INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 16, No. 4, p. 366-379, 2020

RESEARCH PAPER OPEN ACCESS

Fortification of cookies with sweet basil leaves powder: an unheeded hematinic

Farah Naz Akbar[1, 2], Shahid Mahmood[1], Ghulam Mueen-ud-din[1], Muhammad Yamin[3], Muhammad Nadeem[1], Huma Bader Ul Ain[4], Tabussam Tufail[5*]

[1]*Institute of Food Science and Nutrition, University of Sargodha, Pakistan*

[2]*Department of AHS, Sargodha Medical College, University of Sargodha, Pakistan*

[3]*Faculty of Agricultural Engineering & Technology, University of Agriculture Faisalabad, Pakistan*

[4]*Riphah College of Rehabilitation & Allied Health Sciences, Riphah International University Faisalabad, Pakistan*

[5]*University Institute of Diet & Nutrition Sciences, Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan*

Key words: Sweet basil (*Ocimum basilicum* L.), Leaves powder, Cookies, Iron deficiency, Anemia.

http://dx.doi.org/10.12692/ijb/16.4.366-382 Article published on April 29, 2020

Abstract

Iron deficiency prevails worldwide which may be reduced through dietary interventions like food fortification. Sweet basil (*Ocimum basilicum* L.) is an iron rich medicinal plant. The present study explores its potential for fortification of cookies as Fe is used to enhance the bioactive components. There were five treatments prepared in this study, which were presented in sweet basil leaves powder i.e. T_0= Control, T_1= 12.699 $FeSO_4.7H_2O$ +*EDTA mg, T_2= 14 g, T_3= 16 g, and T_4=18 g. Cookies of all treatments were examined for proximate composition and sensory aspects along with the measurement of calorific and TBA values. The storage stability of cookies was also determined for 60 days. Iron content and other minerals were determined by atomic absorption spectrophotometry in fresh and dried leaves. The findings showed that T_3 was the most appropriate treatment of sweet basil leaves powder cookie. The score of color, taste, and texture were 6.07±0.06, 5.93±0.08, and 6.07±0.04, respectively for T_3. A physico-chemical test showed that cookies of T_3 contained water (4.74±0.08%), protein (13.79±0.02%), carbohydrate (52.31±0.099%), crude fibre (6.08±0.003%), fat (20.68±0.04%), and ash (2.40±0.02 %). Study concluded that ash, protein, fiber and iron contents are increased with increased the amount of sweet basil leaves powder. Calorific value and NEF were declined by adding the sweet basil leaves powder. Therefore, it has potential of being healthy caloric snack which can accomplish the nutritional requirements of all age groups and helps in the alleviation of anemia.

* **Corresponding Author:** Tabussam Tufail ✉ tufail@dnsc.uol.edu.pk

Introduction

Hematinic is a nutrient essential for hematopoiesis including Fe, B_{12}, and folate and scarcity in hematinics consequent anemia (Hightower *et al.,* 2020). Iron supplements are readily available in the world, and fortified food is a chief constituent of the diet in the developed world, but approach to supplements and fortified food is limited due to a high cost factor. Efforts to combat iron deficiency are being made all over the world, but the issue remains a public health concern (Faqih *et al.,* 2006).

The consumption of aromatic and medicinal plants is growing around the world. Numerous medicinal plant contains rich sources of minerals which belongs to Lamiceae family (Shan *et al.,* 2005). The constituents i.e. antioxidants, phenolic acids, flavonoids, dietary fiber, antimicrobials and neuropharmacological agents in a variety of plants are widely recognized as playing a crucial role in the prevention of many diseases such as cardiovascular disease, cancer and other generative disorders (Amrani *et al.,* 2006). Currently, synthetic food additives which could have harmful health effects are being increasingly replaced by natural basic plants (Paradiso *et al.,* 2008).

Sweet basil (*Ocimum basilicum* L.) is a medicinal herb being used throughout the globe not only in a diseased state but also as a natural substance that is essential to sustain human health (Patel *et al.,* 2018). It is a non-toxic herb, originally grown in India as well as in central Asia and now grown in tropical and subtropical regions all over the world.

It is also aroma and flavor to food in raw or cooked form e.g. in tomato dishes, pasta sauces, beans (Sonmezdag *et al.,* 2018). Generally fresh leaves are used, but dried leaves are often used in winter. Some pharmacological effects have been observed in a variety of diseases with potent antioxidants, anti-aging, anticancer, antiviral and antimicrobial properties (Güez *et al.,* 2017). Studies have stated that rosmarinic acid (RA) is the most biologically active compound in sweet basil (Lee and Scagel, 2009; Javanmardi *et al.,* 2002). Basil has many secondary metabolites, such as polyphenols, flvonoids and terpenes, with known possible biological effects (Lee and Scagel, 2009). This belongs to caffeic acid esters of Rosmarinic acid (RA) (R-O-caffeoyl-3-4-dihydroxyphenyllactic acid) which is antioxidant and anti-HIV (Guine and Goncalves, 2015).

Therefore Basil is very effective natural element to act as a source of different minerals especially the iron in different food products.

Foods that are used as ready-to-eat and available at reasonable rates contain cookies (Kulkarni, 1997). Different types of cookies are prepared with the addition of various kinds of fortificants, like iron salt which are mostly artificial in nature with the combination of Ethylene-Diamine Tetraacetic Acid (Zoulias *et al.,* 2002). Such chemical fortifiers can have adverse effects, including nausea, vomiting, dark stools, loss of appetite, epigastric discomfort, abdominal cramps and constipation (Paradiso *et al.,* 2008). These effects have been observed in more than 10 % of users of artificial iron fortificants. Diarrhea, staining of teeth, heartburn, discolored urine may occur in 1 to 10 % of cases. Uncommon consequences of artificial iron supplements may include hypersensitivity and intoxication (El Khouly, 2017). Sweet basil showed high Fe content of 89.80 mg/100 g but its anti-anemic activity is unknown.

A little attempt has been made to overcome anemia of anemic teenage girls by using Fe fortified cookies with dietary approaches. Although, it is a slow process but very effective to overcome the anemia in anemic adolescent girls. Therefore, it is also a good and cost effective option to add Sweet basil in cookies through fortification process for fulfilling the partial requirement of iron especially in adolescents. Because fortification is a cost-effective, reliable and successful way to settle micronutrient deficiencies. (Mohamed *et al.,* 2010). In the food industry, food fortification is on the rise and mineral addition is increasing in the fortification phase. A research study was planned to develop and evaluate sweet basil leaves powder cookies with baking and storage stability.

Materials and methods

Commercial straight grade flour, sweet basil leaves and other substances were procured from the indigenous market. Clean sweet basil leaves have been dried.

De-bittering of sweet basil leaves

To remove bitterness of sweet basil, leaves were socked for 1 hour and boiled for 5-15 minutes at 100 °C in 5-20 % concentrations of NaCl solution for the suppression of bitterness as Keast *et al.,* (2001) mentioned in a study.

Product development

Sweet basil leaves powder with appropriate physical, chemical and sensory characteristics were prepared after some initial studies. Cookies were tested for the baking and storage stability of iron to assess the correct dose of fortificant.

Preparation of cookies

After the de-bittering leaves were dried and prepared powder through grinding. Creaming was performed in Hobart Mixer (Model N-50, Hobart Mfg. Co. Troy, Ohio, USA) for 30 min; water was added and mixed for 8 min, then eggs were added and mixed until homogeneity. Commercial straight grade flour, baking powder and sweet basil leaves powder were mixed to a homogeneous mass (Table). The cookies were baked at 175±5 °C for 25 min. The cookies were cooled, sealed in bi-oriented polypropylene (BOPP) wraps, packed in box and placed at room temperature for further analysis.

Stability of sweet basil, leaves powder cookies

Storage stability of the treatments

Fortifying stability was examined by assessing losses that occurred in the baking and storage cycle. The batter and freshly baked cookies were tested for iron content. Furthermore, processed cookies have also been tested for up to 2 months per fortnight.

Determination of iron content

Iron was introduced in the batter of cookies from the vegetable shortening, egg and the fortificant. Spectrophotometric measurement of the iron content of cookies was conducted in accordance with the AOAC protocol (Feldsine *et al.*, 2002).

Physical analysis of cookies

The cookies that have various levels of Fe fortificant were examined for diameter (cm), thickness (cm) and spread factor at 0 days and fortnightly up to 2 months according to the method defined in AACC (2000).

Proximate composition of the cookies

The proximate examination of cookies was done at the start of the storage test, followed by 2 months per fortnight. Proximate constituents, i.e. moisture content, nitrogen free extract (NFE), total ash, crude fat, crude protein and crude fiber were recorded on a dry weight basis.

Thiobarbituric acid value

To assess the development of rancidity in the product, thiobarbituric acid number (TAB no.) of all the treatments of the cookies at stated storage intervals was measured by following the protocol described by Kirk (1999).

Calorific value of treatments

The amount of heat released during the complete oxidation of a commodity is its gross energy value. Cookies were examined using Oxygen Bomb Calorimeter (Model: 1341, Parr Instrument Company, Werke IKA). Calorific values of the cookies were calculated as stated by Krishna and Ranjhan (1981).

Sensory evaluation

Sensory assessment of the cookies with different treatments and different characteristics, including the taste, texture, color, flavor and overall acceptability, was done every fortnight up to two months by a professional panel using the hedonic score scheme as defined by Meilgaard *et al.*, (2007). During the test, cookies from all treatments were put in transparent containers labeled randomly. Panelists were supplied distilled water to nullify the mouth taste during the tests. Cookies samples were given in random order and panelists were requested to assess the score on all factors.

Results and discussion

Nutritional value of fresh and dried sweet basil leaves

The data pertaining to nutritional value of fresh and dried leaves of sweet basil estimation (Table). The data shows that the dried leaves of sweet basil are a rich source of all nutrients in comparison with fresh leaves. The data exhibited that dried sweet basil leaves with a moisture content of about 91% and 0.356% were in dried leaves. The determination of the proximate composition involves the minerals of the dried leaves, which are important not only for the quality of the product after drying, but also for better preservation.

Table 1. Various treatments of sweet basil leaves powder used to formulate cookies.

Treatments	$FeSO_4.7H_2O$ (mg)	Sweet basil leaves powder (g)
T_0	-	-
T_1	12.699+*EDTA	-
T_2	-	14
T_3	-	16
T_4	-	18

* Iron dosages for anemic adolescent girls were formulated for their RDAs.

De-bittering of sweet basil leaves

Bitterness of sweet basil leaves owes to the presence of phenols, flavonoids and related composites. Its bitter taste makes it unpleasant for consumption. Therefore, NaCl solution was used for the improvement of its taste which made it acceptable for human consumption. Leaves were socked for 1 hour and boiled for 5-15 minutes at 100 °C in 5-20 % concentrations of NaCl solution for the suppression of bitterness. The most appropriate result appeared at 15 minutes of boiling (100 °C) in 15 % concentration of NaCl (Fig. 1).

Table 2. Mean nutritional value of sweet basil leaves.

Nutritional value/100 g	Fresh leaves	Dried leaves
Moisture (%)	91.000± 0.5774^{A}	0.353 ± 3.333E-03^{B}
Fibre (%)	1.520±0.0436^{B}	36.057±0.4288^{A}
Protein (%)	3.150±0.0173^{B}	22.580±0.4561^{A}
Ash (%)	1.473±0.0176^{B}	14.467± 0.2028^{A}
Fat (%)	0.6467±3.333E-03^{B}	4.0567 ±0.0296^{A}
NFE (%)	2.210 ±0.6043 ^{B}	22.487 ±0.9264^{A}
Fe (mg)	3.187± 8.819E-03 ^{B}	89.833 ± 0.0882^{A}
Ca (mg)	176.9±0.0702^{B}	2239.0 ±1.5275^{A}
Cu (mg)	0.3850±2.887E-03^{B}	2.1000± 0.0577^{A}
K (mg)	294.8±0.1719^{B}	2697.0±0.5774^{A}
Mn (mg)	1.2617±0.1142^{B}	9.8000± 0.5774^{A}
Mg (mg)	64.50±0.2887^{B}	710.00±0.5774^{A}
Na (mg)	4.057±0.0285^{B}	76.017±0.5630^{A}
P (mg)	56.33±0.3333^{B}	275.00±0.5774^{A}
Zn (mg)	0.8067±3.333E-03^{B}	7.1000±0.0577^{A}
Selenium (mg)	0.3233±0.0285^{B}	3.0000±0.0577^{A}

Baking and storage stability

Iron content of sweet basil leaves powdered cookies decreased significantly from 11,264±0.06 to 11.00±0.03 mg/100 g (Table). However, overall baking stability was lost by 2.34%. Before baking, maximum iron was noted in T_4 15.907±0.0065 mg/100 g followed by 13.867±0.001 mg/100 g in T_3, 12.600±0.003 mg/100 g in T_2 and13.933±0.001 mg/100 g in T_1 whilst the minimum amount was estimated in T_0 (Table). After baking, highest iron was noted in T_4 as 15.300 ±0.006 mg/100 g followed by 13.727±0.001 mg/100 g in T_3, 12.200±0.002 mg/100 g in T_2 and13.767±0.003 mg/100 g in T_1 whilst the lowest amount was estimated in T_0 (control) as shown in Table. Karimian-Khosroshahi *et al.,* (2016) investigated that rainbow trout has Fe content of 6.18 mg/kg and its baking has no major impact on the content of Fe (p≤0.05).

Table 3. Impact of treatments and baking stability on iron mg/100 g of sweet basil leaves powder cookies.

Treatments	Before	After	Means ± SEM
T_0	0.013±0.006 ^{d}	0.007 ±0.006 ^{d}	0.010±0.006 ^{D}
T_1	13.933±0.01 ^{b}	13.767±0.03 ^{b}	13.850±0.06 ^{B}
T_2	12.600±0.03 ^{c}	12.200±0.02 ^{c}	12.400±0.06 ^{C}
T_3	13.867±0.01 ^{b}	13.727±0.01 ^{b}	13.797±0.04 ^{B}
T_4	15.907±0.06^a	15.300±0.06 ^{a}	15.603±0.01^A
Means ± SEM	11.264±0.06 ^{A}	11.000 ±0.03 ^{A}	

The maximum amount of Fe 15.020±0.03 mg/100 g was reported in T_4, while the least level (0.008±0.006 mg/100 g) was found in T_0 (Control). Storage of Fe content was non-significant but a decreasing trend was observed from 11.00±0.02 mg/100 g at study initiation to 10.908±0.05 mg/100 g at 60 days. Storage losses were ranged from 1-2% among the treatments.

Table 4. Impact of treatments and storage on iron mg/100g of sweet basil leaves powder cookies.

Treatments	Storage Period (Days)					Means ± SEM
	0	15	30	45	60	
T_0	0.007±0.06 ^{e}	0.0130±0.04^e	0.007±0.01^e	0.007±0.03^e	0.007±0.01^e	0.008±0.02^D
T_1	13.767±0.01^c	13.800±0.01^c	13.733±0.03^c	13.693±0.01^c	13.660±0.01^c	13.828±0.04^B
T_2	12.200±0.01^d	12.033±0.02^d	12.400±0.01^d	12.133±0.02^d	12.067±0.00^d	12.160±0.01^C
T_3	13.727±0.03^c	13.907±0.01^{bc}	13.767±0.01^c	13.733±0.01^c	14.007±0.01^c	13.828±0.05^B
T_4	15.300±0.01^a	15.233±0.01^{ab}	14.767±0.04^a	15.00±0.01^a	14.800±0.01^{ab}	15.020±0.03^A
Means ± SEM	11.00±0.03^A	10.991±0.04^A	10.935±0.01^A	10.913±0.04^A	10.908±0.05^A	
T_0 =	Control					
T_1 =	12.699 $FeSO_4.7H_2O$ +*EDTA mg					
T_2 =	14 g sweet basil leaves powder					
T_3 =	16 g sweet basil leaves powder					
T_4 =	18 g sweet basil leaves powder					

In a similar study, biscuit products were analyzed to determine mineral contents and the data were presented by Ziena *et al.,* (2019). They reported that content of iron as 1.84 mg/100 g which increase to 2.95 mg/100 g in biscuit products made by mixing some cereals and some legumes. Likewise in a study by Chelladurai *et al.,* (2019), cookies were developed with major constituents of Chia seeds, date syrup and jiggery while other ingredients include refined wheat flour, margarine, rava, cocoa powder, milk powder and baking powder. Chia seed enriched cookies prepared with control, 10% T_1, 20% T_2 and 30 % T_3 Chia seed. The results showed that iron contents were 0.6 mg, 1.4 mg, 1.6 mg and 1.5 mg in control, T_1, T_2 and T_3 respectively. Zoulias *et al.,* (2000) studied that amount of iron contents increased with increasing amount of dried moringa leaves powder. Patimah *et al.,* (2019) and Sahé *et al.,* (2019) prepared nutritious cookies and analyzed their nutritional properties to meet the needs of the population and create business opportunities.

Table 5. Impact of treatments and storage on proximate composition of the sweet basil leaves powder cookies.

Treatments		Storage period (Days)					Means ± SEM
		0	15	30	45	60	
Moisture contents (%)	T0	4.30±0.01^{mn}	4.23±0.03^{n}	4.42±0.04^{k}	4.63±0.02^{i}	5.83±0.03^{f}	4.48±0.07^{D}
	T1	4.22±0.00^{n}	4.42±0.04^{k}	4.62±0.04^{i}	4.82±0.04^{fg}	5.02±0.04^{cd}	4.62±0.06^{C}
	T2	4.34l±0.04^{m}	4.56±0.04^{ij}	4.74±0.07^{gh}	4.95±0.06d^{e}	5.05±0.02^{c}	4.73±0.06^{B}
	T3	4.34l±0.05^{m}	4.54±0.05^{j}	4.74±0.04^{h}	4.94±0.04^{e}	5.14±0.05^{b}	4.74±0.08^{B}
	T4	4.42±0.04^{kl}	4.62±0.01^{ij}	4.82±0.04^{fgh}	5.02±0.03^{cde}	5.23±0.04^{a}	4.82±0.08^{A}
	Means ± SEM	4.32±0.02^{E}	4.47±0.04^{D}	4.67±0.04^{C}	4.87±0.04^{B}	5.05±0.03^{A}	
Ash content (%)	T0	0.37±0.08^{e}	0.39±0.004^{e}	0.38±0.002^{e}	0.36±0.004^{e}	0.37±0.002^{e}	0.37±0.00^{E}
	T1	2.30±0.07^{b}	2.49±0.07^{b}	2.31±0.03^{b}	2.40±0.07^{b}	2.42±0.07^{b}	2.30±0.01^{B}
	T2	2.14±0.05^{c}	2.15±0.03^{c}	2.13±0.03^{c}	2.13±0.08^{c}	2.12±0.03^{c}	2.13±0.00^{C}
	T3	2.40±0.09^{b}	2.39±0.04^{b}	2.41±0.04^{b}	2.40±0.04^{b}	2.42±0.04^{b}	2.40±0.02^{B}
	T4	2.66±0.04^{a}	2.68±0.02^{a}	2.66±0.03^{a}	2.69±0.06^{a}	2.67±0.03^{a}	2.67±0.00^{A}
	Means ± SEM	1.82±0.23^{A}	1.84±0.22^{A}	1.83±0.21^{A}	1.82±0.22^{A}	1.83±0.22^{A}	
Crude protein (%)	T0	10.18±0.03^{e}	10.18±0.02^{e}	10.16±0.02^{e}	10.18±0.04^{e}	10.17±0.02^{e}	10.18±0.01^{E}
	T1	10.35±0.04^{d}	10.34±0.04^{d}	10.33±0.03^{d}	10.34±0.01^{d}	10.34±0.03^{d}	10.34±0.03^{D}
	T2	13.1±7.06^{c}	13.16±0.05^{c}	13.21±0.03^{c}	13.18±0.04^{c}	13.17±0.03^{c}	13.17±0.01^{C}
	T3	13.7±7.02^{b}	13.79±0.08^{b}	13.80±0.04^{b}	13.78±0.06^{b}	13.79±0.06^{b}	13.79±0.02^{B}
	T4	14.44±0.02^{a}	14.43±0.03^{a}	14.45±0.05^{a}	14.46±0.04^{a}	14.45±0.05^{a}	14.44±0.01^{A}
	Means ± SEM	12.383±0.11^{A}	12.382±0.12^{A}	12.391±0.08^{A}	12.389±0.09^{A}	12.385±0.07^{A}	
Crude fat (%)	T0	20.72±0.06^{a}	20.71±0.06^{a}	20.76±0.04^{a}	20.69±0.04^{a}	20.76±0.03^{a}	20.72±0.02^{A}
	T1	20.76±0.08^{a}	20.72±0.06^{a}	20.70±0.02^{a}	20.68±0.06^{a}	20.68±0.04^{a}	20.70±0.05^{A}
	T2	20.69±0.03^{a}	20.71±0.04^{a}	20.66±0.02^{a}	20.72±0.06^{a}	20.68±0.02^{a}	20.69±0.02^{A}
	T3	20.68±0.02^{a}	20.67±0.05^{a}	20.68±0.01^{a}	20.68±0.03^{a}	20.69±0.03^{a}	20.68±0.04^{A}
	T4	20.64±0.03^{a}	20.68±0.07^{a}	20.65±0.03^{a}	20.65±0.03^{a}	20.59±0.05^{a}	20.64±0.04^{A}
	Means ± SEM	20.70±0.039^{A}	20.70±0.038^{A}	20.69±0.038^{A}	20.68±0.037^{A}	20.43±0.028^{A}	
Crude fiber (%)	T0	0.55±0.003^{d}	0.58±0.003^{d}	0.56±0.004^{d}	0.55±0.003^{d}	0.57±0.002^{d}	0.56±0.002^{D}
	T1	0.56±0.001^{d}	0.57±0.002^{d}	0.58±0.003^{d}	0.59±0.002^{d}	0.56±0.003^{d}	0.58±0.002^{D}
	T2	5.31±0.003^{c}	5.32±0.003^{c}	5.31±0.003^{c}	5.30±0.003^{c}	5.31±0.001^{c}	5.31±0.000^{C}
	T3	6.08±0.007^{b}	6.10±0.005^{b}	6.07±0.004^{b}	6.08±0.003^{b}	6.08±0.005^{b}	6.08±0.003^{B}
	T4	6.85±0.003^{a}	6.82±0.002^{a}	6.86±0.003^{a}	6.84±0.001^{a}	6.84±0.003^{a}	6.84±0.002^{A}
	Means ± SEM	3.87±0.03^{A}	3.88±0.02^{A}	3.87±0.02^{A}	3.86±0.001^{A}	3.87±0.03^{A}	
Nitrogen free extract (%)	T0	63.87±0.08^{cde}	63.59±0.06^{cde}	63.41±0.04d^{e}	63.21±0.09^{e}	63.08±0.02^{e}	63.44±0.067^{B}
	T1	61.58±0.04^{a}	61.60±0.09^{cde}	61.54±0.093^{e}	61.22±0.05^{dc}	61.03±0.03^{bcd}	61.39±0.061^{A}
	T2	54.48±0.09^{f}	54.24±0.07^{fg}	54.05±0.09^{fg}	53.80±0.09^{g}	53.67±0.08^{g}	54.06±0.076^{C}
	T3	52.72±0.07^{h}	52.48±0.09^{hi}	52.30±0.09^{hi}	52.12±0.05^{hi}	51.92±0.01^{i}	52.31±0.099^{D}
	T4	50.92±0.06^{j}	50.73±0.03^{jk}	50.53±0.09^{jk}	50.310±0.04^{jk}	50.16±0.03^{k}	50.53±0.078^{E}
	Means ± SEM	56.71±0.07^{A}	56.53±0.09^{AB}	56.37±0.09^{B}	56.13±0.06^{C}	55.97±0.07^{C}	
	T_0 =	Control					
	T_1 =	12.699 $FeSO_4.7H_2O$ +*EDTA mg					
	T_2 =	14 g sweet basil leaves powder					
	T_3 =	16 g sweet basil leaves powder					
	T_4 =	18 g sweet basil leaves powder					

Physical analysis of the sweet basil leaves powder cookies

Diameter

The mean values of the diameter obtained by the study of the sweet basil leaves powder cookies with different concentrations (Fig. 2) showed that the non-significant variations between treatments ranged from 5.17±0.03 to 5.23±0.08 cm. There is a non-significant effect of storage on diameter. The mean value at 0 days was 5.238±0.0144 cm which showed a non-significant drop with time and diameter of 5.182±0.01cm was noted after 60 days (Fig.). The non-significant result of the sweet basil leaves powder may be due to the fact that the leaves powder has not affected the characteristics of dough / batter responsible for retaining the diameter of the cookies. Degrading in the physical parameters generally depends on the storage conditions.

In this analysis, airtight polythene bags were used to pack the cookies and fading in texture was examined which proceeded gradually, thus increasing the diameter of cookies. In a similar study, Butt *et al.,* (2007) also determined non-significant differences between treatments and storage for this attribute in sweet basil leaves powdered cookies.

Furthermore, While dissimilar findings were reported by Šimurina *et al.,* (2008). They explored that on addition of molasses as ingredients in biscuits, the diameter of the biscuits was increased from 6.1 to 8.9 %.

Thickness

The mean values for the thickness of the different treatment of cookies obtained by measurement are illustrated in **Error! Reference source not found.**. The thickness of the sweet basil leaves powdered cookies ranged from 0.65±0.002 to 0.66±0.01 cm. There were non-significant variations among treatments over 60 days.During the sixty days of study no such reaction was carried out because cookies were wrapped in bi-oriented polypropylene capable of altering the thickness of cookies. (Pareyt and Delcour, 2008).

In a Similar observation T_1 (control) had a thickness of 4.99 mm, while T_4 (25.85 µg retinyl acetate) had a thickness of 4.92 mm, supporting the present results; a non-significant decrease in thickness was reported by Butt *et al.,* (2007) as a feature of varying strength levels. Furthermore, a similar study was performed by Mahmood (2009) who investigated a declining trend in the thickness of value-added cookies with a gradual increase in the proportion of rice bran oil.

Table 6. Impact of treatments and storage on TBA (mg malenaldehyde/kg) of sweet basil leaves powder cookies.

Treatments	Storage period (Days)					Means ± SEM
	0	15	30	45	60	
T_0	0.0463±0.004[abcd]	0.0453±0.004[bcd]	0.0490±0.004[abcd]	0.0497±0.004[abcd]	0.0510±0.004[abcd]	0.0483±0.004[A]
T_1	0.0457±0.004[bcd]	0.0450±0.004[bcd]	0.0457±0.004[bcd]	0.0510±0.004[abcd]	0.0497±0.004[abcd]	0.0481±0.004[A]
T_2	0.0430±0.004[d]	0.0450±0.004[bcd]	0.0467±0.004[abcd]	0.0497±0.004[abcd]	0.0533±0.004[ab]	0.0475±0.003[A]
T_3	0.0437±0.004[cd]	0.0447±0.004[bcd]	0.0520±0.004[abc]	0.0473±0.004[abcd]	0.0547±0.004[a]	0.0485±0.003[A]
T_4	0.0457±0.004[bcd]	0.0463±0.004[abcd]	0.0497±0.004[abcd]	0.0533±0.004[ab]	0.0503±0.004[abcd]	0.0491±0.005[A]
Means ± SEM	0.0449±0.004[B]	0.0453±0.003[B]	0.0493±0.005[A]	0.0502±0.003[A]	0.0518±0.00[A]	
T_0 =	Control					
T_1 =	12.699 $FeSO_4.7H_2O$ +*EDTA mg					
T_2 =	14 g sweet basil leaves powder					
T_3 =	16 g sweet basil leaves powder					
T_4 =	18 g sweet basil leaves powder					

Spread factor

Spread factor is the ratio that depends on the values of width and thickness. Means for spread factor (Fig.) showed non-significant variations between sweet basil leaves powder. The spread factor for cookies was recorded from 78.30±0.01 to 79.361±0.01. Moreover, the preservation of cookies for 60 days did not make any significant difference in cookies. The spread factor of cookies ranged from 78.30±0.01 to 79.361±0.01. Similarly, storage of cookies for 60 days did not impart any significant difference (Fig.).

Present findings are consistent with previous researchers who documented substantial changes in vitamin A fortified cookies during storage (Butt *et al.,* 2007; Mahmood *et al.,* 2008). Dissimilar results have also been reported by Šimurina *et al.,* (2008) who investigated an increase in the density and spread ratio (15 to 20% molasses) of biscuits on the inclusion of molasses as ingredients in biscuits.

Proximate composition of the sweet basil leaves powder cookies

Statistical analysis of moisture content showed that treatment and storage stability had statistically significant differences, ranging from 4.48±0.07% to 4.82±0.08%. The concept of moisture absorption during the storage time is also confirmed by Patimah *et al.,* (2019) who researched that the nutrient content of foxtail millet and flying fish cookies as a functional food moisture content was 5.94 per cent of the best treatment. Similarly Vijerathna *et al.,* (2019) recorded that cookies enriched with sugar cane bagasse had a 3% moisture content.

Table 7. Impact of treatments and storage on calorific value of sweet basil leaves powder cookies.

Treatments	Storage period (Days)					Means ± SEM
	0	15	30	45	60	
T_0	453.75±0.01^{ab}	451.88±0.03^{bc}	456.01±0.02^{a}	449.62±0.04^{cd}	454.08±0.04^{ab}	453.73±0.08^{A}
T_1	448.19±0.02^{d}	448.63±0.03^{d}	448.19±0.03^{d}	448.63±0.03^{d}	448.19±0.03^{d}	447.37±0.05^{B}
T_2	427.69±0.03^{e}	426.70±0.04^{efg}	427.69±0.03^{e}	427.16±0.04^{ef}	427.37±0.03^{ef}	427.28±0.03^{C}
T_3	422.14±0.04^{gh}	423.23±0.03^{h}	423.74±0.05^{h}	424.58±0.03^{fgh}	423.74±0.03^{h}	423.88±0.01^{D}
T_4	418.37±0.03^{i}	418.33±0.03^{i}	418.41±0.03^{i}	418.54±0.04^{i}	418.08±0.03^{i}	418.34±0.03^{E}
Means ± SEM	434.43^{A}±0.04	433.76^{A}±0.03	434.82^{A}±0.03	433.70^{A}±0.05	434.23^{A}±0.02	
T_0 =	Control					
T_1 =	12.699 $FeSO_4.7H_2O$ +*EDTA mg					
T_2 =	14 g sweet basil leaves powder					
T_3 =	16 g sweet basil leaves powder					
T_4 =	18 g sweet basil leaves powder					

The presence of higher amount of ash indicates the higher availability of minerals in the food. Mean values for the ash content of various treatments have been provided in Table. The results showed that maximum ash contents were found in T_4 (2.67±0.00%) and minimum ash contents were found in T_0 (0.37±0.00%).

The amount of ash increased with the amount of forticant. Chelladurai *et al.,* (2019) developed Chia seed enriched cookies with similar findings. Average values for ash after two months of storage showed statistically non-significant differences between fortified cookies. This finding is consistent with previous research that there has been a non-significant decrease in ash content during storage (Butt, Sharif *et al.,* 2004) and rice bran oil cookies (Mahmood, 2009). The amount of ash content recorded by Patimah *et al.,* (2019) was 1.26% in cookies made from foxtail millet and flying fish.

The mean values for crude protein elucidated statistically significant variations among the sweet basil leaves powder cookies. During 60 days of storage, the protein content of cookies was not significant, but T4 was the highest in crude protein due to the highest fortifying content (Table). In all trials for crude protein, the mean values ranged from 10.18 ± 0.02 % to 14.44 ± 0.01% (Table). In a similar study, the amount of protein increased with the amount of chai seed added by Chelladurai *et al.,* (2019). Patimah *et al.,* (2019) reported that amount of protein was 11.89% in cookies developed from foxtail millet and flying fish. Non-significant effect was reported by Mahmood *et al.,* (2008) in protein content of iron fortified cookies during 90 days storage.

Table explained non-significant differences with varying levels of sweet basil leaves powder ranged from 20.64±0.004 to 20.72±0.002%. There were statistically non-momentous variations of 20.70±0.038 to 20.43±0.02 in sweet basil leaves powder cookies during storage (Table).

This decreasing trend in fat content may have been attributed to a rise in the moisture content of cookies, increasing the oxidation of fatty acids. According to the Mahmood *et al.,* (2008) report, a non-significant difference in the crude fat content of vitamin 'A' fortified cookies was determined during storage. Patimah *et al.,* (2019) reported the amount of fat content was 21.30% in cookies developed from foxtail millet and flying fish.

Table 8. Impact of treatments and storage on sensory parameters of sweet basil leaves powder cookies.

Treatments		Storage period (Days)					Means ± SEM
		0	15	30	45	60	
Color	To	8.00 ± 0.06^{a}	7.33 ± 0.03^{a}	7.33 ± 0.00^{a}	7.33 ± 0.09^{a}	7.33 ± 0.09^{a}	7.47 ± 0.09^{A}
	T1	8.00 ± 0.09^{a}	6.33 ± 0.03^{b}	6.33 ± 0.09^{b}	6.67 ± 0.09^{b}	6.33 ± 0.06^{b}	6.73 ± 0.06^{AB}
	T2	6.33 ± 0.06^{b}	6.67 ± 0.03^{b}	6.33 ± 0.03^{b}	6.33 ± 0.04^{b}	6.33 ± 0.08^{b}	6.40 ± 0.08^{BC}
	T3	6.67 ± 0.09^{b}	6.67 ± 0.02^{a}	6.00 ± 0.09^{b}	6.00 ± 0.09^{b}	5.00 ± 0.03^{c}	6.07 ± 0.06^{BC}
	T4	5.67 ± 0.08^{c}	6.00 ± 0.01^{c}	5.67 ± 0.09^{c}	5.33 ± 0.06^{c}	5.00 ± 0.09^{c}	5.53 ± 0.03^{C}
	Means ± SEM	6.93 ± 0.09^{A}	6.60 ± 0.01^{A}	6.33 ± 0.001^{A}	6.33 ± 0.00^{A}	6.00 ± 0.06^{A}	
Flavor	To	7.00 ± 0.03^{ab}	7.33 ± 0.08^{a}	8.00 ± 0.08^{a}	8.33 ± 0.02^{a}	6.67 ± 0.05^{ab}	7.33 ± 0.08^{A}
	T1	7.00 ± 0.08^{ab}	6.33 ± 0.05^{a}	6.67 ± 0.03^{ab}	6.67 ± 0.08^{ab}	5.33 ± 0.08^{bc}	6.73 ± 0.06^{AB}
	T2	6.00 ± 0.04^{ab}	6.67 ± 0.08^{a}	6.33 ± 0.08^{a}	6.33 ± 0.06^{a}	6.67 ± 0.03^{ab}	$6.47\pm0.10A^{AB}$
	T3	6.67 ± 0.08^{a}	6.00 ± 0.06^{ab}	6.00 ± 0.02^{ab}	6.00 ± 0.09^{abc}	6.00 ± 0.08^{abc}	5.93 ± 0.06^{BC}
	T4	6.67 ± 0.07^{abc}	6.00 ± 0.04^{ab}	6.67 ± 0.08^{ab}	6.00 ± 0.05^{ab}	6.67 ± 0.06^{ab}	5.60 ± 0.08^{C}
	Means ± SEM	6.47 ± 0.19^{A}	6.53 ± 0.23^{A}	6.60 ± 0.23^{A}	6.667 ± 0.20^{A}	5.87 ± 0.21^{A}	
Taste	To	7.00 ± 0.08^{ab}	7.33 ± 0.00^{a}	8.00 ± 0.05^{a}	8.33 ± 0.05^{a}	6.67 ± 0.07^{ab}	7.33 ± 0.12^{A}
	T1	7.00 ± 0.05^{ab}	6.33 ± 0.05^{a}	6.67 ± 0.04^{ab}	6.67 ± 0.09^{ab}	5.33 ± 0.05^{bc}	6.73 ± 0.11^{AB}
	T2	6.00 ± 0.07^{ab}	6.67 ± 0.04^{a}	6.33 ± 0.05^{a}	6.33 ± 0.02^{a}	6.67 ± 0.06^{ab}	6.47 ± 0.08^{ABC}
	T3	6.67 ± 0.05^{a}	6.00 ± 0.01^{ab}	6.00 ± 0.03^{ab}	6.0 ± 0.05^{abc}	6.00 ± 0.05^{abc}	5.93 ± 0.08^{BC}
	T4	6.67 ± 0.06^{abc}	6.00 ± 0.04^{ab}	6.67 ± 0.05^{ab}	6.00 ± 0.03^{ab}	6.67 ± 0.08^{ab}	5.60 ± 0.05^{C}
	Means ± SEM	6.47 ± 0.13^{A}	6.533 ± 0.14^{A}	6.60 ± 0.16^{A}	6.667 ± 0.14^{A}	5.87 ± 0.18^{A}	
Texture	To	8.00 ± 0.04^{a}	7.33 ± 0.07^{a}	7.33 ± 0.08^{a}	7.33 ± 0.05^{a}	7.33 ± 0.03^{a}	7.47 ± 0.05^{A}
	T1	8.00 ± 0.05^{a}	6.33 ± 0.05^{a}	6.33 ± 0.05^{a}	6.67 ± 0.08^{a}	6.33 ± 0.02^{a}	6.53 ± 0.09^{AB}
	T2	6.33 ± 0.06^{a}	6.67 ± 0.09^{a}	6.33 ± 0.07^{a}	6.33 ± 0.05^{a}	6.33 ± 0.05^{a}	6.47 ± 0.03^{BC}
	T3	6.67 ± 0.05^{a}	6.67 ± 0.05^{a}	6.00 ± 0.00^{a}	6.00 ± 0.00^{a}	5.00 ± 0.06^{a}	6.07 ± 0.04^{BC}
	T4	5.67 ± 0.00^{a}	6.00 ± 0.02^{a}	5.67 ± 0.08^{a}	5.33 ± 0.03^{a}	5.00 ± 0.01^{a}	5.60 ± 0.05^{C}
	Means ± SEM	6.93 ± 0.05^{A}	6.60 ± 0.02^{A}	6.33 ± 0.08^{A}	6.33 ± 0.0^{A}	5.93 ± 0.05^{A}	
Crispness	To	7.00 ± 0.05^{ab}	6.67 ± 0.05^{ab}	8.00 ± 0.05^{ab}	8.33 ± 0.05^{a}	6.67 ± 0.05^{ab}	7.33 ± 0.05^{A}
	T1	7.33 ± 0.05^{ab}	7.33 ± 0.05^{ab}	7.00 ± 0.05^{ab}	6.67 ± 0.05^{ab}	6.33 ± 0.05^{ab}	6.93 ± 0.05^{AB}
	T2	6.00 ± 0.05^{ab}	6.67 ± 0.05^{ab}	5.33 ± 0.05^{ab}	6.33 ± 0.05^{ab}	6.33 ± 0.05^{ab}	6.40 ± 0.05^{ABC}
	T3	6.67 ± 0.05^{ab}	6.00 ± 0.05^{ab}	6.00 ± 0.05^{ab}	6.00 ± 0.05^{ab}	5.30 ± 0.05^{ab}	5.93 ± 0.05^{BC}
	T4	5.33 ± 0.05^{ab}	6.00 ± 0.05^{ab}	5.33 ± 0.05^{ab}	6.00 ± 0.05^{ab}	5.30 ± 0.05^{ab}	5.53 ± 0.05^{C}
	Means ± SEM	6.47 ± 0.05^{A}	6.533 ± 0.05^{A}	6.60 ± 0.05^{A}	6.667 ± 0.05^{A}	5.87 ± 0.05^{A}	
Overall acceptability	To	8.00 ± 0.00^{ab}	7.67 ± 0.08^{ab}	7.00 ± 0.03^{ab}	7.33 ± 0.02^{a}	6.67 ± 0.06^{ab}	7.33 ± 0.04^{A}
	T1	7.33 ± 0.08^{ab}	7.33 ± 0.03^{ab}	7.00 ± 0.03^{ab}	6.67 ± 0.02^{ab}	5.33 ± 0.05^{ab}	6.73 ± 0.03^{AB}
	T2	6.00 ± 0.0^{ab}	6.67 ± 0.08^{ab}	6.67 ± 0.02^{ab}	6.33 ± 0.07^{ab}	6.67 ± 0.07^{ab}	6.47 ± 0.04^{B}
	T3	6.66 ± 0.08^{ab}	6.00 ± 0.04^{ab}	6.00 ± 0.06^{ab}	6.00 ± 0.08^{ab}	5.00 ± 0.02^{b}	5.93 ± 0.03^{BC}
	T4	5.33 ± 0.08^{ab}	6.00 ± 0.00^{ab}	5.33 ± 0.09^{ab}	6.00 ± 0.02^{b}	5.33 ± 0.01^{ab}	5.60 ± 0.01^{C}
	Means ± SEM	6.67 ± 0.03^{A}	6.60 ± 0.04^{A}	6.53 ± 0.05^{A}	6.47 ± 0.06^{A}	5.80 ± 0.06^{A}	
	T_0 =	Control					
	T_1 =	12.699 $FeSO_4.7H_2O$ +*EDTA mg					
	T_2 =	14 g sweet basil leaves powder					
	T_3 =	16 g sweet basil leaves powder					
	T_4 =	18 g sweet basil leaves powder					

Average values of the fiber acquired by examining samples of treatments with various amounts of sweet basil leaves powder. Table reveals that the fiber content ranged from 0.56±0.002 to 6.84±0.002%.

The statistical studies indicate substantial improvements in treatment due to a rise in the concentration of powder in cookies with an increase in fiber content. Maximum fiber content was observed in T_4 which contains 18 g of sweet basil leaves powder. The amount of crude fiber increased with the amount of chai seed addition as studied by Chelladurai *et al.,* (2019). The amount of fiber content recorded by Patimah *et al.,* (2019) was 4.51 percent in cookies made from foxtail millet and flying fish. Vijerathna *et al.,* (2019) studied the fiber content (wet weight basis) of bagasse powders with peel were

12.43±0.30%, and without peel and 8.61±0.38% in cookies enriched with sugarcane bagasse as a fiber source without addition of sugars.

The mean values for NFE elucidated statistically significant variations among the sweet basil leaves powder cookies. During 60 days of storage, the NFE content of cookies has had a significant impact. The means of treatments for NFE content in cookies were ranged from 50.53±0.078 to 63.44±0.067% (Table). Furthermore; the present study was supported with Patimah *et al.,* (2019) who reported the amount of NFE was 45.19% in cookies developed from foxtail millet and flying fish. Chelladurai *et al.,* (2019) studied carbohydrate present in control (44.8%), T_1 (46.7%), T_2 (48%) and T_3 (48.38%) Chia seed enriched cookies.

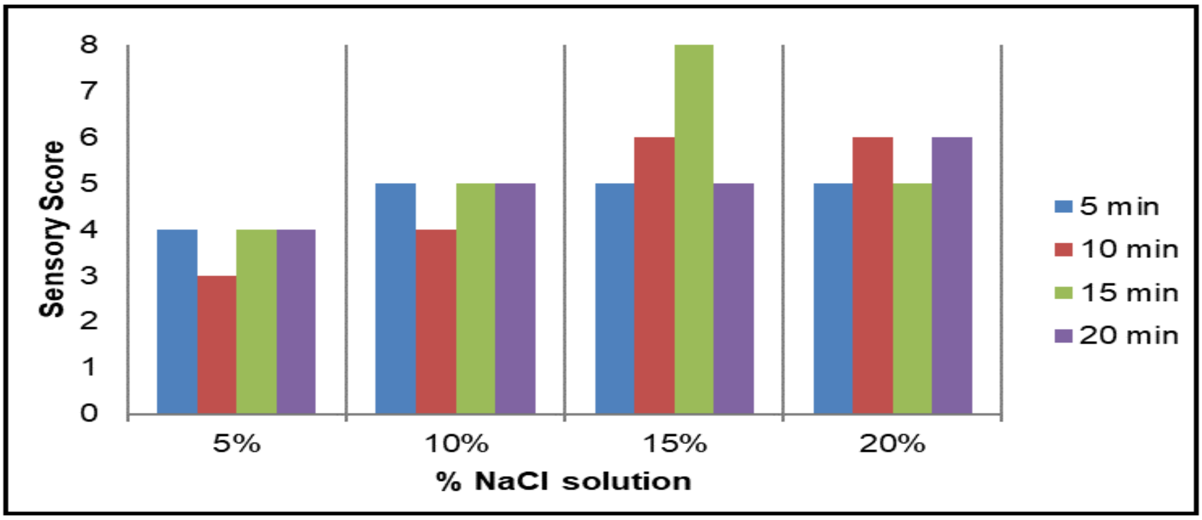

Fig. 1. Sensory evaluation score of de-bittering of sweet basil leaves.

Thiobarbituric acid value

Thiobarbituric acid number is a quantity based on the reaction of thiobarbituric acid with the oxidation of oils to form a red color. Means for TBA No. (Table) showed non-significant variations between cookies fortified with sweet basil leaves powder, while TBA No. ranged from 0.047±0.003 to 0.0491±0.005 mg malenaldehyde/kg. Nevertheless, there was an improvement in TBA no. cookies during two months of storage (Table 6) with a minimum value at research initiation (0.0449±0.004 mg malenaldehyde/kg) which was increased substantially to 0.0453±0.003, 0.0493±0.005, 0.0502±0.003 and 0.0518±0.004 mg malenaldehyde/kg, respectively, after 15, 30, 45 and 60 days of storage.

This may be due to a rise in moisture during storage. However, all interventions were found within safe limits (Table). In similar study by Fellers and Bean (1977) an increasing trend possibly due to intrinsic enzymatic activity, intensified by increased moisture during the storage, was detected in cereal-based baked food. Good quality refined oil has a TBA value of 0.02-0.08, whereas low-storage oils have a value of 0.1-0.2 mg malenaldehyde/kg. Higher temperature, light and moisture are the main reasons that enhance the TBA value during storage period (Kent, 1994).

Calorific values of treatments

Means for calorific value indicated highly significant differences among the cookies fortified with sweet basil leaves powder and ranged from 418.34±0.03 to 453.73±0.05 kCal/100 g (Table). Storage interval indicated non-significant effects on calorific value. Its mean value at baseline (0 day) was 434.43±0.04 kCal/100 g kcal that remained non-significant during interval of 60 days. However, highly significant effects of treatments on this variable were appeared. The mean calorific values of T_0 (control), T_1, T_2, T_3 and T_4 were 453.73±0.08, 447.37±0.05, 427.28±0.03, and 423.88±0.01 and 418.34±0.03 kCal/100 g respectively. In a similar study, Sahé *et al.,* (2019) calculated energy of cookies as 509.1-579.7 kCal/100 g.

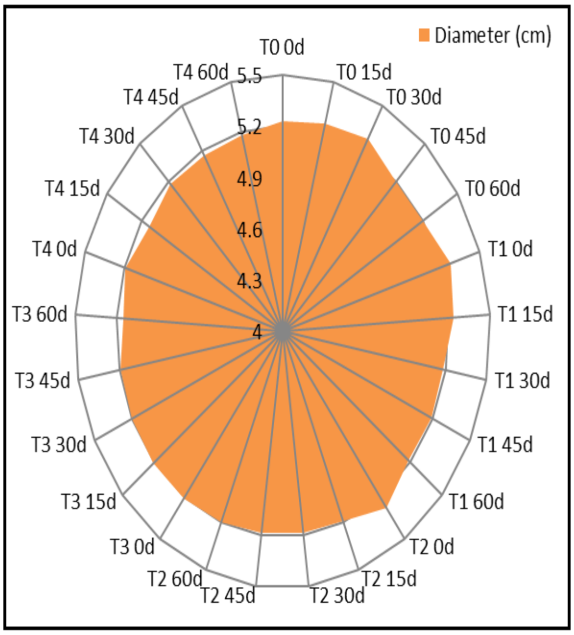

Fig. 2. Impact of treatments and storage on diameter of sweet basil leaves powder cookies.

Sensory evaluation

Sensory assessment was performed by getting the judge's reaction on final product and to score it on a scale. Cookies were tested by a professional taste panel for various sensory characteristics including color, smell, taste, texture and overall acceptability up to 60 days of storage.

Cookies were analyzed on a 9-point Hedonic scale to identify the most appropriate treatments for efficacy purposes by following the process of Meilgaard *et al.,* (2007). Below the findings showed that all sensory properties were substantially influenced by the storage. Treatments and their interaction had a non-differential effect on these characteristics.

The difference among treatment might be due to addition of fortificant. Overall, the color score ranged from 7.47±0.09 to 5.53±0.03 (Table 8). In a comparison test, a substantial decrease in the color of cookies fortified with retinyl acetate was observed (Butt *et al.,* 2007). Nonetheless, cookies were not significantly impacted during storage (Table 8) where the maximum score was observed in fresh cookies (6.93±0.09). It decreased steadily (6.00±0.06) over 60 days, likely due to a rise in the moisture content of cookies.

Absorption of moisture results in a loss of color during storage. There is also a natural pattern of fading color with progressive storage, which eventually affects appearance (Manley, 2011). Similar study by Šimurina *et al.,* (2008) explored that the color of the biscuit was changed (dark brown) by addition of 20% molasses. These results are in close agreement with the findings of Pasha *et al.,* (2002) and Sharif *et al.,* (2005). Likewise, a substantial drop in color scores (7.25 to 6.00) was observed in cookies fortified with retinyl acetate (Mahmood *et al.,* 2008).

Patimah *et al.,* (2019) reported that the score of cookies was 3.7 ± 0.9 for color. Means for flavor scores in Table 8 showed major differences in cookies fortified with different amounts of sweet basil leaves powder ranging from 7.33±0.08 to 5.60±0.08. Nevertheless, storage greatly influenced the taste sensitivity of panelists and continues to decline (6.47±0.19 to 5.87±0.21) over time (Table).

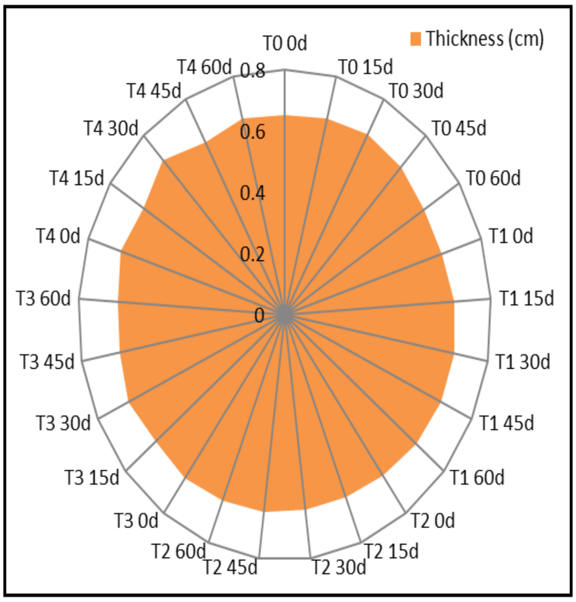

Fig. 3. Impact of treatments and storage on thickness of sweet basil leaves powder cookies.

In previous research, the decrease in flavor scores of retinyl acetate fortified cookies was observed as a feature of storage (Butt *et al.,* 2007). Similar decreases in the flavor of cookies were reported during storage intervals (Sharif *et al.,* 2005).

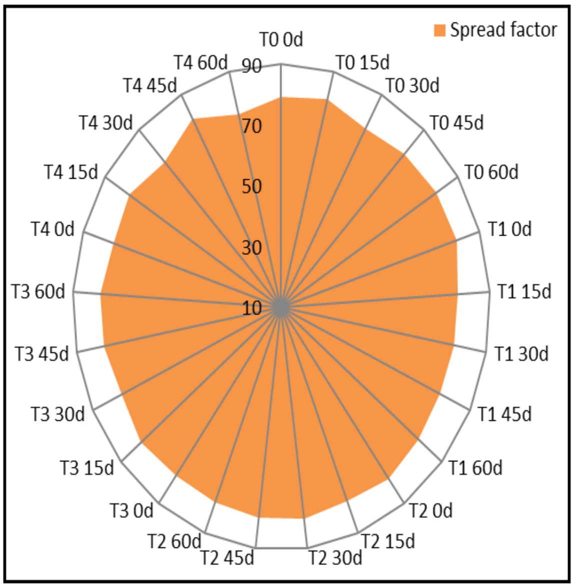

Fig. 4. Impact of treatments and storage on spread factor of sweet basil leaves powder cookies.

Mean scores for the taste of cookies are given in Table 8 where substantial changes in the taste scores of fortified cookies were observed by varying levels of sweet basil powdered leaves from 5.60±0.20 to 7.14±0.14. Furthermore, storage had a differential, deteriorating effect on the taste of cookies (Table 8). Maximum score (6.47±0.13) was obtained by fresh cookies, which then decreased (5.87±0.18) after three months of storage, possibly due to lipolytic changes, which increased the increase in moisture content (Butt *et al.,* 2007). Patimah *et al.,* (2019) reported the score for taste as 3.7±0.9, 3.7±0.9, and 3.5±0.8.

Means for texture scores in Table were described and ranged from 5.60±0.05 to 7.47±0.05. However, there was a small decrease in texture scores with the passage of time from 5.93±0.05 to 6.93±0.05 (Table 8). Patimah *et al.,* (2019) reported that the score for color, taste, and texture was 3.7±0.9, 3.7±0.9 and 3.5±0.8 respectively.

Generally, the crispiness score ranged from 5.53 to 7.33. However, the crispness of fortified cookies during storage period was not declined significantly i.e. 5.87 to 76.4 (Table). The decreasing tendency in quality scores for cookie crispness was probably due to a rise in moisture, which has an inverse association with crispness (Butt *et al.,* 2007).

Total acceptability scores ranged from 5.60 to 7.33. The overall acceptability of cookies during storage had a non-significant decline. Maximum score was obtained by fresh cookies 6.67 on 0 days, which decreased to 5.80 on 60 days of storage.

The reduction in the overall acceptability score was probably due to an increase in moisture during storage, promoting proteolytic and lipolytic changes, leading to a reduction in the quality score for color, flavor, taste, texture and cookie crispness. Related, rising trend in overall acceptability scores was detected by Pasha *et al.,* (2002); Sharif *et al.,* (2005) and Mahmood *et al.,* (2008) in storage stability of cookies.

In this research, maximum levels of sweet basil leaves powder showed no harmful fluctuations in proximate composition. But in sensory assessment, acceptability of cookies is low. Therefore, after product development, three treatments with T_0 (Control), T_1 (12.6991 mg $FeSO_4.7H_2O$ +*EDTA) and T_3 (16 g *Ocimum basilicum* L. leaves powder) were selected to meet the 50% requirement of iron in adolescent girls.

Conclusion

Dried leaves of sweet basil are a rich source of all nutrients as compare to fresh leaves. Bitter taste of sweet basil leaves was discouraging in human consumption. In this study, de-bittering was done with NaCl solution for the improvement of its taste. Sensory attributes revealed that sweet basil leaves powder can be used as fortificant to produce acceptable and high nutritional value biscuits.

Storage stability and fortificant amount both did not affect the physical parameters of powder cookies. Ash, protein, fiber and iron contents are increased with increased the amount of sweet basil leaves powder. Addition of sweet basil leaves powder reduced the calorific value and NEF.

Therefore, it is a healthy caloric snack which can accomplish the nutritional requirements of all age groups and helps in alleviation of anemia.

References

AACC. 2000. Approved methods of the AACC: AACC St. Paul**.**

Amrani S, Harnafi H, Bouanani NEH, Aziz M, Caid HS, Manfredini S, Besco E, Napolitano M, Bravo E. 2006. Hypolipidaemic activity of aqueous ocimum basilicum extract in acute hyperlipidaemia induced by triton WR‐1339 in rats and its antioxidant property. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives **20,** 1040-1045.

Butt M, Sharif K, Huma N, Mukhtar T, Rasool J. 2004. Storage studies of red palm oil fortified cookies. Nutrition & Food Science **34,** 272-276.

Butt MS, Arshad MU, Alam MS, Nadeem MT. 2007. Bioavailability and storage stability of vitamin A fortificant (retinyl acetate) in fortified cookies. Food Research International **40,** 1212-1219.

Chelladurai C, Pandey AA, Panmand SA, Nikam S. 2019. Development of innovative bakery product chia seed enriched cookies. Development **4**.

El Khouly NI. 2017. Comparison of intravenous ferrous sucrose and oral ferrous sulphate in treatment of postpartum iron deficiency anemia. The Journal of Maternal-Fetal & Neonatal Medicine **30,** 967-971.

Faqih AM, Kakish S, Izzat M. 2006. Effectiveness of intermittent iron treatment of two-to six-year-old Jordanian children with iron-deficiency anemia. Food and nutrition bulletin **27**, 220-227.

Feldsine P, Abeyta C, Andrews WH. 2002. AOAC International methods committee guidelines for validation of qualitative and quantitative food microbiological official methods of analysis. Journal of AOAC International **85,** 1187-1200.

Fellers D, Bean M. 1977. Storage stability of wheat based foods: A review. Journal of Food Science **42,** 1143-1147.

Güez CM, Souza ROd, Fischer P, Leão MFdM, Duarte JA, Boligon AA, Athayde ML, Zuravski L, Oliveira LFSd, Machado MM. 2017. Evaluation of basil extract (Ocimum basilicum L.) on oxidative, anti-genotoxic and anti-inflammatory effects in human leukocytes cell cultures exposed to challenging agents. Brazilian Journal of Pharmaceutical Sciences **53**.

Hightower NC, Dworken HJ, Sircus W, Keeton WT. 2020. Human digestive system Encyclopædia Britannica, inc.

Javanmardi J, Khalighi A, Kashi A, Bais H, Vivanco J. 2002. Chemical characterization of basil (Ocimum basilicum L.) found in local accessions and used in traditional medicines in Iran. Journal of agricultural and food chemistry **50,** 5878-5883.

Karimian-Khosroshahi N, Hosseini H, Rezaei M, Khaksar R, Mahmoudzadeh M. 2016. Effect of different cooking methods on minerals, vitamins, and nutritional quality indices of rainbow trout (Oncorhynchus mykiss). International Journal of Food Properties **19**, 2471-2480.

Keast RS, Breslin PA, Beauchamp GK. 2001. Suppression of bitterness using sodium salts. Chimia International Journal for Chemistry **55**, 441-447.

Kent NL. 1994. Kent's Technology of Cereals: An introduction for students of food science and agriculture. Elsevier.

Kirk R. 1999. Sawyer R Pearsons composition and analysis of foods: Addison-Wesley Lingmam Inc., Harlow, England.

Krishna G, Ranjhan S. 1981. Gross energy value of herbage, faeces, urine, milk, meat and silage. Laboratory Manual for Nutrition Research.

Kulkarni S. 1997. Roasted soybean in cookies: Influence on product quality. Journal of food science and technology **34**, 503-505.

Lee J, Scagel CF. 2009. Chicoric acid found in basil (Ocimum basilicum L.) leaves. Food Chemistry **115**, 650-656.

Mahmood S. 2009. Efficacy studies of vitamin A fortified cookies in pregnant and lactating women. University of Agriculture Faisalabad.

Mahmood S, Butt MS, Anjum FM, Nawaz H. 2008. Baking and storage stability of retinyl acetate (vitamin A) fortified cookies. Pakistan Journal of Nutrition **7**, 586-589.

Manley D. 2011. Manley's technology of biscuits, crackers and cookies. Elsevier.

Meilgaard M, Civille G, Carr B. 2007. The spectrum descriptive analysis method. Sensory evaluation techniques **4,** 189-253.

Mohamed S, El Tawila M, Ismail H, Gomaa N. 2010. Evaluation of the level of micronutrients in fortified foods in Alexandria, Egypt.

Paradiso VM, Summo C, Trani A, Caponio F. 2008. An effort to improve the shelf life of breakfast cereals using natural mixed tocopherols. Journal of Cereal Science **47**, 322-330.

Pareyt B, Delcour JA. 2008. The role of wheat flour constituents, sugar, and fat in low moisture cereal based products: a review on sugar-snap cookies. Critical reviews in food science and nutrition **48**, 824-839.

Pasha I, Butt M, Anjum F, Shehzadi N. 2002. Effect of dietetic sweeteners on the quality of cookies. International Jarnal of Agricculture Biololgy **4,** 245-248.

Patel M, Gadhvi H, Patel S, Mankad A, Pandya H, Rawal R. 2018. Holy basil: Holy herb to multimodal medicine for human health.

Patimah S, Arundhana AI, Mursaha A, Syam A. 2019. Development of Foxtail Millet and Flying Fish Flour-Based Cookies as Functional Food. Current Research in Nutrition and Food Science Journal **7**.

PF Guine R, J Goncalves F. 2015. Chemistry and health effects of bioactive compounds in selected culinary aromatic herbs. Current Nutrition & Food Science **11**, 145-164.

Sahé AC, Agbenorhevi JK, Wireko-Manu FD. 2019. Quality Characteristics of Cassava-Ackee-Groundnut Composite Cookies. American Journal of Food Science and Technology **7,** 57-64.

Shan B, Cai YZ, Sun M, Corke H. 2005. Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. Journal of agricultural and food chemistry **53,** 7749-7759.

Sharif K, Sadiq Butt M, Huma N. 2005. Oil extraction from rice industrial waste and its effect on physico-chemical characteristics of cookies. Nutrition & Food Science **35**, 416-427.

Šimurina OD, Filipčev BV, Lević LB, Pribiš VD. 2008. Application of sugar beet molasses in the production of tea biscuits. Food and Feed Research **35,** 201-205-201-205.

Sonmezdag AS, Amanpour A, Kelebek H, Selli S. 2018. The most aroma-active compounds in shade-dried aerial parts of basil obtained from Iran and Turkey. Industrial crops and products **124**, 692-698.

Vijerathna M, Wijesekara I, Perera R, Maralanda S, Jayasinghe M, Wickramasinghe I. 2019. Physico-chemical Characterization of Cookies Supplemented with Sugarcane Bagasse Fibres. Vidyodaya Journal of Science **22**.

Ziena HM, Shamsia SM, Mahgoub SA, Emara MA. 2019. Nutritious Biscuits for Celiac Patients: Effect of Different Cereals and Legumes Blends. Alexandria Science Exchange Journal **40,** 340-346.

Zoulias EI, Oreopoulou V, Kounalaki E. 2002. Effect of fat and sugar replacement on cookie properties. Journal of the Science of Food and Agriculture **82,** 1637-1644.

Zoulias EI, Piknis S, Oreopoulou V. 2000. Effect of sugar replacement by polyols and acesulfame-K on properties of low-fat cookies. Journal of the Science of Food and Agriculture **80,** 2049-2056.