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Physical & sensory properties of cookies prepared by utilizing wheat germ oil and defatted wheat germ

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ABSTRACT

The weight and thickness of DFWG supplemented cookies was affected significantly by the treatments as well as storage intervals. However, diameter and spread ratio of these cookies differed significantly by the variation in treatments but differed non significantly throughout the storage period of two months. The weight of cookies increased from 14.11 g to 15.67 g among different treatments, while thickness decreased from 1.37 cm to 1.29 cm by the incorporation of DFWG flour in the formulation of cookie. The diameter and spread ratio of cookies decreased from 7.43 cm to 6.16 cm and 5.75 to 4.44, respectively as the proportion of DFWG flour increased in the blends. The sensory parameters of cookies i.e. color, flavor, crispiness and overall acceptability varied significantly due to differences in treatments as well as storage intervals. The scores assigned to these sensory attributes of cookies containing DFWG flour upto 15% were almost similar or even more than that of cookies prepared from 0% DFWG. The cookies prepared from 20% and 25% supplementation of DFWG were least preferred by the panellists for all of these sensory parameters. Scores for overall acceptance assigned by judges to the cookies prepared from different flour blends decreased progressively with the passage of time during storage and the lowest values for color, flavor, crispiness and overall acceptability were attained by the cookies tested after 60 days of storage.

Key words: sensory properties, defatted wheat germ (DFWG),

Introduction

Wheat (*Triticum aestivum*) is an important food crop of the world in terms of both areas cultivated and production of the world. The major products resulting from the dry milling of wheat are flour, bran and wheat germ. These products resulting from separating the wheat grain into its three distinct parts: the mealy or starchy endosperm, which is subsequently processed into fine flour; the bran which is composed of the pericarp, the seed coat and the aleurone layer; and the germ that consists of the embryonic axis and the scutellum (Kent and Evers, 1994). Belderok (2000) reported that wheat grains from current commercial varieties normally contained about 2 to 3% germ, 13 to 17% bran and 80 to 85% endosperm, on dry matter basis. The wheat germ is the embryo of wheat kernel which is separated from wheat during milling (Grela *et al.,* 1993). It is sodium and cholesterol free, and dense in nutrients such as protein, lipids, dietary fiber, tocopherols, magnesium, phosphorus, thiamine, and zinc (Ge *et al*., 2000). The wheat germ averages about 27 to 30 % protein (mainly albumin and globulin), 8 to 11% lipids (mainly poly unsaturated fatty acids), 15 to 20% sugars (mainly saccharose and raffinose), 4 to 5% ash and 8 to 10% fiber (mainly cellulose and hemicellulose) (Kent and Evars, 1994). Similarly, Claver and Zhou (2004) also reported the composition of wheat germ as 36% protein, 10% oil, 4% ash and 5% crude fiber.

Defatted wheat germ (DFWG)

Wheat is a significant source of protein but wheat protein is limited by the low content of two essential amino acids, lysine and threonine. Lookhart and Bean (2000) reported the low levels of lysine in the wheat kernel due to low proportions of lysine in the gluten proteins, which are located mainly in the endosperm, whereas the lysine-rich albumins and globulins are located mainly in the bran and the germ. Thus the deficiency of these essential amino acids in wheat may be recovered by the addition of more essential amino acid-rich proteins to provide a balanced diet.Ge *et al.* (2000) has reported that the DFWG amino acid contained amino acid content 26.79 g/100g, with relatively higher amount of eight essential amino acids. The lysine and threonine, two limiting amino acids in wheat, have been reported

to be present in amount of 2.35 mg/100g and 0.975 mg/100g, respectively in DFWG. Matz (1991) also found that DFWG protein contained the highest lysine content (5.3 to 6.3%) as compared to other wheat fractions. Zhu *et al.* (2006) found crude protein content of DFWG flour to be 30.42% while that of DFWG protein isolate was 84.18%. The amino acid composition of DFWG flour and protein isolate were compared to the Food and Agriculture Organization/World Health Organization (FAO/WHO) reference protein and DFWG flour and DFWG protein isolate had well-balanced amino acid profiles except the deficiency of cystine.

Sidhu *et al.* (1999) have observed that DFWG had a protein content of 27.88% compared with 11.35, 12.69 and 15.76% for white flour, whole wheat flour and red fine bran, respectively. The chemical composition of DFWG containing breads, in terms of minerals, protein, fat and dietary fiber contents, has been found to be far superior to that of the white and whole wheat flour bread samples. The DFWG possesses reasonable substantial amounts of mineral elements that are essential to human nutrition (Ge *et al*., 2000). The researchers reported that potassium and phosphorus are the major mineral elements of DFWG with significant quantities of iron, zinc, and manganese. Xue *et al.* (2007) reported that a 100g portion of DFWG provided 100 % of the US recommended daily allowance (RDA) for potassium, and manganese, 87 % of magnesium, 57 % to 65 % of iron and phosphorus, and 13 % to 35 % of zinc, calcium and copper but deficient in sodium.

Materials and methods

The research work was conducted to characterize the wheat germ and assess its suitability for the preparation of cookies. The cookies made by using WGO was evaluated for chemical composition.

Extraction of WGO

The oil was extracted from wheat germ through solvent extraction technique by using n-hexane. The extracted oil was heated at 40°C to remove the last traces of solvent. The crude oil recovered in this way was kept in desiccator over anhydrous calcium chloride for 24 hours, so that the traces of moisture (if present) could be removed. The percentage recovery of oil was calculated by the formula:

$$\text{Wheat germ oil (\%)} = \frac{\text{Wt. of oil (g)}}{\text{Wt. of wheat germ sample (g)}} \times 100$$

Characterization and utilization of defatted wheat germ (DFWG)

Preparation of DFWG flour

The defatted wheat germ (DFWG) residue after oil extraction from collected germ was smashed and passed through a 200-mesh sieve to obtain DFWG flour, which was packed in polypropylene bags for further studies.

Flour blends formulation

The flour blends were prepared by incorporating DFWG flour in to wheat flour at different concentration levels for the preparation of high protein cookies. The wheat flour was replaced with DFWG flour for blends formulation at different levels as given here in Table 1.

Table.1. Formulation of DFWG supplemented flour blends

Treatments	Wheat Flour (%)	DFWG Flour (%)
T_0	100	0
T_1	95	5
T_2	90	10
T_3	85	15
T_4	80	20
T_5	75	25

The choice of the above levels of DFWG was based on the report of Dreuiter (1978) who reported the maximum level (25%) of wheat flour substitution for an acceptable baked product.

Preparation of DFWG supplemented cookies

The cookies were prepared from DFWG blended flours according to the procedure given in AACC (2000) with some modifications. The basic ingredients used were 380 g of flour blend, 100 g vegetable shortening, 225 g of granulated cane sugar, 21 g of beaten whole egg, 3.75 g of salt, and 1.8 g of baking powder. The dry ingredients were weighed and

mixed thoroughly in a mixing bowl for 3 to 5 minutes. The shortening was added and rubbed-in until uniform mass is formed. The egg was added and dough thoroughly kneaded in a mixer for 5 minutes. The dough was rolled thinly on a sheeting board to a uniform thickness (8 mm) and cut out using a round scorn cutter to a diameter of 35 mm. The cut out dough pieces were baked on greased pans at 160°C for 15 minutes in baking oven. The cookies were cooled at room temperature (30°C) and packed in high density polyethylene bags and stored for two months.

Physical analysis of DFWG supplemented cookies

The physical parameters including, weight, thickness, diameter and spread ratio of cookies were determined during storage period of two months at fortnight basis. The diameter and thickness of cookies were measured with a vernier caliper. The weight of cookies was determined using a Mettler digital top loading balance (PC 400; Mettler, Buchi Switzerland). The procedure outlined by Zoulias *et al.* (2002) was followed for the measurement of thickness and diameter of cookies. Four cookies were placed next to each other and the total diameter was measured. Then, all four cookies were rotated by 90^{o} and the new diameter was measured. The average of the two measurements divided by four was taken as the final diameter of a cookie. Similarly the thickness was measured by placing four cookies over each other and then dividing the total thickness by four. The spread ratio of cookies was expressed as diameter/thickness.

Organoleptic evaluation of DFWG supplemented cookies

The cookies were subjected to sensory evaluation for color, flavor, crispiness and overall acceptability on fortnightly basis according to the preference method of Land and Shepherd (1988). Ten (trained) judges from the National Institute of Food Science and Technology, University of Agriculture, Faisalabad, participated in the sensory evaluation of the cookies on a 9-point hedonic scale. The coded cookie samples were randomized and presented to the judges.

Physical characteristics of DFWG supplemented cookies

Weight

The analysis of variance regarding weight of cookies prepared from different flour blends is presented in Table 1, which revealed that both treatments and storage intervals possessed significant effect on the weight of cookies. However, the interaction between both of these variables did not show significant effect on this parameter. The results for weight of cookies presented in Table 2 indicated that the weight of cookies prepared from different treatments ranged from 14.11 to 15.67 g/cookie. The cookies prepared from flour blends supplemented with 25% DFWG flour (T_5) gave maximum weight i.e. 15.67 g/cookie. The lowest weight was given by the cookies of control T_0 treatment (0% DFWG flour). The results indicated that the weight of the cookies increased progressively with the addition of DFWG flour in the cookie formulation. The means for weight of cookies (Table 2) showed that storage also significantly affected the weight of cookies. The minimum weight (14.46 g/cookie) was observed at 0 day where as increasing trend in weight of cookies was observed with progressive increase of storage period. At 30 days, it was 14.72 g/cookie that increased to 14.94 g/cookie at 60 days of storage. The increase in weight of cookies prepared from different flour blends may be attributed to the higher retention of oil by DFWG flour, which ultimately improved the weight of cookies. Similarly, Larrea *et al.* (2004) prepared the biscuits by incorporating extruded orange pulp and observed that the weight of biscuits was increased during storage. This increase in weight was directly proportional to the amount of moisture absorbed by the biscuits during storage.

Thickness

The results pertaining to analysis of variance for the thickness of cookies prepared from different flour blends explicated in Table 1 indicated that thickness of cookies was significantly affected by the treatments as well as storage intervals. The interaction between treatments and storage intervals was found to be non significant for the thickness of cookies. The results presented in Table 3 showed a consistent decrease in the thickness of cookies with an increase in level of DFWG flour in the formulation of cookies. The thickness (1.37 cm) observed to be the highest in T_0 (control) followed by the cookies of T_1 (5% DFWG flour) with a non significant difference between both of these treatments. The thickness of cookies decreased linearly by supplementation of DFWG flour obtaining lower values for thickness of cookies prepared from T_4 (1.29 cm) and T_5 (25% DFWG). The results for the thickness of cookies indicated that the thickness of cookies decreased progressively during the storage period (Table 3). The cookies prepared freshly possessed higher thickness (1.34 cm) which reduced to 1.33 cm and 1.31 cm after 30 and 60 days of storage, respectively.

Table 2. Effect of treatments and storage on weight (g/cookie) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	13.76	13.99	14.13	14.27	14.41	**14.11^{c}**
T_1	13.87	14.06	14.19	14.33	14.49	**14.18^{bc}**
T_2	14.09	14.22	14.36	14.42	14.55	**14.32^{b}**
T_3	14.12	14.28	14.35	14.49	14.58	**14.36^{b}**
T_4	15.46	15.59	15.64	15.77	15.82	**15.65^{a}**
T_5	15.49	15.6	15.66	15.78	15.83	**15.67^{a}**
Mean	**14.46^{d}**	**14.62^{cd}**	**14.72^{bc}**	**14.84^{ab}**	**14.94^{a}**	

Means carrying same letters within a column or row do not differ significantly (P < 0.01)

Table 3. Effect of treatments and storage on thickness (cm) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					Means
	0	**15**	**30**	**45**	**60**	
T_0	1.40	1.37	1.37	1.37	1.35	**1.37^{a}**
T_1	1.39	1.39	1.37	1.36	1.33	**1.37^{a}**
T_2	1.35	1.33	1.33	1.32	1.32	**1.33^{b}**
T_3	1.33	1.31	1.31	1.30	1.30	**1.31^{c}**
T_4	1.31	1.31	1.30	1.28	1.28	**1.29^{d}**
T_5	1.29	1.30	1.29	1.29	1.29	**1.29^{d}**
Means	**1.34^{a}**	**1.33^{ab}**	**1.33^{ab}**	**1.32^{bc}**	**1.31^{c}**	

M same letters within a column or row do not differ significantly (P < 0.01)

Taylor *et al.* (2008) opined that the gluten development contributes to an expansion in the thickness of cookies. The flour blends supplemented with DFWG flour had lower gluten content due to less gluten proteins in DFWG flour as compared to commercial straight grade flour which might be the reason of the lower values of thickness of cookies prepared from DFWG supplemented flour blends. Hence the reduced gluten content of DFWG supplemented flour blends negatively affected the thickness of cookies.

Diameter

The statistical results in Table 1 indicated that diameter of cookies was affected significantly by the treatments and storage intervals. The interaction between both of these variables showed non significant effect on this parameter of cookies. It is obvious from the results (Table 4) that the diameter was found to be significantly higher (7.43 cm) in the cookies prepared from control treatment T_0 (0% DFWG flour). The cookies prepared from flour blends having 20% DFWG flour (T_4) gave the lowest values of diameter (6.06 cm). The cookies prepared from flour blends containing 20 and 25% DFWG flour were found to be statistically at par for diameter of cookies. It is evident from the results (Table 4.25) that the cookies produced by using DFWG flour supplementation were smaller in diameter than that of control cookies. The effect of storage on the diameter of cookies was found to be non significant (Table 4). However, higher diameter (6.94 cm) was observed in the fresh cookies which remained 6.91 cm after 15 days and then reduced non significantly to 6.89 cm at the end of study (60 days). The data from this study is in conformity to that reported by McWatters (1978), who has studied the effect of soy flour supplementation for the production of cookies and concluded that the extreme water-absorptive properties of soy flour are the cause of these deleterious effects. Similar was in this case where the flour blends supplemented with DFWG gave lower diameter than the cookies prepared from wheat flour (control).

Spread ratio

The spread ratio of cookies reflects the viscous flow of batter during baking. It is obvious from the statistical results given in Table 1 that the spread ratio of the cookies differed significantly among the treatments but varied non significantly among the storage intervals. The statistical results further substantiated that the interaction between storage intervals and treatments was found to be non significant for the spread ratio of cookies. The spread ratio of cookies prepared from different flour blends in Table 5 depicted the highest spread ratio (5.75) for cookies prepared from control treatment (0% DFWG flour) followed by T_1 (5.70) with non significant differences between these two treatments. The results further showed that the minimum spread ratio was observed in treatment T_4 (20% DFWG) and T_5 (25% DFWG) i.e. 4.46 and 4.44, respectively but with non significant difference between both these treatments. The results presented in Table 5 revealed that spread ratio of cookies was not affected significantly by the storage intervals. The spread ratio of the cookies increased from 5.18 (freshly prepared cookies) to 5.23 for the cookies tested at the expiry of study. This slight increase in spread ratio during storage may be attributed to the increase in moisture content which would results flattening effect on the cookies and increased their spread ratio.

Table 4. Effect of treatments and storage on diameter (cm) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	7.35	7.49	7.45	7.47	7.41	**7.43^{a}**
T_1	7.24	7.40	7.44	7.45	7.26	**7.36^{b}**
T_2	7.47	7.35	7.25	7.25	7.21	**7.31^{b}**
T_3	7.30	7.17	7.09	7.08	7.06	**7.14^{bc}**
T_4	6.13	6.12	6.05	6.07	6.11	**6.09^{d}**
T_5	6.16	6.14	6.11	6.04	6.01	**6.16^{d}**
Mean	**6.94^{a}**	**6.94^{a}**	**6.91^{a}**	**6.89^{a}**	**6.89^{a}**	

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

Table 5. Effect of treatments and storage on spread ratio (D/T) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	5.70	5.76	5.78	5.79	5.74	**5.75^{a}**
T_1	5.53	5.65	5.72	5.82	5.67	**5.70^{ab}**
T_2	5.62	5.61	5.53	5.58	5.55	**5.58^{b}**
T_3	5.41	5.39	5.33	5.36	5.35	**5.37^{c}**
T_4	4.41	4.40	4.42	4.46	4.59	**4.46^{d}**
T_5	4.40	4.48	4.46	4.41	4.45	**4.44^{d}**
Mean	**5.18^{a}**	**5.22^{a}**	**5.21^{a}**	**5.24^{a}**	**5.23^{a}**	

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

Sensory Evaluation of DFWG supplemented cookies

Sensory evaluation is usually performed towards the end of the product development or formulation cycle. It is carried out to get opinion of judges towards the product and they rate the liking on a hedonic scale. The cookies are the most important baked product due to their ready-to-eat form, wide consumption and relatively long shelf-life as compared to other baked products (Lorens *et al*. 1979). The sensory evaluation of cookies for various sensory attributes such as color, flavor, taste and overall acceptability was carried out after 0, 30 and 60 days of storage interval by a trained panel of judges. The product was scored on Hedonic score system to find out the most suitable incorporation level of DFWG for cookies preparation.

Color

The results regarding analysis of variance for scores assigned to the color of cookies prepared from different flour blends are shown in Table 6. It is obvious from the results that the treatments as well as storage intervals significantly affected the color scores of cookies, while the interaction between both these variables showed non significant effect on this sensory parameter.

The scores for color of cookies presented in Table 7 revealed that the cookies prepared from T_0 (0%DFWG flour) got the highest color scores (6.46) followed by T_2 (10% DFWG flour) which obtained 6.41 scores for the color and both of these treatments exhibited non significant differences with each other. The cookies from the treatments T_1 (5% DFWG flour) and T_3 (15% DFWG flour) were assigned 6.20 and 6.08 scores, respectively and these scores were statistically at par. However, the cookies prepared from flour blends supplemented with 20 and 25% DFWG flour were not liked by the judges for color scores. The lowest color scores (5.77) were given to the cookies prepared

Table 6. Mean squares for sensory characteristics of DFWG supplemented cookies

SOV	df	Color	Flavor	Crispiness	Overall acceptability
Treatments (A)	5	1.909^{**}	1.566^{**}	1.335^{**}	0.796^{*}
Storage intervals (B)	4	0.342^{*}	0.947^{**}	12.560^{**}	1.525^{**}
A x B	20	0.007^{NS}	0.020^{NS}	0.026^{NS}	0.007^{NS}
Error	60	0.080	0.104	0.085	0.108

**Significant (P < 0.01)

*Significant (P < 0.05)

^{NS} Non significant

Table 7. Effect of treatments and storage on color (scores) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	6.65	6.55	6.50	6.35	6.25	**6.46^{a}**
T_1	6.35	6.25	6.20	6.15	6.05	**6.20^{b}**
T_2	6.55	6.45	6.40	6.35	6.30	**6.41^{a}**
T_3	6.15	6.10	6.10	6.05	6.00	**6.08^{b}**
T_4	6.05	5.95	5.90	5.80	5.75	**5.89^{c}**
T_5	5.90	5.85	5.75	5.70	5.65	**5.77^{c}**
Mean	**6.27^{a}**	**6.19^{ab}**	**6.14^{abc}**	**6.06^{bc}**	**6.00^{c}**	

Means carrying same letters within a column or row do not differ significantly (P < 0.01)

from T_5 (25% DFWG) and T_4 (20% DFWG) but these scores showed non significant difference with each other. It is obvious from the results that decrease in assigning score to the color was observed with increase in the level of DFWG flour incorporation beyond 15% in the cookies. This may be primarily due to the color difference of DFWG flour as compared to commercial straight grade flour. The cookies prepared from straight grade flour got the highest scores (Figure 1) as compared to that of made from 15% and 20% DFWG flour supplementation. The cookies prepared from different levels of DFWG flour are presented in Figure 1 which clearly depicted the color of cookies become lighter as the DFWG incorporation increased. The increase in the lightness may be attributed to the lower content of fat and carbohydrates in DFWG. As maillard reaction of carbohydrates produces the darker color so, the color of DFGW supplemented is lighter than control cookies.

The results presented in Table 7 indicated that storage showed significant effect on the color of cookies prepared

from different flour blends. At the beginning, scores assigned to the color of cookies was 6.27 which decreased to 6.14 and 6.0 after 30 and 60 days of storage intervals, respectively. At 0 day T_0 got the highest color scores (6.65) and the lowest color scores (5.90) were obtained by T_5. The assigning of scores to the color by the judges decreased significantly as the storage of cookies prolonged.

Flavor

The perceptions of flavor are a synthesis of taste and smell impressions, along with texture and are even influenced by appearance. The analyses of variance for scores assigned to flavor of cookies prepared from different flour blends are presented in Table 6. The flavor of cookies was affected significantly by the treatments as well as storage intervals. However, the interactive effect of treatments and storage intervals was found to be non significant for this sensory attribute. The scores for flavor of cookies are presented in Table 4.29. The highest scores assigned to flavor (7.23) for the cookies prepared from flour blends containing 5% DFWG flour (T_1) followed by the cookies prepared from control (T_0) and T_3 (15% DFWG flour). The results further demonstrated that the differences between cookies prepared from 15% DFWG flour and 0% DFWG flour were found to be non significant. The minimum scores for flavor were obtained by the cookies prepared by incorporation 25% DFWG (T_5). It is obvious from the results that the cookies containing DFWG flour upto 15% were acceptable by the judges while the higher levels of DFWG flour incorporation adversely affected the flavor scores given by the judges. The flavor of the cookies prepared from flour blends was affected by the incorporation of DFWG flour in the formulation because DFWG has a typical beany flavor which might resulted in lowering scores in cookies when used in higher amount than acceptable limits. The results further depicted that storage has significant effect on flavor of cookies prepared from different flour blends. The flavor scores obtained by freshly prepared cookies were 7.25 which decreased significantly to 7.0 and 6.80 when cookies evaluated after 30 and 60 days of storage, respectively (Table 8).

Table 8. Effect of treatments and storage on flavor (scores) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	7.50	7.25	7.15	7.00	6.95	**7.17^{b}**
T_1	7.50	7.35	7.25	7.20	7.00	**7.23^{a}**
T_2	7.45	7.30	7.05	6.90	6.85	**7.10^{a}**
T_3	7.35	7.25	7.20	7.10	6.95	**7.17^{b}**
T_4	6.95	6.85	6.70	6.65	6.60	**6.75^{c}**
T_5	6.80	6.75	6.65	6.60	6.50	**6.66^{d}**
Mean	**7.25^{a}**	**7.12^{ab}**	**7.00b^{c}**	**6.90^{cd}**	**6.80^{d}**	

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

Different treatments of DFWG supplemented cookies

Crispiness

The results pertaining to analysis of variance for scores assigned to the crispiness of cookies from different flour blends have been explicated in Table 6. The crispiness of cookies was affected by the treatments as well as storage intervals. The interactive effect of storage and treatments was found to be non significant for this sensory attribute. The scores assigned to the crispiness of cookies made from different flour blends are presented in Table 9. The crispiness scores were found to be the highest (6.54) for the cookies prepared from flour blends containing 10% DFWG flour in the formulation (T_2) followed by T_3 (15% DFWG flour), T_1 (5% DFWG flour), T_0 (0% DFWG flour) but scores for all these treatments showed non significant difference among one an other. All of these four treatments obtained statistically higher scores for crispiness as compared to cookies prepared from remaining two treatments i.e. T_4 (20% DFWG flour) and T_5 (25% DFWG flour). The crispiness scores given to the cookies indicated that judges preferred the incorporation of DFWG flour in the cookies upto 15%, while further increase in the DFWG flour level in the formulation inversely affected the liking of judges for crispiness of cookies. The crispiness of cookies during storage presented in

Table 4.30 showed that crispiness was inversely affected by the storage intervals. The highest scores (6.98) was assigned to the freshly prepared cookies and the lowest scores (5.30) were given to the cookies evaluated at the end of storage period. It is evident from the results that cookies prepared from different flour blends lost their preference for crispiness by the judges with the passage of storage period. The cookies prepared from treatments T_4 (20% DFWG flour) and T_5 (25% DFWG flour) obtained relatively less scores, which may be attributed to the less gluten in the flour blends due to higher level of DFWG flour. However, such a correlation could not be established clearly and other factors like baking of cookies, panelist's attitude and environment at periodical analysis may have contributed towards such factors affecting crispiness.

Table 9 Effect of treatments and storage on crispiness (scores) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	7.20	6.90	6.50	6.00	5.40	**6.40[a]**
T_1	7.00	6.80	6.60	6.20	5.50	**6.42[a]**
T_2	7.30	7.00	6.70	6.10	5.60	**6.54[a]**
T_3	7.10	6.80	6.50	6.00	5.50	**6.48[a]**
T_4	6.70	6.50	6.30	5.70	5.20	**6.08[b]**
T_5	6.00	6.30	6.20	5.60	5.00	**5.94[b]**
Mean	**6.98[a]**	**6.71[b]**	**6.46[c]**	**5.93[d]**	**5.30[e]**	

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

Overall acceptability

The statistical results for scores assigned to overall acceptability of cookies made from different flour blends are presented in Table 6. The overall acceptability of cookies was significantly affected by the treatments and storage intervals but differed non significantly due to interaction between these two variables. The overall acceptability scores of the cookies prepared from different flour blends mentioned in Table 10 showed the highest scores (7.35) for cookies prepared from T_0 (100% straight grade flour) followed by the cookies prepared from T_1 (5% DFWG flour) (7.23), while minimum scores (6.88) were assigned to cookies of T_5 (25% DFWG flour). The results further showed non significant change in the cookies prepared from T_3 (10% DFWG flour) and T_4 (15% DFWG flour), while both of these treatments were significantly different from other treatments for overall acceptability scores. It is obvious from the results that overall acceptability of the cookies remained acceptable upto 15% supplementation of DFWG flour in the cookies. However, further increase in DFWG flour level decreased the liking of panellists for the overall acceptability of cookies. The mean scores for overall acceptability of cookies shown in Table 4.31 indicated that overall acceptability scores reduced significantly as a function of storage. The highest overall acceptability score (7.45) were assigned to the freshly prepared cookies which decreased gradually during storage and the lowest overall scores (6.88) were got by the cookies evaluated at 60 days of storage. For an effective food enrichment program there should be no changes in color, flavor, taste and overall acceptability of enriched food. However, the sensory characteristics degrade during storage of food. During sensory evaluation of cookies it has been found that there was decrease in overall acceptability as a function of storage period and the supplementation level of DFWG flour beyond acceptable limits i.e.15% in the cookies. The decrease in flavor scores could be attributed to the increase in TBA value during storage as reported in the earlier section which may enhance the lipolytic activity and thus rancidity. Moreover increase in the moisture content of cookies during storage also favors hydrolytic rancidity and all these may be the contributory factors towards decline of flavor scores.

Table 4.31. Effect of treatments and storage on overall acceptability (scores) of DFWG supplemented cookies

Treatments	Storage Intervals (days)					
	0	**15**	**30**	**45**	**60**	**Mean**
T_0	7.65	7.50	7.35	7.15	7.10	**7.35[a]**
T_1	7.55	7.35	7.20	7.05	7.00	**7.23[a]**
T_2	7.50	7.4	7.20	7.05	6.90	**7.21[a]**
T_3	7.55	7.35	7.15	7.05	6.95	**7.21[a]**
T_4	7.30	7.05	6.95	6.85	6.70	**6.97[b]**
T_5	7.15	6.95	6.90	6.75	6.65	**6.88[b]**
Mean	**7.45[a]**	**7.26[b]**	**7.12[bc]**	**6.98[cd]**	**6.88[d]**	

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

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