Development of high protein and low calorie cookies

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Abstract Cookies high in proteins and low in calories were prepared by substituting wheat *maida* with defatted soy flour (DSF) at 0, 10, 15, 20 and 25% levels and sugar with stevia leaves powder (SLP) at 0, 15, 20, 25 and 30% levels using traditional creamery method. Cookies were evaluated for physico-chemical and sensory quality parameters. The thickness and hardness of cookies increased; weight, diameter, spread ratio and spread factor decreased with increasing levels of DSF while there was increase in protein, crude fiber and ash content and decrease in fat and carbohydrate contents. The cookies with 20% substitution each of DSF and SLP scored maximum for all the sensory quality attributes. On storage of such cookies in LDPE, HDPE and PP for 90 days at ambient temperature, the sensory quality attributes were decreased, but the cookies were acceptable. The HDPE was better packaging material than LDPE and PP with regard to sensory quality of cookies during storage.

Keywords Cookies · Defatted soy flour · Stevia leaves powder · Spread factor · Spread ratio · Protein · Calories · Sensory quality

Introduction

Soybean (*Glycine max* L.) is a major oilseed crop in India next to groundnut and Indian mustard. Soybean has great potential to provide good quality proteins at low prices.

Soybean has twice as much as proteins as compared to other pulses, groundnut, meat and fish. Soy proteins are unique among plant proteins by virtue of their relatively high biological value and presence of essential lysine which is a limiting amino acid in most of the cereals (Riaz 1999; Kaur et al., 2005).

Protein rich cookies can be prepared from composite flours such as wheat flour fortified with soy, cottonseed, peanut or corn germ flours (Tsen 1976). Defatted soy flour (DSF) is a cheaper, convenient, conventional and richest source of protein for the fast expanding population worldwide (Tripathi and Mishra 2005). Several workers have studied the possibilities of using DSF with wheat *maida* in the formulation of various food products such as cookies (Ranhotra 1980), crackers (Sathe et al. 1981) and biscuits (Singh et al. 1996).

Stevia (*Stevia rebaudiana*) is a small, herbaceous, semi-bushy, perennial shrub of the *Asteraceae* family. It is being cultivated domestically and is used as raw leaf or as commercially processed sweetener (Dwivedi 1999; Dzyuba 1998). Stevia leaves contain a complex mixture of sweet diterpene glycosides, including stevioside, steviolbiosides, rebaudiosides (A, B, C, D, E and F) and dulcoside A (Starrat et al. 2002). Stevioside is the major compound responsible for the sweetness. It constitutes 5–15% of the dried leaves of stevia. Stevia is found to be very beneficial to man because it is 100% natural, zero calories, do not affect blood sugar levels like common sugar, 250–300 times sweeter than table sugar, heat stable up to 200 °C, non-fermentable, flavor enhancer, prevents cavities, recommended for diabetics and obese persons, non-toxic, leaves can be used in their natural state, non-addictive and can be cooked or baked (Panpatil and Polasa 2008). Therefore by supplementing the wheat flour with good quality soy protein, nutritional quality of blend can be improved.

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Moreover, to enhance the utilization of soybean in the daily diet of people, it is highly desirable to develop novel and value added food products of soybean. Also the replacement of sugar with stevia leaves powder (SLP) can help for the utilization of cookies by the health cautious population. The present investigation visualizes the utilization of DSF and SLP for development of protein rich and low calorie cookies.

Materials and methods

The raw materials such as *maida*, defatted soy flour, fat, sugar, vanilla essence, sodium bicarbonate, ammonium bicarbonate, etc. were purchased from local market. The stevia leaves powder was procured from Pune.

Preparation of cookies Cookies were prepared using the traditional creamery method. The ingredients included wheat *maida* 100 g, sugar 50 g, *vanaspati* 40 g, ammonium bicarbonate 1 g, sodium bicarbonate 0.75 g, vanilla essence 0.25 ml and required amount of water. Cookies were prepared by substituting wheat *maida* with 0, 10, 15, 20 and 25% (w/w) DSF and its level was standardized by sensory evaluation. In the DSF standardized cookies the sugar was replaced with 0, 15, 20, 25 and 30% (% sweetness basis) SLP. The cookies were evaluated for physico-chemical and sensory quality.

Physical parameters Weight, diameter, thickness, spread ratio and spread factor of cookies were estimated as per AACC (1976) methods. Hardness of cookies was measured using Instron Universal Texturometer. Each cookie was placed on the loading cell and compressed. The conditions employed were as follows; cross head speed: 50 mm/min, maximum load cell force: 1 kg and compression: 75%. The maximum force required to just break the cookies is the hardness. It was expressed in terms of Newton (N).

Sensory evaluation The cookies were evaluated for sensory attributes by a panel of 50 semi-trained judges, using a 9 point Hedonic scale system (Amerine et al.; 1965) for different parameters like color and appearance, flavor, texture and grain, crispiness, taste and overall acceptability.

Chemical parameters The proximate composition of *maida*, DSF, SLP and cookies was determined as per AOAC (1995) procedures. The crude fiber was determined as per AACC (1976) method.

Storage studies The cookies with maximum sensory score were packed in high density polyethylene (HDPE), low density polyethylene (LDPE) and polypropylene (PP) packages and stored at ambient temperature. The sensory quality of cookies was evaluated after storage period of 90 days.

Statistical analysis The data obtained was analyzed statistically to determine statistical significance of treatments. Completely Randomized Design (CRD) was used to test the significance of results as per the method of Panse and Sukhatme (1967). The experiments were conducted in quadruplicate and the mean values are reported.

Results and discussion

The proximate composition (%) of *maida*, DSF and SLP used to prepare cookies was moisture: 11.5, 6.2 and 8.7; protein: 12.2, 43.2 and 6.0; fat: 1.9, 0.9 and 4.8; ash: 1.0, 1.0 and 1.3; crude fiber: 0.30, 5.49 and 0.45 and carbohydrates: 73.0, 43.3 and 78.8 respectively.

Physical parameters The physical parameters of cookies prepared by substituting *maida* with 0–25% DSF are presented in Table 1. It was observed, the diameter of

Table 1 Effect of different levels of DSF and SLP on physical parameters of cookies

	Levels of DSF (%)							Levels of SLP (%)						
	0	10	15	20	25	SE±	CD at 5%	0	15	20	25	30	SE±	CD at 5%
Weight (g)	9.9	9.9	9.9	9.8	9.6	0.009	0.026	9.8	9.6	9.7	9.7	9.6	0.005	0.014
Diameter (mm)	35.4	35.3	35.1	35.0	34.9	0.112	0.338	35.0	34.3	33.9	33.1	32.5	0.102	0.307
Thickness (T) (mm)	7.0	7.5	7.5	7.5	7.6	0.004	0.013	7.5	7.5	7.5	7.5	7.5	0.003	0.010
Spread ratio (D/T)	5.1	4.7	4.7	4.7	4.6	–	–	4.7	4.6	4.5	4.4	4.4	–	–
Spread factor (%)	100	93.1	92.5	92.1	91.5	–	–	100	98.1	97.2	94.6	93.8	–	–
Hardness (N)	26.9	28.7	29.4	30.4	32.5	0.006	0.017	30.4	30.1	29.7	27.3	25.3	0.004	0.012

Each observation is the mean of four determinations

Table 2 Effect of different levels of DSF and SLP on chemical parameters of cookies

	Levels of DSF (%)							Levels of SLP (%)						
	0	10	15	20	25	SE±	CD at 5%	0	15	20	25	30	SE±	CD at 5%
Moisture (%)	2.3	3.5	3.7	3.9	4.5	0.006	0.019	3.9	3.7	3.5	2.9	2.4	0.008	0.024
Ash (%)	0.9	1.4	1.8	1.9	1.9	0.006	0.019	1.9	1.9	1.9	1.9	1.9	0.156	0.480
Crude fat (%)	23.8	23.1	22.5	21.6	21.0	0.227	0.699	21.6	18.7	17.6	16.7	15.8	0.242	0.747
Protein (%)	6.1	8.1	8.9	10.0	10.5	1.180	3.556	9.9	13.5	12.8	13.1	13.4	1.549	4.667
Crude fiber (%)	0.5	0.44	0.55	0.70	0.85	0.002	0.005	0.70	0.80	0.83	0.87	0.90	0.002	0.005
Carbohydrate (%)	66.8	63.4	62.6	61.9	61.4	0.168	0.519	61.9	62.4	63.4	64.5	65.7	0.212	0.653

Each observation is the mean of four determinations

cookies decreased gradually from 35.4 to 34.9 mm with increasing proportion of DSF. Also there was simultaneous increase in thickness from 7.0 to 7.6 mm. No trend was observed for weight of cookies because the baking was not performed under strict conditions of temperature and humidity. The spread ratio of cookies decreased significantly from 5.1 to 4.6 with increasing level of DSF. The spread factor of cookies decreased from 100 to 91.5% with increased addition of DSF. Reduced spread ratio and spread factor of cookies were attributed to the fact that composite flours of wheat and soy apparently form aggregates with increased number of hydrophilic sites available for competing, for the limited free water in cookies dough (Mc Watters 1978; Yamazaki et al. 1977). Similar results were observed by Singh et al. (1996).

Table 1 also reveals the physical parameters of cookies prepared by replacing sugar with 0–30% SLP. It was observed that the diameter of cookies decreased gradually from 35.0 to 32.7 mm with increasing proportion of SLP. Also there was simultaneous decrease in thickness from 7.5 to 7.5 mm. No trend was observed for weight of cookies because the baking was not performed under strict conditions of temperature and humidity. The spread ratio of cookies decreased significantly from 4.7 to 4.4 with increasing level of SLP. The spread factor of cookies decreased from 100 to 93.8% with increased addition of

SLP. The decreased spread ratio and spread factor was observed because of decreased level of sugar in cookies. This was due to less sugar crystals available for melting which supposed to cause spreading action. Also it was observed that substitution of sugar with SLP caused lowering of shortening required in cookies making. Similar findings were observed by Abboud et al. (1985) who reported that amount of fat affected the cookie spread ratio. Significant decrease in hardness was observed in cookies from 30.4 to 25.3 N with increased SLP. The effect was due to decreasing levels of sugar and fat in the formulation which led to shortness and tenderness. The decreased hardness was due to action of sugar in dispersing of flour gluten. Patel and Rao (1996) reported the tenderizing effect of sugar in biscuits prepared from composite flours (containing 10% untreated, 15% heat treated and 10% germinated bengal gram flours). The decreased hardness could be due to competition of sugar and flour proteins for water which resulted in lack of or reduction in gluten development. Singh et al. (1997) also reported similar results while standardizing the fat and sugar levels in biscuits containing 20% DSF.

Chemical parameters The chemical composition of cookies regarding moisture, ash, crude fat, crude protein, crude fiber and carbohydrate are presented in Table 2. With the increase

Table 3 Effect of different levels of DSF and SLP on sensory quality of cookies

	Levels of DSF (%)							Levels of SLP (%)						
	0	10	15	20	25	SE±	CD at 5%	0	15	20	25	30	SE±	CD at 5%
Color & appearance	7.5	7.3	7.0	7.0	6.8	0.204	0.615	8.0	7.0	7.8	6.5	6.3	0.204	0.629
Texture & grain	7.3	6.3	6.8	7.8	6.5	0.258	0.778	7.5	7.0	7.8	6.5	6.3	0.242	0.728
Flavor	7.5	6.8	6.3	7.8	6.5	0.266	0.802	7.3	7.0	7.5	6.8	6.5	0.303	0.912
Crispiness	9.0	6.8	6.3	7.8	6.5	0.233	0.701	7.3	6.8	7.5	6.8	6.3	0.242	0.728
Taste	9.0	7.5	7.3	8.0	6.5	0.242	0.745	7.5	7.3	8.0	6.5	6.3	0.303	0.912
Overall acceptability	7.5	7.0	7.3	7.8	6.5	0.242	0.728	7.8	6.8	8.0	6.5	6.3	0.296	0.891

Each observation is the mean of four determinations

Table 4 Effect of DSF and SLP incorporation on protein and calorie contents of cookies

Cookies	Protein (%)	Increase in proteins (%)	Calorific value (kcal/100 g)	Decrease in calories (%)
Control	6.1	–	505.7	–
DSF (20%)	10.0	63.9	482.3	4.6
SLP (20%)	12.8	109.8	454.2	10.2

in DSF level in cookies, there was increase in proteins, crude fiber and ash content and decrease in fat and carbohydrate content. The protein content of cookies increased from 6.09 to 10.53% with increasing DSF in cookies from 0 to 25%. The protein of DSF blended cookies was significantly higher than that of control. The crude fiber and ash contents increased from 0.149 to 0.849% and from 0.85 to 1.95% respectively, thus being significantly higher in cookies prepared from DSF compared to that of control. The increase in proteins, crude fiber and ash content of cookies supplemented with DSF might be due to their appreciably higher contents in DSF than *maida*. The moisture content was increased from 2.32 to 4.51% because of high moisture retention capacity of DSF than *maida*. The fat and carbohydrate content of cookies were found to be significantly decreased from 23.77 to 20.96% and from 66.82 to 61.40% respectively with increasing levels of DSF in cookies. The lowered fat and carbohydrate content in cookies might be due to their lower contents in DSF than *maida*. Sathe et al. (1981) reported increased protein content in crackers prepared by replacing wheat flour with soy flour. They reported that the high protein content was associated with the water binding properties of soy flour.

The data in the Table 2 also revealed increase in protein, crude fibre, ash and carbohydrate contents of cookies with increasing levels of SLP up to 30%. The protein, crude fibre, ash and carbohydrate content of cookies increased gradually from 9.96 to 13.38%, from 0.699 to 0.898%,

from 1.92 to 1.99% and from 61.94 to 65.69% respectively, with increasing proportion of SLP. The increase in above nutrients of cookies might not be due to SLP but due to their higher contents in DSF and also because of decrease in the quantities of sugar and shortening in the formulation of cookies. Also there was simultaneous decrease in content of fat and moisture from 21.63 to 15.78% and from 3.85 to 2.39%. This might be because of the decrease in sugar and shortening content in the cookies. Similar results were observed by Singh et al. (1997) in the standardization of fat and sugar contents of biscuits containing 20% DSF. The incorporation of DSF and SLP in cookies had great influence on the protein and calorie contents of cookies. The data regarding changes in protein and calories contents presented in Table 2 show that the protein content was increased significantly ($P>0.05$) from 6.09 to 10.53% on substitution of *maida* with 25% DSF and from 9.96 to 13.38% on substitution of sugar with 30% SLP. All other chemical constituents were also significantly ($P>0.05$) changed more predominantly the decrease in crude fat content.

The data regarding changes in protein contents presented in Table 2 show that the protein content was increased from 6.1 to 10.0% on substitution of *maida* with 20% DSF and to 12.8% on substitution of *maida* with 20% DSF and substitution of sugar with 20% SLP. However, the ash and crude fiber contents in cookies were increased with increasing amount of DSF and SLP. The increase in protein content was because of use of DSF in the formulation which itself contained high amount of protein. In the present investigation, the use of DSF and reduction in the quantities of sugar and shortening might be the reason for decrease in carbohydrate and fat contents of cookies, which might have resulted in reduction of calories in cookies.

Sensory evaluation The data about sensory evaluation of cookies incorporated with DSF and SLP are presented in Table 3. The data revealed that cookies with 20% DSF obtained highest scores of texture and grain (7.8), flavor

Table 5 Sensory quality of cookies during storage for 90 days

Storage conditions fresh	Sensory quality attributes					
	Color & appearance 8.0	Texture & grain 8.0	Flavor 8.8	Crispiness 8.6	Taste 8.4	Overall acceptability 8.0
Packaging materials LDPE	6.6	6.6	6.4	6.4	6.4	6.4
HDPE	7.2	7.2	7.0	7.4	7.0	7.2
PP	6.0	6.4	6.2	6.0	6.0	5.8
Mean	6.6	6.7	6.5	6.6	6.5	6.5
SE±	0.183	0.231	0.183	0.200	0.141	0.216
CD at 5%	0.563	0.712	0.563	0.61	0.436	0.666

Each value is the average of 10 observations

(7.8) and overall acceptability (7.8) as compared to control and other samples. It was observed that, the score of color (7.5), crispiness (9.0) and taste (9.0) were higher in control sample. However, the cookies with 20% DSF were better with respect to overall acceptability. Thus on overall acceptability score of cookies with 20% DSF was considered as standardized and used for further studies. Sathe et al. (1981) reported similar results after replacing *maida* with soy and groundnut flours at 15% level to prepare protein enriched crackers. Singh et al. (1996) reported that DSF could be incorporated up to 20% level in biscuits without affecting their overall quality.

Per cent increase in protein and decrease in calories content of standardized cookies The standardized and the maximal scored cookies for overall acceptability on addition of DSF and SLP each at 20% were assessed for % increase in protein content and decrease in calories content. The data are presented in Table 4. The protein content was increased from 6.1 to 10.0 on addition of 20% DSF and to 12.8% on addition of DSF and SLP each at 20%. The increase in protein content of above standardized cookies was 63.9% over the control sample prepared with 20% DSF and 109.8% over the control sample prepared with DSF and SLP each with 20%. Singh et al. (2000) reported increased protein content by about 115.0% in biscuits containing 20% DSF. The calorific value of cookies was found to be decreased from 505.7 to 454.2 kcal/100 g with the substitution of *maida* with DSF and sugar with SLP in the cookies. Thus the % decrease in the calories of the above standardized cookies containing 20% each of DSF and SLP was 10.2%. Onweluzo and Iwezu (1998) reported increase in calories of biscuits prepared from blends of wheat-soy flour and cassava-soy flour.

Storage studies The data on sensory quality of cookies with 20% substitution each of DSF and SLP stored in different packaging materials at ambient temperature for 90 days presented in Table 5 show that scores for color and appearance, texture and grain, flavor, crispiness, taste and overall acceptability of cookies packed in LDPE, HDPE and PP packages decreased during storage. However, no undesirable changes were noticed in any of the sensory quality attributes in the cookies. Among the packaging materials HDPE was better than LDPE and PP.

Conclusion

High protein and low calorie cookies can be prepared by substituting wheat *maida* with DSF and sugar with SLP up to 20% each in the formulation without affecting their overall acceptability. The substitution of *maida* with DSF

(20%) and sugar with SLP (20%) in cookies resulted in 109.8% increase in proteins while 10.2% decrease in calories of the cookies. The high protein and low calorie cookies can be stored at ambient temperature (30–35 °C) for 90 days with acceptable sensory attributes. The HDPE packaging material was better than LDPE and PP.

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