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Physico-chemical and sensory properties of cakes supplemented with different concentration of soy flour

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Abstract
The aim of this work, evaluation of some physicochemical and sensory properties of cake supplemented with soy flour as partially substituted of flour at different levels (5, 10, 15 and 20 %). The protein content of cake samples is increased with increasing percentage of soy flour fortification. During storage period the level of peroxide value and acid value are reasonable range 10-20 m Eq/kg which is more acceptable. Though L*value decreased but a* and b* values were nearly same after 20 days storage period. For crumb color, as the level of soy flour increased, the L, a, and b values decreased. Control sample is not more acceptable than soy based cakes in terms of sensory properties. While in taste, color and texture there were significant differences in control and other concentrations but still acceptable. Overall, soy based cake could be developed as a food with more effective protein content.

Keywords: soy flour, cake, physico-chemical properties, crumb, sensory characteristics

Introduction

Generally legumes are known as "a poor man's meat". Soybeans (*Glycine max*) belonging to the family leguminosae constitute and it is one of the oldest cultivated crops of the tropics and sub-tropical regions. It is one of the richest and cheapest sources of plant protein that can be used to improve the diet of millions of people, especially the poor and low income earners in developing countries because it produces the greatest amount of protein used as food like bread, cake, biscuit etc. (Man Liu, 2000).

Nutritionally, soybean proteins are mainly vegetable protein more closely animal protein. They supply protein, complex carbohydrates, fibre, essential vitamins and minerals to the diet, which are low in fat and contain no cholesterol. Soybean contains, 43% protein, 9.5% fat, 21% carbohydrate and provides 432 kcal per 100g Gandhi (2005).

In Bangladesh, in terms of area and production soybean is such a minor crop concentrated only in few distinct locations. The total cropped area of soybean is 5000 ha and the total production of the country stands at 4000 tons (Sattar, 2005). Improved variety and irrigation in particular can improve the yield of soybean Rabbani *et al.* (2004).

Soybean provides high quality nutrition, nutraceuticals and therapeutic ingredients that help people to feel better and live longer with enhanced quality of life. According to the FDA, the risk of heart diseases and cancer can reduce by adding more soy to the diet. From the last few decades soy protein has an increasing role in human nutrition Riaz (2001). Health benefits which include in soy protein have reduced blood pressure, lower cholesterol levels and improved bone health Adelekun*et al.* (*2005*). Nine essential amino acids also present on soy protein Riaz (2001).

Soy proteins have been widely accepted in applications because they provide desirable functionalities in fabricated foods with lower costs Amudha (2002) [5]. Soy has been researched when incorporated in cookies, bread, extruded puffs, pasta Buck *et al*. (1987) [8] or in combination with rice Payumo*et al*. (1982) or with corn.

Cakes are baked products highly appreciated by the consumers worldwide, being characterized by a dense, tender crumb and sweet taste. Their quality mostly depends on ingredients used in the recipe, i.e. wheat flour, eggs, sugar, fat or oil and leavening agents, as well as on conditions prevailing during their preparation e.g. mixing & baking (Contorti, 2014).

The term food fortification or enrichment is the process of adding micronutrients (essential trace elements and vitamins) to food. Several studies have previously reported increased protein content in soybean fortified cereals and tubers, which make a very significant contribution towards the alleviation of protein energy malnutrition Kolapo and Sanni (2005) [14].

The research intended to explore the possibility of fortifying the soya to formulate the functional cake which has the ability to improve the quality of food products due to various functional properties. Being a good source of protein and minerals, soy flour also helps in keeping good health. With all ingredients in value added products the utilization of soy flour in convenience food has a long way to utilize the flour with value addition for marketability and to create employment among rural women for economic empowerment.

The utilization of soy flour in an industrial level is important for product market strategy. Hence, the study was undertaken with making soy flour based cake with following specific objectives.

1. Prepare cake supplemented with soy flour as a functional food for improves protein quality.
2. Analysis of physical and proximate composition of prepared cake samples.
3. To measure color and sensory properties of soy based cakes.

Materials and Methods

Materials

In this study, after determined in accordance with previous studies the most consumed variety of soybeans flour were purchased from the Karwan bazar, Central region of Dhaka and refined wheat flour, shortening, baking powder, milk powder, salt, ghee and other general ingredients were procured from the local market.

Formulation of composite flour for cake preparation

This experimental work was done with different high levels of Soy Flour (SF) incorporation so as to select the range of percent incorporation which could be used in formulating composite flour for cakes. In order to justify the use of cakes as a healthier product, ghee was used instead of using other flavor components. Sugar powder was also used as a sweetener and coloring agent. Further systematic studies have been carried out by considering following composite flour formulation for cake preparations:

T_0 - Refined wheat flour (RWF) without incorporation of soy flour (SF)
T_1- 5% replacement of RWF with SF
T_2 - 10% replacement of RWF with SF
T_3 - 15% replacement of RWF with SF
T_4- 20% replacement of RWF with SF

Recipe

Wheat flour: 23%
Milk powder: 1.6%
Sugar: 23%
Baking powder: 1.8%
Egg: 23%
Ghee: 1.8%
Oil: 20%
Salt: .17%

Proximate composition analysis

Determination of Moisture content

Moisture content was determined by oven drying method (AOAC, 2004). Samples were dried in the oven under a certain temperature and brought to constant weight. The amount of moisture was calculated from the resulting weight loss.

Determination of Ash content

AOAC method (2000) [6] was used to determine the total ash content in sample. The organic matter in the sample was burned in the ash oven at certain temperatures (550 ± 25ºC or 900 ± 10° C) and the residue obtained was weighed and the amount of ash was calculated.

Determination of Protein content

Bradford method was used to determine the crude protein content in sample with quite modification as described by Kruger (1997).

Determination of Fat content

Fat content of the sample was determined according to the method (AOAC, 2004). The amount of fat was determined with the soxhlet device.

Color measurement

Color measurement was carried out by Minolta colorimeter following the modified method reported by Saeid *et al*., (2016) [27].

Cross- sectional observation and color determinations of soya cake

The center of each cake was cut lengthwise after cooling the cake and the picture of the section was taken with a digital camera (Sony). The color determinations of the soya cake sample (Crumb only) from the midsection of the cakes were measured using a color spectrophotometer set for Hunter L (lightness), a (redness), b (yellowness) and ΔE (total color difference) values. The results of the Hunter L, a, b values from three replicates.

$$\Delta E = \sqrt{[(L_{sample} - S_{tandard})^2 + (a_{sample} - s_{tandard})^2 + (b_{sample} - s_{tandard})^2]}$$

Volume determination of soy based cake

The volumes of cakes were determined immediately after baking by the rapeseed displacement method (Campbell, *et al*., 1987). Baking loss (BL) was determined by weighing cakes 24 h after baking and using the following equation:

$$BL\ (\%) = [(B\text{-}C)/IW] \times 100$$

Preparation of Lipid Extract

The preparation of lipid was according to the modified Baiano *et al.* (2005) procedure. The lipid was extracted from sponge cake sample (100 g), mixed with 200mlpetroleum ether in a flask with a stopper, and kept at room temperature over night, then filtered through what man No. 1 filter paper. The extracted lipid was stored for subsequent determination.

Peroxide Value

Peroxide value (PV) of extracted lipid was determined according to the GB/T of the Chinese standard (GB/T 5009.37-2003).

Three grams lipid samples were mixed with a mixture of chloroform and acetic acid (2:3) solution. Then, 1 ml saturated potassium iodide was added and the solution was kept in the dark for 3 minutes. After stabilization, 100 ml distilled water and 1ml starch solution (1 g 100 mL-1) was added into the solution and titrated with $Na_2S_2O_3$ until reaching the end point (colorless). Peroxide values were calculated as follows:

$$PV\ (meq\ kg\text{-}1) = \frac{(V_1 - V_2) \times c \times 100}{m}$$

Where, V_1 is the titration amount of standard volumetric $Na_2S_2O_3$ for the sample (ml); V_2 is the titration amount of standard volumetric $Na_2S_2O_3$ for the blank (ml); *c* is the concentration of standard volumetric $Na_2S_2O_3$ (mol L-1), and *m* is the weight of the sample (g).

Acid Value

Acid value (AV) of the extracted lipid was determined according to the GB/T of the Chinese standard (GB/T 5009.37-2003).Three grams lipid sample was weighed and50ml mixture of diethyl ether and ethanol (2:1) was added. Then, 0.1mlphenolphthalein indicator was poured into the solution. The solution was titrated with0.05 mol L^{-1}KOH until reaching the endpoint (reddish). Acid values were calculated as follows:

$$\text{Acid value} = \frac{v \times C \times 56.1}{m}$$

Where, V is the titration amount of standard volumetric KOH solution used (ml); c is the concentration of the standard volumetric KOH solution (mol L-1), and *m* is the weight of the sample (g).

Organoleptic quality of cakes

The sensory evaluation of prepared soya cakes was carried out by a 15 member trained panel comprising of undergraduate and postgraduate students and academic staff members of faculty who had some previous experience in sensory evaluation of bakery products.

The panel members were requested in measuring the terms identifying sensory characteristics and in use of the score. Judgments were made through rating production a 9 point Hedonic Scale with corresponding descriptive terms ranging from 9 'like extremely' to 1 'dislike extremely' according to the method reported Saeid *et al*., (2021) [26].

Results and Discussion

As considering poor man's meat, soy flour is a good source of protein and has several potentialities for value addition. The results of the studies on soy based cake in terms of physical and compositional properties, storage quality, and standardization and consumer acceptability of value added product are presented in this chapter.

Proximate composition of wheat - soybean cakes

The nutritional analysis of the cakes indicated that all the cakes contained favorable proportion of protein, fat and other nutritional composition.

Table 1: Proximate Compositions of Prepared Cake Samples.

Samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
T1	12.81±0.20^{a}	12.55±0.07^{d}	21.51±0.01^{e}	1.71±0.00^{c}	51.40±0.28^{a}
T2	12.56±0.06^{b}	15.04±0.10^{c}	27.73±0.04^{d}	1.58±0.05^{c}	43.08±0.16^{b}
T3	11.00±0.02^{c}	18.06±0.43^{b}	27.95±0.01^{c}	1.92±0.01^{bc}	40.17±0.43^{c}
T4	11.94±0.03^{c}	19.08±0.69^{b}	28.40±0.01^{b}	2.2±0.08^{b}	38.38±0.81^{c}
T5	11.88±0.02^{c}	21.21±1.55^{a}	32.90±0.01^{a}	2.88±0.33^{a}	31.13±1.92^{d}

Mean ± standard deviation values (n = 5) followed by a different lower-case letter within the same column are significantly different (P <0.05) by Duncan's multiple range test.

Moisture

The highest moisture content of 12.81% was observed in control cake. The results showed that the moisture content gradually decreased from 12.81 to 11% with the increase of soy flour from 0 to 10% as shown in Table 1. This is due to the fact that soy flour contained greater amount of total dry solid with high emulsifying properties compared to wheat flour. The moisture content of the cake decreased with the increasing amount of soy flour in the blend due to low moisture content of the beans. This is an agreement with the findings of Sutharshan *et al*. (2001) [29] who reported that increase in proportion of soy flour reduces the moisture content of the soy bean flour supplemented cake. But suddenly the moisture content increased 11 to 11.94% with increase of soy flour from 10 to 15%.The moisture content of the cake increase with the increase in supplementation this is could be due to the fact that soya and wheat flour absorb moisture in baked product.

Protein content

The basic use of soy flour as an economical protein supplement in cake, biscuit, bread, pasta and other cereal products, hence the soybean protein is an excellent complement to lysine-limited cereal protein Hegstad (2008). The protein content of the cakes were increased from 12.55 to 21.21% (Table 1) with the increase in soybean flour from 0 to 20%.

In the flour blend the proportion of soybean increased so that the protein content could be increased. The quantity &quality of protein content of the food product improved by adding of soy flour. Soybean is a high protein legume and incorporation of soy flour inevitable increase the protein content in the cakes. Addition of soy flour increase the protein, fat and the essential amino acids content thereby has a greater potential in overcoming protein-calorie malnutrition in the world Akubor and Ukwuru (2005) [2].

Fat content

Soybean is a protein rich oil seed, which is presently number one edible oil source globally. Soybean is rich in polyunsaturated fats, including the two essential fatty acids, linoleic and linolenic, that are not produced in the body. Linoleic and linolenic acids aid the body's absorption of vital nutrients and are required for human health Hegstad (2008). Soybean oil is 61% polyunsaturated fat and 24% monounsaturated fat which is comparable to the total unsaturated fat content of other vegetable oils (85%). The fat content of the cakes increased from 21.51 to 32.9% with increase in soybean flour from 0 to 20% (Table 1).The increase in the fat content could be due to the increase in the proportion of soybean in the flour blend. This could be due to the fact that soy flour contained higher percentage of fat

than wheat flour. Our results are in agreement with the finding of Akubor and Ukwuru (2005) [2]. Reddy (2004) [25] reported that soy flour contained 20–24% of fat whereas wheat flour contains 0.9–1.1% and most of which are unsaturated in nature.

Ash Content

These are the inorganic material present in ash. Ash content indicated an estimate of the total mineral content in a given quantity of food substance. From Table 1 it is observed that the mineral content of the most preferred composite cake was higher mineral content (2.88) as compare to the control (1.71). The increase in mineral content could be due to the soya flour has higher mineral content as compare to wheat flour.

Peroxide Value

The peroxide value (PV) was employed for determining the formation of lipid oxidation products during storage of the cakes. The changes in PV of lipids are shown in Table 2.

Table 2: Peroxide value and Acid value of prepared cake samples.

Storage time (days)	Analysis value	Samples				
		T1	T2	T3	T4	T5
0	PV	11.02±0.03	10.11±0.13	8.52±0.23	6.17±0.11	4.05±0.42
	AV	2.62	2.13	2.07	1.78	1.75
7	PV	13.62±0.01	10.92±0.07	9.19±0.06	8.01±0.53	5.11±0.15
	AV	2.09	1.78	1.71	1.28	1.32
14	PV	16.45±0.06	12.02±0.04	11.08±0.02	9.92±0.51	7.31±0.07
	AV	1.72	1.22	1.35	1.07	0.99
20	PV	17.22±0.12	13.96±0.17	11.82±0.34	11.32±0.22	8.82±0.18
	AV	1.26	1.03	1.11	0.98	0.81

Peroxide values are mean ± standard deviation for (n=5) samples

PV range of 10-20 mEq/kg indicate that food product is considered rancid but still acceptable, while more than 20 mEq/kg, the food product will considered already rancid and unacceptable to consume (Pearson, 1970). In present study, all samples were considered not rancid and still acceptable. Amongall samples, the cakes treated with marjoram showed the lowest PV throughout storage period than control sample. These results suggested that soy flour were effective in suppressing the oxidation of cakes. Similar findings have been reported by Lu *et al.* (2010); however, the ydid not study the changes of PV during long period. This result indicated that lipid oxidation in cakes could be inhibited by the use of antioxidant activity (Juskiewicz *et al.*, 2008). This result is slightly less with green tea having high antioxidative and radical-scavenging activity (Almajano *et al.*, 2008 and Huvaere *et al.*, 2011) [4].

Acid Value

The acid value (AV) measures free fatty acids and is usually considered to be one of the main parameters reflecting the quality of food during the storage period Rao *et al.*, (2009) [24]. The effect of changes in formulation of lipids is shown in Table 2. Acid value of the control and others concentrations samples at zero time were 2.62, 2.13, 2.07, 1.78 and 1.75 mlequiv O2/ Kg., after three weeks of storage they changed to 1.26, 1.03, 1.11, 0.98 and 0.81 ml equiv. O2/kg respectively. Wagdy and Taha (2012) reported that acid value (AV), IV and PV of the control butter cake was fortified with jojoba hull at zero time were 0.71%, 37.60 g/100g , and 2.7 ml equivalent O2/ Kg., after three weeks of storage changed to3.88%, 19.63 g/100g, and 15.37ml. Equiv. O2/kg, respectively. The increase in AV when compared to control at zero time is explained by the hydrolysis of the oil to free fatty acids which will lead to further formation of aldehydes and ketones Kun (1988).

Physical characteristics of prepared cake samples

Crust and crumb color

All color data are expressed as Hunter L, a, and b values corresponding to lightness, redness, and yellowness respectively. The crumb and crust color of sample were affected by replacement of cake flour with soy flour (Table 3).

All color data are expressed as Hunter L, a, and b values corresponding to lightness, redness, and yellowness respectively. The crumb and crust color of sample were affected by replacement of cake flour with soy flour (Table 3). In general, as soy flour level increased, the crust color became darker, as measured by the color spectrophotometer. The crust of the control (T1) cake was lighter and more yellow compare with the other samples. There was significant difference in crust color of samples and T3 sample contained more similarities to control sample (T1). For crust color as the percentage of soy flour increased L and a values slightly increased, but the total color difference ΔE value showed and increasing trend, indicating that a darker, redder and deep yellow crust was obtained as result of soy flour substitution.

On the other hand similarly the crumb color became darker as the increasing of percentage of soy flour. The crumb of control (T1) cake was lighter yellow compare with the other cake samples. Im and Kim (1999) also reported that for crumb color, the addition of green tea powder or chive powder caused L and a value increased.

Table 3: Physical Characteristics of Prepared Cake Samples.

Properties	T1	T2	T3	T4	T5
Crust color					
L	34.7 ± 1.67^{b}	44.8 ± 0.47^{a}	43.85 ± 0.39^{a}	38.67 ± 3.34^{ab}	32.44 ± 3.2^{ab}
A	13.84 ± 0.56^{a}	16.38 ± 1.04^{a}	17.1 ± 0.59^{a}	13.66 ± 1.21^{a}	15.11 ± 1.66^{a}
B	23.6 ± 1.26^{b}	32.56 ± 1.51^{a}	30 ± 0.97^{a}	28.12 ± 1.90^{ab}	26.49 ± 2.1^{ab}

ΔE	109.87±1.03	98.71±1.26	100.04±.95	105.60±1.13	108.27±1.34
Crumb color					
L	51.17±0.81[a]	59.86±3.6[a]	58.41±3.3[a]	56.02±4.6[a]	63.45±5.6[a]
A	4.97±0.79[a]	2.1±0.16[c]	2.83±0.27[bc]	3.51±0.23[b]	3.72±0.18[b]
B	29.31±2.0[a]	26.01±1.72[ab]	23.49±0.83[b]	25.32±1.37[ab]	26.09±1.33[ab]
ΔE	106.96±1.72	108.96±1.53	110.22±1.27	109.12±1.9	106.99±0.1
Weight (g)	28.46	35.26	35.71	38.4	42.5
Volume (cm^3)	65.0	74.5	75.0	80.4	38.7
Sp. Volume (g/cm^3)	2.28	2.11	2.10	2.09	1.97
Firmness (kg/min)	0.29±0.02[a]	0.316±0.01[a]	0.32±0.03[a]	0.42±0.11[b]	0.82±0.34[c]

Mean ± standard deviation values (n = 5) followed by a different lower-case letter within the same column are significantly different (*P* <0.05) by Duncan's multiple range test.

Browning degrees by amino carbonyl reactions and pyrolysis are reported to influence the chromaticity of prepared cake. In the case of adding a powder different from flour, browning is influenced by the type and color of the added flour, in addition to the folding process in confectioneries and the baking of products (Shin, Choi and Kwon, 2007) [28].

Weight, volume & Specific volume of prepared cake samples

According to (Table 3) cake volume increased as the soy flour percentage increased. During the baking process, baking powder generates gasses, which should be retained in order to guarantee good cake volume, and in that respect flour quality has an important role to play.

The specific volume of the samples gradually decreased with the increasing of soy percentage of cake. Howard *et al.* (1972) pointed out for layer cakes, whereas Mizukosh *et al.* (1997) reached the same conclusion for sponge cakes. On the contrary, no significant effect was observed due to the kind of soy flour on volume in prepared cakes. These results indicated the lower effects of the changes in soy flours in cakes.

Firmness of cake

Cake prepared without soy flour had lower firmness than cake prepared with soy flour. From Table 3, the firmness of prepared soy based cake samples ranges from 0.31 to 0.89 kg/min. Firmness depends on transfer of water from moist to dry zone into cake. Another one is starch retro gradation Zhou *et al.* (2011) [31].

Sensory analysis

Sensory attributes like color, flavor, texture, taste and overall acceptability of prepared soy based cakes were evaluated by using 15 experienced panelists. Mean score for sensory evaluation of soy based cakes were given in (Table 4).

Table 4: Mean score of sensory attributes of soya-based cakes

Sample	Color	Flavor	Texture	Taste	Overall acceptability
T1	7.67±0.62[ab]	7.93±0.88[a]	8.20±0.68[a]	8.20±0.68[a]	8.20±0.86[a]
T2	8.33±0.62[a]	7.93±0.70[a]	7.73±0.70[ab]	8.13±0.74[a]	7.67±0.98[a]
T3	7.93±0.88[ab]	7.53±0.63[a]	7.47±0.92[ab]	7.67±1.29[a]	7.87±0.83[a]
T4	7.87±0.91[ab]	7.27±0.79[a]	7.20±0.68[b]	6.80±1.52[b]	7.67±0.98[a]
T5	7.53±1.25[b]	7.33±1.39[a]	5.53±1.59[c]	5.40±1.35[c]	5.27±1.33[b]

From Table 4 the sensory analysis of cake for color (ANOVA) shows that there was slightly significance difference among the samples. The color of the ranked of control treatment T1 (8.33) at top due to excellent appearance, whereas T2 (7.93), T3 (7.67) and T4 (7.87) while minimum color was observed in T5 (7.53). The mean score of color had been decline from 8.33 to 7.53 with increasing level of substitution. Due to color change of cake from light brown to dark brown which leads to lower acceptance O latidoyeop *et al.*, (2011). The one enzymatic reaction (Maillard reaction) between reducing sugar molecules and lysine protein occurs so that the color may be darker Dhingra and Jood (2000) [9].

There were no significant differences in terms of flavor among the five cake samples. Flavor of cake decreased from 7.93 to 7.33 with increasing in the substitution of soybean flour. This could be due to the be any flavor of soy flour Akubor and Ukwuru (2005) [2]. The texture of the cake was related to the external appearance which implies smoothness or roughness of the crust. The texture of crust was decreased from 8.20 to 5.53 with the increased in substitution of soybean flour from 0 to 20% to the cakes. The control treatment had the highest mean value and 20% soy flour added cake had the least mean value.

Taste is the important factor which determines the acceptability of any product, which has the highest impact as far as market success of product. The score for taste had also been decreased from 8.2 to 5.40 with the increased in the level of substitution of soy flour. Cake containing 20% soybean flour was the poorest in taste (5.40). The control treatment (T1) has the highest mean value and 20% soy flour added cake (T5) has the least mean value.

Overall acceptability includes many implications, which is the important parameter in organoleptic estimation. The 10% soy flour added cake had the highest mean value and 20% soy flour added cakes had the least mean value for the overall acceptability. At 10% level of soy flour incorporation, cakes had higher scores for all the sensory attributes evaluated. Above this level, cakes received lower sensory scores.

Conclusion

Soy based cake has much more nutritional quality than previously thought since the protein, carbohydrates, fibre, potassium and magnesium contents observed in this study were quite high. Significant difference was found in organoleptic quality of cakes and T_3 sample (15% replacement of refined wheat flour with soy flour) has more acceptable in terms of color, texture and taste from other samples. Though the color values L^*, a^*, b^* are nearly same but as the percentage of soy flour increased, the color become dark. The volume and firmness of cake samples gradually changes with the percentage of soy flour. The peroxide value and acid value was slightly increased of soy based cakes that refined wheat flour cake and keep good after 20 days. In the point of nutritional view though the

cake samples were slightly dark but had more protein as sufficient to supply as school tiffin.

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