed powder. Minimum absorption was noticed in $T_0$ (59%) in which no chia seed powder was added. The increasing water absorption trend in treatments can be explained by increasing proportion of dietary fiber that contains larger number of hydroxyl groups that results into the formation of stronger bonds with water contents (Rosell et al., 2001). Chia seeds flour is the pure source of dietary fiber so this increasing water trend is predictable. Mean values are given in Table 3 that predicts an increasing trend in the treatments values with a range of 1.88 min to 3.55 min. The maximum values were obtained in $T_4$ (3.55 min) which contains 80% wheat flour and 20% chia seeds powder. Lowest value was observed in $T_0$ (1.88 min) in which no chia seeds powder was added. Dough development time is the time that shows a final point of the dough formation. The increase in dough development time with increase in chia powder may be due to decease in dough resistance because of more dilution values of gluten proteins resulted from dietary fiber addition. Fiber have ability to absorb more water thus prolonging dough development time. Dough stability is the time at which dough exhibit maximum stability. Mean values (Table 3) shows an increasing trend in the values between the treatments with increasing chia powder contents and it ranges from 1.89 min to 3.94 min. Highest value was obtained in $T_4$ (3.94 min) whereas lowest value was observed in $T_0$ (1.89) which contains no added chia seeds flour. The increasing trend can be explained by the increasing addition of powder because of its higher dilution values for dough gluten proteins. Mean values in Table 3 shows a difference range from 44 .00BU to 78.00BU. $T_4$ (76.00BU) contained maximum value of MTI and $T_0$ (44.00BU) contained minimum value for MTI as there was no chia seeds powder added in it.MTI is the value from top point of curve to the top point of the curve after five min. This increasing trend indicates more stability to weakening of dough during mixing which might be due to added fiber that interacts with gluten proteins. Rosell et al. (2001) and Eshak (2016) reported the similar findings while working on bread by supplementing various fiber sources. Švec et al. (2016) observed the similar trends of increase while making flour blends of chia.

*Mixographic parameters*

Mixograph studies are related with chewiness and vigorous properties. Mixograph analysis are simple and quite reliable. It is an indicator of dough properties like optimum dough development time, tolerance to over or under mixing. Peak time is the time (min) required to attain the peak value. The data introduced to the analysis of variance indicated a highly significant difference in the peak time value among the various treatments supplemented with chia seeds powderMixing tolerance is the measure of the ability of the dough to resist breakdown during mixing and thus it is recorded in the form of a curve. It describes stability to over mixing and is shown in the form of a number derived by

**Table 2**. Proximate analysis of the composite flour.

| Parameters (%) | Treatment | | | | |
|---|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
| Moisture | 12.73 ± 0.02$^{A}$ | 12.57 ± 0.02$^{B}$ | 12.57 ± 0.02$^{B}$ | 12.20 ± 0.04$^{D}$ | 11.93 ± 0.02$^{E}$ |
| Crude fat | 1.77 ± 0.03$^{E}$ | 2.82 ± 0.02$^{D}$ | 3.44 ± 0.05$^{C}$ | 3.92 ± 0.03$^{B}$ | 4.41 ± 0.01$^{A}$ |
| Crude protein | 12.32 ± 0.04$^{E}$ | 13.44 ± 0.05$^{D}$ | 14.20 ± 0.05$^{C}$ | 15.25 ± 0.02$^{B}$ | 15.97 ± 0.02$^{A}$ |
| Crude fiber | 0.82 ± 0.02$^{E}$ | 2.14 ± 0.03$^{D}$ | 3.09 ± 0.01$^{C}$ | 3.94 ± 0.04$^{B}$ | 4.85 ± 0.04$^{A}$ |
| Ash | 0.53 ± 0.02$^{E}$ | 0.66 ± 0.03$^{D}$ | 0.84 ± 0.04$^{C}$ | 0.95 ± 0.04$^{B}$ | 1.15 ± 0.03$^{A}$ |
| NFE | 71.94 ± 0.03$^{A}$ | 69.10 ± 0.02$^{B}$ | 67.65 ± 0.05$^{C}$ | 64.42 ± 0.03$^{D}$ | 62.31 ± 0.02$^{E}$ |

$T_0$, $T_1$, $T_2$, $T_3$ and $T_4$ are the composite flour samples with 0%, 5%, 10%, 15%and 20% chia seed flour respectively; values are expressed as mean ± SD; means with different letter superscript are significantly different ($p < 0.05$).$T_0$: 100% wheat flour, $T_1$: 95% wheat flour and 5% chia flour, $T_2$: 90% wheat flour and 10% chia flour, $T_3$: 85% wheat flour and 15% chia flour, $T_4$: 80% wheat flour and 20% chia flour.

**Table 3**. Rheological analysis of the composite flour with farinographic and mixographic parameters.

| Parameters $T_0$ | | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| **Farinograph** | WA | 59 ± 0.48$^{C}$ | 62 ± 1.00$^{BC}$ | 65 ± 0.03$^{ABC}$ | 68 ± 0.06$^{AB}$ | 71 ± 0.03$^{A}$ |
| | DDT | 1.88 ± 0.02$^{E}$ | 2.30 ± 0.04$^{D}$ | 2.73 ± 0.03$^{C}$ | 3.00 ± 0.04$^{B}$ | 3.53 ± 0.05$^{A}$ |
| | DST | 1.89 ± 0.03$^{E}$ | 2.49 ± 0.04$^{D}$ | 3.00 ± 0.02$^{C}$ | 3.60 ± 0.03$^{B}$ | 3.94 ± 0.03$^{A}$ |
| | MTI | 44 ± 2.00$^{D}$ | 54 ± 2.64$^{CD}$ | 61 ± 2.09$^{BC}$ | 66 ± 2.00$^{B}$ | 76 ± 2.00$^{A}$ |
| **Mixograph** | Peak time | 1.95 ± 0.02$^{E}$ | 2.08 ± 0.02$^{D}$ | 2.55 ± 0.02$^{C}$ | 2.75 ± 0.05$^{B}$ | 3.00 ± 0.10$^{A}$ |
| | MTI | 1.57 ± 0.012$^{E}$ | 1.75 ± 0.05$^{D}$ | 2.13 ± 0.03$^{C}$ | 2.33 ± 0.03$^{B}$ | 2.67 ± 0.02$^{A}$ |

$T_0$, $T_1$, $T_2$, $T_3$ and $T_4$ are the composite flour samples with 0%, 5%, 10%, 15%and 20% chia seed flour respectively; values are expressed as mean ± SD; means with different letter superscript are significantly different ($p < 0.05$).WA: water absorption, DDT: dough development time, DST: dough stability, MTI: mixing tolerance. $T_0$: 100% wheat flour, $T_1$: 95% wheat flour and 5% chia flour, $T_2$: 90% wheat flour and 10% chia flour, $T_3$: 85% wheat flour and 15% chia flour, $T_4$: 80% wheat flour and 20% chia flour.

comparing with a control. Mean values are given in Table 3 which shows a range from 1.95 min to 3.00 min. Means of peak values showed that $T_4$ contained highest value (3.00 min) and lowest value (1.95 min) was observed in $T_0$ which had no substituted chia seed powder. The values of this study fall under the results of Rosell et al. (2001) and who added dietary fiber in flour in the form of hydrocolloids and apple pomace respectively. They all noted the similar trend in their findings.

### *3.3 Dietary fibre content of supplemented rusk*

Dietary fibres are analogous carbohydrates that are unable to metabolize in body and they excrete out from the body as such by increasing the faecal bulk. Dietary fiber consists of insoluble and soluble form. The data subjected to ANOVA revealed that the dietary fiber values varied, which shows increasing trend and highly significant among the treatments, as it is shown in Table 4. The maximum value of insoluble dietary fiber obtained is in $T_4$ (6.92%) as it contained 80% wheat flour and 20% chia seed powder and minimum value observed is in $T_0$ (0.76%) as it contains no added chia powder. The maximum value of soluble dietary fiber observed is in $T_4$ (1.84%) as it contained 80% wheat flour and 20% chia flour and minimum value observed is in $T_0$ (0.21%) as it contain 100% wheat flour. The maximum value for total dietary fiber obtained is in $T_4$ (8.44%) and minimum value observed is in $T_0$ (1.18%) as it consist of 100% wheat flour.

Chia seeds powder is fiber rich source. The values obtained in this study showed that addition of chia seeds in rusk increases the dietary fiber content of rusk, with the increasing percentage of chia seed addition in rusk the dietary fiber content of the rusk also increased. The findings of this study are in line to the observations of Sodchit et al. (2013) result. Romankiewicz et al. (2017) also observed the similar increasing values of dietary fiber content of the wheat based other bakery product prepared with added chia seeds powder.Dietary fiber (DF) refers to soluble (SDF) (pectin, gums and mucilage) and insoluble (IDF) (lignin, cellulose and hemicelluloses) type, which resists digestion in humans as human beings lack the enzyme to digest it. DF has important role in the product optimization by addition or removal from product according to its chemical composition and properties and need of the food processing operation. SDF improve food texture by solubilizing the water and form gel or as thickening agent. IDF causes firmness of food product and have tendency for fat absorption. Fiber gives feeling of satiety by adding bulk, necessary for cleansing of digestive system and responsible for smooth bowel movement. The seeds of chia plant contain high amount of dietary fiber, upon water absorption it forms gel this helps to retain high amount of water in the final product and keep the product fresh for longer time. Fibrous portion from chia contains higher amount of IDF and SDF comprises mainly mucilage, which absorbs approximately 27 times more water than its own weight (Muñoz & García-Manrique, 2015).

### ***3.4 Fatty acid profile***

Lipids play important role in human beings along providing energy gives several health benefits especially the unsaturated fat. The more consumption of unsaturated fat and less utilization of saturated fat is body need. Polyunsaturated fatty acids covers various health aspects as *n-3* and *n-6* cannot be synthesized by human body and should be taken up through diet for normal body functioning. So, due to the paramount of such fatty acids they were assessed in the rusk and statistical analysis represent highly significant increasing trend as maximum value for Omega-3 fatty acid obtained was in $T_4$ (3.84%) and minimum value observed was in $T_0$ (0.2%) as it consist of 100% wheat flour. Similarly, the maximum value for omega-6 fatty acid obtained was in $T_4$ (2.07%) and minimum value observed in $T_0$ (0.74%) as it consist of 100% wheat flour. The observed study values are in accordance to the study of Coelho & Salas-Mellado (2015) who noted a highly significant and varied PUFA's result among the treatments in product. Venturini et al. (2019) also observed an increasing trend in PUFA's on using chia oil in formulations. Chia is rich in PUFA (good fats have health promoting activity) especially omega-3 and omega-6. PUFA's are essential in lowering the heart diseases. Omega-3 lower the triglyceride which causes arteries blockage, improve blood lipid profile and heart functions, reduce blood pressure and lower the risk of cancer occurrence and type-2 diabetes (Grancieri et al., 2019).

**Table 4**. Dietary fiber, fatty acid profile, color properties of chia supplemented rusks.

| Parameters (%) | | Treatments | | | | |
|---|---|---|---|---|---|---|
| | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
| **Dietary fibre** | ISDF | $0.76 \pm 0.03^{E}$ | $2.91 \pm 0.03^{D}$ | $4.16 \pm 0.02^{C}$ | $5.71 \pm 0.02^{B}$ | $6.92 \pm 0.03^{A}$ |
| | SDF | $0.21 \pm 0.02^{E}$ | $0.89 \pm 0.03^{D}$ | $1.14 \pm 0.04^{C}$ | $1.61 \pm 0.02^{B}$ | $1.84 \pm 0.03^{A}$ |
| | TDF | $1.18 \pm 0.02^{E}$ | $3.57 \pm 0.04^{D}$ | $5.47 \pm 0.02^{C}$ | $7.12 \pm 0.03^{B}$ | $8.43 \pm 0.02^{A}$ |
| **Fatty acid profile** | Omega-3 fatty acid | $0.20 \pm 0.10^{E}$ | $1.54 \pm 0.045^{D}$ | $1.96 \pm 0.025^{C}$ | $2.91 \pm 0.02^{B}$ | $3.81 \pm 0.03^{A}$ |
| | Omega-6 fatty acid | $0.74 \pm 0.02^{E}$ | $1.23 \pm 0.035^{D}$ | $1.39 \pm 0.03^{C}$ | $1.84 \pm 0.03^{B}$ | $2.07 \pm 0.025^{A}$ |
| | Palmitic acid | $0.57 \pm 0.02^{A}$ | $0.53 \pm 0.02^{A}$ | $0.47 \pm 0.01^{B}$ | $0.39 \pm 0.01^{C}$ | $0.34 \pm 0.02^{D}$ |
| | Stearic acid | $0.31 \pm 0.02^{A}$ | $1.26 \pm 0.02^{B}$ | $1.769 \pm 0.01^{C}$ | $0.13 \pm 0.01^{CD}$ | $0.10 \pm 0.01^{D}$ |
| **Texture & Color properties** | Hardness | $5.60 \pm 0.02^{A}$ | $5.40 \pm 0.03^{B}$ | $5.10 \pm 0.02^{C}$ | $4.21 \pm 0.017^{D}$ | $3.9 \pm 0.04^{E}$ |
| | *L** | $71.81 \pm 0.17^{A}$ | $67.58 \pm 0.04^{B}$ | $63.47 \pm 0.02^{C}$ | $61.94 \pm 0.04^{D}$ | $59.92 \pm 0.03^{E}$ |
| | *a** | $3.40 \pm 0.01^{A}$ | $3.52 \pm 0.02^{B}$ | $3.60 \pm 0.03^{C}$ | $3.72 \pm 0.02^{D}$ | $3.90 \pm 0.04^{D}$ |
| | *b** | $12.94 \pm 0.03^{A}$ | $12.12 \pm 0.02^{B}$ | $11.55 \pm 0.05^{C}$ | $10.82 \pm 0.02^{D}$ | $10.06 \pm 0.03^{E}$ |

$T_0$, $T_1$, $T_2$, $T_3$ and $T_4$ are the rusks samples with 0%, 5%, 10%, 15%and 20% chia seed flour respectively; values are expressed as mean ± SD; means with different letter superscript are significantly different ($p < 0.05$).ISDF: insoluble dietary fiber, SDF: soluble dietary fiber, TDF: total dietary fiber.

The analysis for unsaturated fatty acids were also documented as palmitic acid existed from 0.57% to 0.34%. The maximum value for stearic acid obtained is in $T_0$ (0.31%) and minimum value observed is in $T_4$ (0.10%) as it consist of 100% wheat flour. The observed values are in accordance to the study of Coelho & Salas-Mellado (2015). Venturini et al. (2019) also observed a decreasing trend in saturated fatty acids on using chia oil in formulations.

### *3.5 Texture and colour properties of supplemented rusk*

Textural analysis is actually analysis related with the hardness of the rusk. It is usually checked via pinching method performed through texture analyser. All bakery items have characteristic textural properties. ANOVA concerned to hardness of rusk prepared from wheat flour and chia

powder produced a highly significant effect among various treatments, as given in Table 4. Mean values for textural analysis are given in Table 4, which is from 6.12 to 3.46among various treatments. The maximum hardness value obtained is 6.12 in $T_0$ while a lowest textural value was observed in $T_4$ which is 3.46. The observations of current study are parallel to study's results of Eshak (2016) who find the similar results in other products. Rusk colour was evaluated by placing the rusk under the photocell of calibrated colorimeter. Results indicated that colour value significantly differed due to various supplementation of chia seed flour in wheat flour. Degree of brightness was represented by '*L**' values, degree of redness was represented by '*a**' while degree of yellowness was represented by '*b**'. The values decreased significantly ($p < 0.05$) among the treatments as shown in Table 3.

### *3.6 TPC and radical scavenging activities*

TPC of the control (unsupplemented) and chia flour-supplemented samples are depicted in Figure 1. Overall the TPC for all samples including control was found in range of 76.18–129.50 mg GAE/100 DW. It was evident from the results that all rusks samples exhibited increasing tendency of TPC with corresponding rises in chia flour supplementation levels (Figure 1A). Lowest TPC was found in $T_0$ (76.18 mg GAE/100 DW) whereas, $T_4$ showed the highest TPC (129.50 mg GAE/100 DW). $T_2$ and $T_3$ exhibited gradual rises in TPC content as compared to that of control. The rising tendency with corresponding increases in chia supplemented flours may be ascribed to that fact of enriched biochemical profile of chia seed comprising of rich quantities of polyphenolic compounds in its composition. Similarly, the DPPH and ABTS-RSA's were also evaluated for all supplemented and control wheat rusks samples. The DPPH-RSA was found in range of 1.02–2.25 µm TE/g DW (Figure 1B). Similar to TPC, the DPPH-RSA also exhibited rising tendency in all supplemented samples as compared to that of control. Among all supplemented samples, $T_1$ showed that lowest DPPH-RSA (1.64 µm TE/g DW) which was slightly higher as compared to that of control (1.02 µm TE/g DW). However, further rises in chia flour causes significant increases in DPPH-RSA of supplemented wheat rusks samples and T4 exhibited the highest DPPH-RSA (2.25 µm TE/g DW) (Figure 1B) when compared with control. Comparatively, there was not so much significant difference ($p > 0.05$) between DPPH-RSA of $T_1$ and $T_2$, however, further

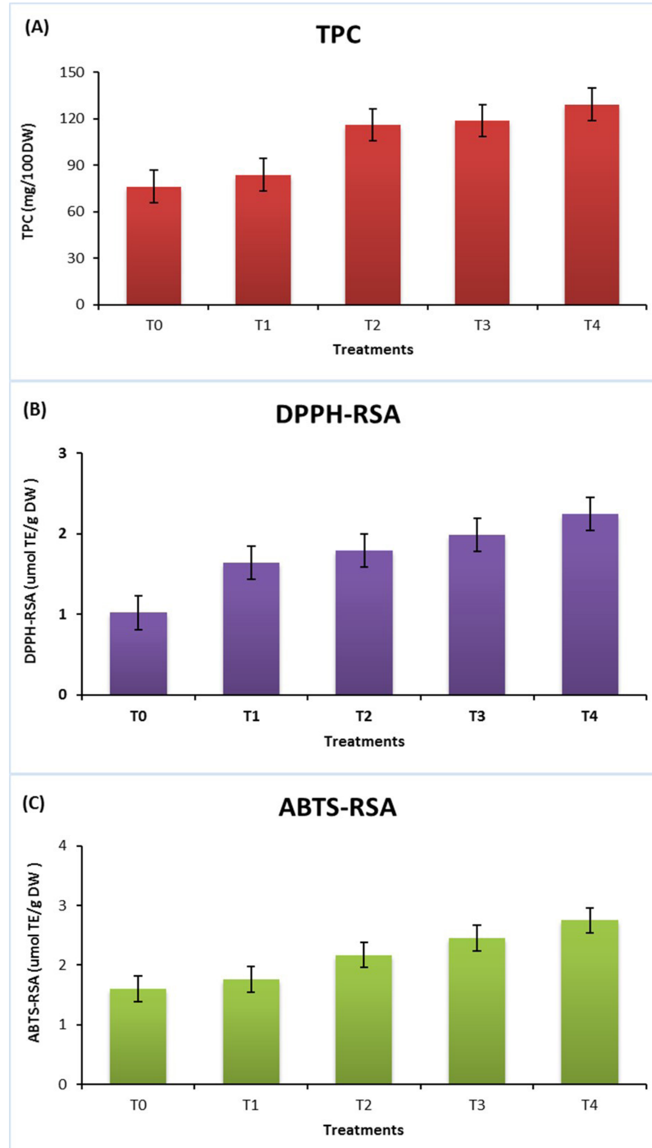


**Figure 1**. Total phenolic content (TPC) (A), DPPH (B) and ABTS-RSA's (C) of chia flour supplemented wheat rusk. $T_0$: 100% wheat flour, $T_1$: 95% wheat flour and 5% chia flour, $T_2$: 90% wheat flour and 10% chia flour, $T_3$: 85% wheat flour and 15% chia flour, $T_4$: 80% wheat flour and 20% chia flour.

rises in chia flour caused significant increases in DPPH-RSA of supplemented samples. Similar to DPPH-RSA, ABTS-RSA was also evaluated for all samples including control. Overall, the ABTS-RSA was found in range from 1.6 to 2.75 µm TE/g DW. Among all supplemented samples, $T_4$ exhibited the highest ABTS-RSA (2.75 µm TE/g DW) whereas, lowest ABTS-RSA was found in $T_1$ (1.76 µm TE/g DW) (Figure 1C). Among all treatments in a comparative manner, $T_2$ and $T_3$ showed the comparable ABTS-RSA's whereas further rises in chia flour caused concentration-dependent significant increases ($p < 0.05$) in ABTS-RSA of supplemented samples. Overall, it could be inferred that the chia flour supplementation enhanced the antioxidant potential of supplemented wheat rusks samples.

The probable reasons for increases in TPC and RSA's could be attributable to the possible presence of rich amounts of phenolic compounds in chia flour composition, such as chlorogenic acid, syringic acid, epicatechin, *p*-coumaric acid, catechin, ferulic acid, isoquercitrin, resveratrol, cinnamic acid and ellagic acid (Oliveira-Alves et al., 2017). Corresponding to results of this study, similar results were reported by Jiang et al. (2021) who prepared wheat biscuits supplemented with papaya seed and peel ranging from 2 to 10%. The authors reported that papaya seed and peel supplemented biscuit samples showed the significant increases in bioactive compounds and antioxidant activities in comparison with control (Jiang et al., 2021).

### *3.7 Sensory evaluation of rusk*

It is the very keen part of the product analysis. It is related towards the likeness and dis likeness of the product. This evaluation was done to check the various characters of the rusk like colour, flavour, texture and overall acceptability. The results disclosed a little variation in color among treatments. Results of sensory parameters Mean values are indicated in Figure 2, which showed that color score ranges from to 8.18 to 6.82. Maximum score (8.18) for color was given to $T_{0,}$ while the lowest score (6.82) was observed in $T_4$ (20% chia seed powder). Results showed that as amount of the chia flour increases lightness of the rusk decreases. The results figured out a little variation in flavour with the supplementation of chia flour among treatments. Mean values are presented in Figure 2, which showed that flavour score ranges from to 6..69 to 8.13 Maximum score (8.13) for flavour was assigned to $T_2$ (10% chia seed flour + 90% wheat flour) while the lowest score (6.69) was given to $T_4$ (20% chia flour + 80% wheat flour). Rusk prepared with $T_4$ was disliked by the judges with respect to flavor. The results disclosed texture was significantly affected by chia seeds addition in treatments (Figure 2). It was implied from the results that texture scores vary from to 7.46 to 8.33. Maximum score (8.33) regarding texture was given to $T_1$ while the lowest score (7.46) was assigned to $T_4$. Mean values for overall acceptability are depicted in Figure 2, which varied from to 6.60 to 8.21. Maximum score (8.21) for overall acceptability was given to $T_0$, while the lowest score (6.60) was given to $T_4$. It is evident from the findings that the rusk with 5% and 10% chia seed flour ($T_{1,}$ $T_2$) is the most acceptable rusk with mean scores almost equal to 8.15 for overall acceptability. Romankiewicz et al. (2017) also observed the related trend in the decreasing of texture values with the increase in chia seeds percentage. Sayed-Ahmad et al. (2018) also noted the similar trend in the decrease of texture values of selected bakery product with the addition of chia seeds.

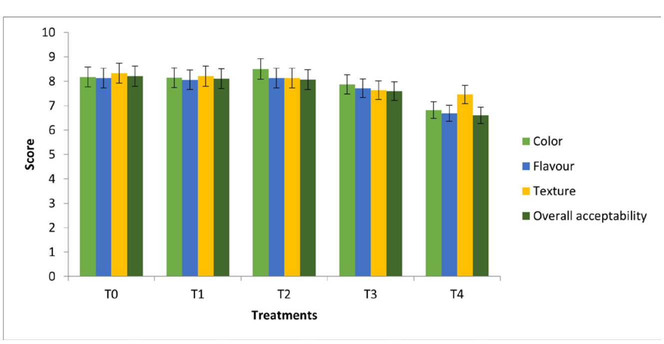


**Figure 2**. Sensory properties (colour, flavour, texture, overall acceptability) of chia flour supplemented wheat rusk. $T_0$: 100% wheat flour, $T_1$: 95% wheat flour and 5% chia flour, $T_2$: 90% wheat flour and 10% chia flour, $T_3$: 85% wheat flour and 15% chia flour, $T_4$: 80% wheat flour and 20% chia flour.

## 4 Conclusions

Chia seed (*Salvia hispanica* L.) as a pre-columbian crop originated from countries of South America, such as Guatemala and Mexico. It has now become popular globally because of its increased utilization in preparing sustainable and healthier diet alternatives. Chia flour is obtained in the form of fine powder prepared by grinding of the chia seeds. It has versatile nutritional profile and is usually employed for replacement of wheat flour and eggs during manufacturing of savory baked and sweet products, such as muffins, cakes, rolls, flatbread and bread. Shia flour contributes to the development of nutty flavor with slightly gummy texture in baked goods. Chia flour is commercially available in various forms, such as defatted chia seed meal, protein concentrate and whole meal. Specifically, the gluten-free aspect of chia flour makes it an ideal candidate for patients suffering from Celiac disease as replacer wheat flour. Chia flour can also be used for flour substitution, flavor enhancement, coloring, thickening agent, and to replace oil in products intended for vegans. In present study, chia seeds were grinded to flour by using a coffee grinder. The chia flour was supplemented at four levels (5%, 10%, 15% and 20%). All these treatments along with a control treatment were subjected to various physicochemical and rheological analysis to check various technological functions and sensory aspects of composite flour and product. Chia seeds are potential nutrients source and can be used in bakery products for useful purposes and a good source of PUFA and dietary fiber. 5% supplementation of chia flour recommended good for rusk preparation without affecting the technological attributes and quality and extremely liked by consumer in sensory evaluation. Rheological properties of the dough were also greatly affected with addition of chia seed flour. Supplementation of chia flour above 5% gives unacceptable characteristics to rusk like unpleasant aroma. The purpose of the current study was to highlight the chia potential as novel and super stuff. By knowing that chia seed contains excellent amount of fiber and contains several other nutritional and biochemical compounds, chia flour was supplemented into rusks to evaluate the various nutritional and technological aspects. Proximate analysis of composite flour revealed variations among the treatments. Means of crude protein, crude fat, crude fiber and ash showed a highly-significant trend with an increase in concentration as wheat flour substitution with chia seeds flour increases. Rheology study of chia flour supplemented composite flour revealed highly significant affects within treatments. Farinograph parameters values were highly significant with increasing trend, mean values for water absorption, dough development time, dough stability time, mixing tolerance index were 59% to 71%, 1.88 min.to 3.53 min., 1.89 min. to 3.94 min., 44 BU to 76 BU respectively. Mixograph value for peak time and mixing tolerance also showed a significant effect with mean values of 1.95 min. to 3.00 min.

and 1.57 BU to 2.67 BU respectively. Both parameters showed an increasing trend in mean values for treatments may be because of increase in resistance due to addition of chia seed flour. All parameters showed an increasing trend with addition of chia seeds flour. Means of insoluble dietary fiber and total dietary fiber showed a highly significant results with mean values of 0.76% to 6.92% and 1.18- 8.43% respectively. Means for soluble dietary fiber showed significant effect with mean values from 0.21% to 1.84%. Means of omega-3 and omega-6 showed a highly significant results with mean values of 0.20% to 3.81% and 0.74- 2.07% respectively. In physical analysis of rusk, the texture showed a highly significant results with a decreasing trend among treatments as the concentration of chia seed flour increases. Sensory evaluation was carried out for a number of parameters related to color, texture, and flavor and for overall acceptability. The score of overall acceptability varies among different treatments and it was observed that $T_1$ was the most acceptable rusk which had 5% chia seed flour and 95% wheat flour.

## References

Ali, N. M., Yeap, S. K., Ho, W. Y., Beh, B. K., Tan, S. W., & Tan, S. G. (2012). The promising future of chia, *Salvia hispanica* L. *Journal of Biomedicine & Biotechnology*, 2012, 171956. http://dx.doi.org/10.1155/2012/171956. PMid:23251075.

Ameer, K., Chun, B. S., & Kwon, J. H. (2017). Optimization of supercritical fluid extraction of steviol glycosides and total phenolic content from *Stevia rebaudiana* (Bertoni) leaves using response surface methodology and artificial neural network modeling. *Industrial Crops and Products*, 109, 672-685. http://dx.doi.org/10.1016/j.indcrop.2017.09.023.

American Association of Cereal Chemists – AACC. (2000). *Approved methods of American Association of Cereal Chemists* (10th ed.). Saint Paul, Minnesota: AACC USA.

Association of Official Analytical Chemists – AOAC. (2005). AOAC official method 996.06. In W. Horwitz (Ed.), *Official methods of analysis of AOAC International* (18th ed.). Gaithersburg: AOAC International.

Ayerza, R. H., & Coates, W. (2004). Composition of chia (*Salvia hispanica*) grown in six tropical and subtropical ecosystems of South America. *Tropical Science*, 44(3), 131-135. http://dx.doi.org/10.1002/ts.154.

Baker, E. J., Miles, E. A., Burdge, G. C., Yaqoob, P., & Calder, P. C. (2016). Metabolism and functional effects of plant-derived omega-3 fatty acids in humans. *Progress in Lipid Research*, 64, 30-56. http://dx.doi.org/10.1016/j.plipres.2016.07.002. PMid:27496755.

Coelho, M. S., & Salas-Mellado, M. M. (2015). Effects of substituting chia (*Salvia hispanica* L.) flour or seeds for wheat flour on the quality of the bread. *Lebensmittel-Wissenschaft + Technologie*, 60(2), 729-736. http://dx.doi.org/10.1016/j.lwt.2014.10.033.

Eshak, N. S. (2016). Sensory evaluation and nutritional value of balady flat bread supplemented with banana peels as a natural source of dietary fiber. *Annals of Agricultural Science*, 61(2), 229-235. http://dx.doi.org/10.1016/j.aoas.2016.07.002.

Grancieri, M., Martino, H. S. D., & Mejia, E. G. (2019). Chia seed (*Salvia hispanica* L.) as a source of proteins and bioactive peptides with health benefits: A review. *Comprehensive Reviews in Food Science and Food Safety*, 18(2), 480-499. http://dx.doi.org/10.1111/1541-4337.12423. PMid:33336944.

Iglesias-Puig, E., & Haros, M. (2013). Evaluation of performance of dough and bread incorporating chia (*Salvia hispanica* L.). *European Food Research and Technology*, 237(6), 865-874. http://dx.doi.org/10.1007/s00217-013-2067-x.

Ixtaina, V. Y., Nolasco, S. M., & Tomas, M. C. (2008). Physical properties of chia (*Salvia hispanica* L.) seeds. *Industrial Crops and Products*, 28(3), 286-293. http://dx.doi.org/10.1016/j.indcrop.2008.03.009.

Jiang, G., Feng, X., Zhao, C., Ameer, K., & Wu, Z. (2021). Development of biscuits supplemented with papaya seed and peel: effects on physicochemical properties, bioactive compounds, in vitro absorption capacities and starch digestibility. *Journal of Food Science and Technology*. In press. http://dx.doi.org/10.1007/s13197-021-05143-z.

Kulczyński, B., Kobus-Cisowska, J., Taczanowski, M., Kmiecik, D., & Gramza-Michałowska, A. (2019). The chemical composition and nutritional value of chia seeds—Current state of knowledge. *Nutrients*, 11(6), 1242. http://dx.doi.org/10.3390/nu11061242. PMid:31159190.

Meilgaard, M., Civille, G. V., & Carr, B. T. (2007). *Sensory evaluation techniques* (4th ed.). Boca Raton: CRC Press.

Muñoz, E., & García-Manrique, J. A. (2015). Water absorption behaviour and its effect on the mechanical properties of flax fibre reinforced bioepoxy composites. *International Journal of Polymer Science*, 2015, 1-10. http://dx.doi.org/10.1155/2015/390275.

Oliveira-Alves, S. C., Vendramini-Costa, D. B., Cazarin, C. B. B., Maróstica, M. R. M. Jr., Ferreira, J. P., Silva, A. B., Prado, M. A., & Bronze, M. R. (2017). Characterization of phenolic compounds in chia (*Salvia hispanica* L.) seeds, fiber flour and oil. *Food Chemistry*, 232, 295-305. http://dx.doi.org/10.1016/j.foodchem.2017.04.002. PMid:28490078.

Raju, M. P., Sailaja, P., Naik, K. M., & Poshadri, A. (2014). Study on hypoglycemic activity of functional food. *International Journal of Food Science & Technology*, 4(2), 1-12.

Romankiewicz, D., Hassoon, W. H., Cacak-Pietrzak, G., Sobczyk, M., Wirkowska-Wojdyła, M., Ceglińska, A., & Dziki, D. (2017). The effect of chia seeds (*Salvia hispanica* L.) addition on quality and nutritional value of wheat bread. *Journal of Food Quality*, 2017, 1-7. http://dx.doi.org/10.1155/2017/7352631.

Rosell, C. M., Rojas, J. A., & Barber, C. B. (2001). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloids*, 15(1), 75-81. http://dx.doi.org/10.1016/S0268-005X(00)00054-0.

Sahoo, A., & Divakar, S. (2018). Development and quality evaluation of jackfruit based baked rusk. *International Journal of Pure & Applied Bioscience*, 6(5), 843-847. http://dx.doi.org/10.18782/2320-7051.6852.

Sayed-Ahmad, B., Talou, T., Straumite, E., Sabovics, M., Kruma, Z., Saad, Z., Hijazi, A., & Merah, O. (2018). Evaluation of nutritional and technological attributes of whole wheat based bread fortified with chia flour. *Foods*, 7(9), 135. http://dx.doi.org/10.3390/foods7090135. PMid:30200180.

Sodchit, C., Tochampa, W., Kongbangkerd, T., & Singanusong, R. (2013). Effect of banana peel cellulose as a dietary fiber supplement on baking and sensory qualities of butter cake. *Songklanakarin Journal of Science and Technology*, 35(6), 641-646.

Švec, I., Hrušková, M., & Jurinova, I. (2016). Pasting characteristics of wheat-chia blends. *Journal of Food Engineering*, 172, 25-30. http://dx.doi.org/10.1016/j.jfoodeng.2015.04.030.

Turck, D., Castenmiller, J., de Henauw, S., Hirsch-Ernst, K. I., Kearney, J., Maciuk, A., Mangelsdorf, I., McArdle, H. J., Naska, A., Pelaez, C., Pentieva, K., Siani, A., Thies, F., Tsabouri, S., Vinceti, M., Cubadda, F., Engel, K. H., Frenzel, T., Heinonen, M., Marchelli, R., Neuhäuser-Berthold, M., Pöting, A., Poulsen, M., Sanz, Y., Schlatter, J. R., van Loveren, H., Gelbmann, W., Matijević, L., Romero, P., & Knutsen, H. K. (2019). Safety of chia seeds (*Salvia hispanica* L.) as a novel food for extended uses pursuant to Regulation (EU) 2015/2283. *EFSA Journal*, 17(4), e05657. PMid:32626283.

Vázquez-Ovando, J. A., Rosado-Rubio, J. G., Chel-Guerrero, L. A., & Betancur-Ancona, D. A. (2010). Dry processing of chía (*Salvia hispanica* L.) flour: chemical characterization of fiber and protein. *CYTA: Journal of Food*, 8(2), 117-127. http://dx.doi.org/10.1080/19476330903223580.

Venturini, L. H., Moreira, T. F. M., da Silva, T. B. V., de Almeida, M. M. C., Francisco, C. R. L., de Oliveira, A., de Campos, S. S., Bilck, A. P., de Souza Leone, R., Tanamati, A. A. C., Gonçalves, O. H., & Leimann, F. V. (2019). Partial substitution of margarine by microencapsulated chia seeds oil in the formulation of cookies. *Food and Bioprocess Technology*, 12(1), 77-87. http://dx.doi.org/10.1007/s11947-018-2188-0.