significantly ($p < 0.01$) higher values than $FeSO_4$ and whole wheat, whereas the latter two groups had similar values. The contents of iron in heart remained almost similar in rats fed basal and supplemented diets. Similarly, no significant variations in serum iron levels were observed among different dietary groups.

Thus, the weights of liver, spleen and heart were influenced by level of dietary iron. Source of iron did not induce significant variations in spleen and heart; however, variation in source did influence the liver weights. Maximum liver weights were observed with ferrous sulphate followed by whole egg, spirulina and least with the whole wheat diet. Kidney weights were neither dependent on iron source nor the level. The iron in liver, kidney and spleen varied both with source and level of dietary iron. Iron storage in tissue was higher with $FeSO_4$, whole egg and spirulina than whole wheat. The concentration of iron in serum and heart remained unchanged regardless of dietary iron source or level.

Comparison of different dietary iron sources in terms of haemoglobin levels revealed that $FeSO_4$ was significantly more efficient than whole egg, spirulina and whole wheat. Associated with this were the significant body weight variations among the groups, which would result in variable total haemoglobin formation depending upon gain in body weight. The haemoglobin concentration does precisely indicate the efficacy of different sources. However, when tissues iron levels were compared, it was seen that feeding of $FeSO_4$, spirulina and whole egg produced significantly higher tissue iron levels than feeding of whole wheat. It can be concluded that the availability of iron from spirulina and whole egg were found comparable to that of standard. Feeding of whole wheat resulted in least contents of tissue iron levels.

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Storage changes in the quality of sound and sprouted flour

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Abstract. Sound and sprouted flours (24 and 48 hr) from bread wheat (WL-1562), durum wheat (PBW-34) and triticale (TL-1210) were stored at room temperature (34.8 °C) and relative humidity (66.7%) for 0, 45, 90 and 135 days to assess the changes in physico-chemical and baking properties. Protein, gluten, sedimentation value, starch and crude fat decreased during storage in all the samples; however, the decrease was more in sprouted flours. Free amino acids, proteolytic activity, diastatic activity and damaged starch decreased with increase in storage period. Total sugars and free fatty acids increased more rapidly in the flours of sprouted wheats during 135 days of storage. Loaf volume of breads decreased during storage in both sound and sprouted flour but the mean percent decrease in loaf volume was more in stored sound flours. Aging of sprouted flour for 45 days improved the cookie and cake making properties but further storage was of no value for these baked products. *Chapati* making properties of stored sound and sprouted flour were inferior to that of fresh counterparts.

Introduction

The bread making quality of freshly harvested wheat or freshly milled wheat flour has been reported to improve during storage for a time depending on the nature of the flour and conditions of storage. Subsequently, a point is reached where further storage no longer seems to be conductive for baking and the bread making properties of flours deteriorated [1]. The expected shelf-life of white flour packed in paper bags and stored in cool dry conditions and protected from infestation varied from 2–3 years. Temperature and relative humidity of the place and the type of packing material used were the important factors affecting flour quality during storage. The flour acidity increased with temperature rise during storage and the flour grade deteriorated. Brown flour, for instance, could be kept for 9 months at 14.0 percent moisture, 4–6 months at 14.5 percent moisture and 2–3 months at 15.5 percent moisture [1]. Much work has been reported on the effect of soaking and sprouting on the flour characteristics [2, 3]. Studies have also been conducted to see the storage changes in the flours of sound wheat [4–9]; however, no efforts have been reported to determine the behaviour of sprouted flour during storage. Keeping in view the incidence of frequent untimely rains and making appropriate use of sprouted wheat flour after storage, the present study was proposed. Results are described in this paper.

Materials and methods

Three commercial cultivars, one each from bread wheat (WL-1562), triticale (TL-1210) and durum wheat (PBW-34) used in the study were obtained from the university farm at Ludhiana.

1. Pre-treatments and milling. Cleaned samples from each variety (10 kg) were given sprouting treatment by soaking in tap water for 10 h and sprouted for 24 and 48 h in a germinating chamber at 30 °C and 80 percent RH and dried in forced air circulation drier at 32 °C to about 14% moisture. The sound and sprouted samples were conditioned at the appropriate moisture levels and were milled in a Buhler Pneumatic Mill (MLU-202).

2. Storage of the flour. The flour was packed in transparent (Pearl Pet) Jars and stored for 0, 45, 90 and 135 days at room temperature (34.8 °C) having mean relative humidity (66.7%).

3. Physico-chemical characteristics of flour. Standard AACC [10] procedures were followed to determine grain weight, moisture, protein, fat, ash, gluten, starch, sugars, diastatic activity and damaged starch. Free amino acids were determined using the method of Lie [11]. Proteolytic activity was determined using modified Ayre & Anderson method as adopted by AACC [10].

4. Baking properties of flour. For bread making, the straight dough method of AACC with remixing procedure of Irvine and McMullan was followed. AACC procedure was used for baking of cakes and cookies. *Chapati* from stored sound and sprouted flours were made using the procedure of Austin & Ram [12].

5. Statistical analysis of data. Data reported are an average of duplicate tests. Values collected on different characteristics were analysed with the help of Factorial design [13]. All the data were expressed at 14% moisture basis, unless otherwise stated.

Table 1. Effect of laboratory sprouting on physical grain characteristics

Varieties	Duration of sprouting (hrs)	1000 Kernel weight (g)	Hecto-litre weight (g)	Pearling index (% over)	Protein (%)	Ash (%)	Fat (%)
WL-1562	0	40.3	81.4	60.1	11.6	1.52	1.59
	24	38.0	68.7	56.4	11.6	1.38	1.51
	48	37.5	67.6	48.1	11.6	1.34	1.41
TL-1210	0	35.3	70.4	52.7	10.8	1.75	1.43
	24	33.0	57.8	41.2	10.8	1.54	1.32
	48	31.2	53.5	40.1	10.8	1.52	1.32
PBW-34	0	45.4	81.0	67.2	9.5	1.59	1.70
	24	42.8	66.9	63.8	9.5	1.55	1.59
	48	39.8	65.1	63.2	9.5	1.53	1.59
LSD (0.05) varieties		1.7	1.9	7.3	0.01	0.12	0.07
LSD (0.05) sprouting		1.7	1.9	N.S.	N.S.	0.12	0.07

Results and discussion

Significant differences were observed among bread wheat, durum wheat and triticale with respect to physical grain characteristics. The grains of durum wheat were bolder and harder than those of bread wheat and triticale. Sprouting treatment given to these grains resulted in decreased hectolitre weight in all cases (Table 1). Neither sprouting nor its duration made any impact on the protein of grains; however, sprouting caused a significant decrease in the ash and fat values.

Table 2 depicts the effect of sprouting and its duration on milling charac-

Table 2. Effect of laboratory spouting on milling characteristics.

Varieties	Duration of sprouting (hrs)	Flour (%)	Bran (%)	Shorts (%)
WL-1562	0	69.3	16.3	12.7
	24	67.3	18.0	13.7
	48	66.0	19.3	14.0
TL-1210	0	66.0	22.0	10.0
	24	65.7	23.3	9.7
	48	62.3	24.0	10.0
PBW-34	0	64.7	16.7	21.7
	24	61.0	17.3	22.0
	48	59.3	18.3	22.3
LSD (0.05) varieties		2.1	0.9	0.9
LSD (0.05) sprouting		2.1	0.9	N.S.

teristics. Flour recovery decreased significantly with sprouting in all cases. As compared to durum wheat and triticale, bread wheat (WL-1562) gave higher flour yield. The lower recoveries in case of durum wheat may be due to excessive hardness of kernels and in triticale the poor grain filling and shrivelling may be responsible for lower yield of flour. With spouring the production of bran increased at the fixed setting of the mill. This may be related to the hardness of the grain and other changes occurred during germination and affecting the affinity of branny layers with endosperm. The percent shorts differed significantly with respect to varieties but the sprouting had a nonsignificant effect in all the three cultivars.

Effect of storage on flour characteristics

Proximate composition. Table 3 depicts the effect of storage of sound and sprouted flour on proximate composition. WL-1562, TL-1210 and PBW-54 differed significantly with respect to crude protein, starch, sugars and ash. Storage of flours (both sound and sprouted) resulted a significant decrease in protein content. The sound and sprouted flour sample showed 13.4 and 18.2% decrease respectively in protein upon 135 days of storage. This indicated that the sprouted flour from bread wheat, durum wheat and triticale under went faster changes than their respective sound flours.

With storage, the fat decreased non-significantly in both sound and sprouted flours but the extent was more in the latter. Similar results were reported by Clayton & Morrison [14]. Storage duration of 45, 90 and 135 days did not bring any significant change in the flour ash from sound and sprouted wheats. However, the ash values of sound flour increased whereas the sprouted flour ash decreased during storage. Compared to sound flour, the sprouted flour showed greater degradation of starch and production of free sugars when stored for longer periods. This could be due to amylolytic changes witnessed more during the germination of grains. In durum samples, the free sugars decreased after 45 days storage and then again increased. The decrease in total sugars was also reported after first month of storage due to sugar consumption probably by the insect infestation during storage and increased during second and subsequent months [15].

Amylolytic and proteolytic properties

The data for amylolytic and proteolytic activities as affected by storage are given in Table 4. The sprouting of grains increased the diastatic activity

Table 3. Effect of sprouting and storage on proximate composition of flour. The means having the same superscript do not differ significantly from each other

		Storage time (days)			
		0	45	90	135
Protein (%)	Sound	10.43^{a}	10.30^{a} (−1.25)	10.20^{a} (−2.21)	9.03^{b} (−13.42)
	Sprouted	9.90^{a}	9.68^{ab} (−2.22)	9.42^{b} (−4.85)	8.10^{c} (−18.18)
Crude fat (%)	Sound	0.84^{a}	0.81^{a} (−3.57)	0.78^{a} (−7.14)	0.72^{a} (−14.29)
	Sprouted	0.74^{a}	0.70^{a} (−5.41)	0.65^{a} (−12.16)	0.62^{a} (−16.22)
Starch (%)	Sound	62.83^{a}	61.90^{ab} (−1.48)	60.80^{bc} (−3.20)	60.13^{c} (−4.30)
	Sprouted	57.36^{a}	55.85^{a} (−2.62)	53.93^{b} (−6.00)	53.75^{b} (−7.15)
Total sugars (%)	Sound	3.32^{a}	4.01^{ab} (+20.78)	4.21^{b} (+26.81)	4.30^{b} (+29.52)
	Sprouted	5.09^{a}	5.66^{ab} (+11.20)	6.01^{b} (+18.07)	6.88^{c} (+35.17)
Ash content (%)	Sound	0.55^{a}	0.57^{a} (+3.10)	0.56^{a} (+1.80)	0.55^{a} (−)
	Sprouted	0.45^{a}	0.44^{a} (−2.90)	0.44^{a} (−2.90)	0.44^{a} (−2.90)

Figures in parenthesis denote % change, + increase, − decrease.

Table 4. Effect of sprouting and storage on amylolytic and proteolytic properties of flour. The means having the same superscript do not differ significantly from each other

		Storage time (days)			
		0	45	90	135
Diastatic activity (mg maltose/10 g)	Sound	554.33^{a}	340.67^{b} (−38.54)	325.33^{b} (−41.31)	278.7^{b} (−49.72)
	Sprouted	850.67^{a}	710.83^{a} (−11.77)	723.17^{a} (−10.24)	584.3^{b} (−27.48)
Damaged starch (%)	Sound	4.94^{ac}	6.24^{b} (+26.32)	6.08^{b} (−23.08)	5.22^{c} (+5.67)
	Sprouted	6.93^{ac}	7.75^{ab} (+11.83)	8.07^{b} (+16.45)	6.85^{c} (−1.15)
Gluten (%)	Sound	10.05^{a}	9.01^{a} (−10.35)	6.55^{b} (−34.83)	5.50^{b} (−45.27)
	Sprouted	4.90^{a}	4.15^{ab} (−15.31)	3.16^{bc} (−35.51)	2.42^{c} (−50.61)
Free amino acid (mg/g)	Sound	1.49^{a}	0.88^{b} (−40.94)	0.88^{b} (−40.94)	0.56^{c} (−62.42)
	Sprouted	2.02^{a}	1.01^{b} (−50.00)	0.99^{b} (−50.99)	0.72^{c} (−64.36)
Proteolytic activity (mg P/100 g)	Sound	99.00^{a}	41.00^{ab} (−58.89)	41.00^{ab} (−58.59)	39.00^{b} (−60.61)
	Sprouted	270.00^{a}	148.00^{b} (−45.19)	131.00^{b} (−58.48)	124.00^{b} (−54.07)
Free fatty acid (% oleic acid)	Sound	0.071^{a}	0.177^{ab} (+149.30)	0.234^{b} (+229.58)	0.305^{b} (+329.58)
	Sprouted	0.098^{a}	0.373^{b} (+280.61)	0.425^{bc} (+333.67)	0.505^{b} (+415.31)
Free fatty acid (% oleic acid, WWF)	Sound	0.120^{a}	0.310^{b} (+158.33)	0.407^{bc} (+291.67)	0.640^{c} (+433.33)
	Sprouted	0.150^{a}	0.530^{b} (+253.33)	0.700^{b} (+366.67)	1.260^{c} (+740.00)

Figures in parenthesis denote % change, + increase, − decrease.

which was affected extensively during storage of flour. The diastatic activity of fresh flour of sound wheat decreased significantly when stored for 45 days; whereas, the flour from sprouted wheat was not affected up to 90 days; however, the activity decreased significantly, thereafter. The decrease in diastatic activity during storage may be due to the frequency of changes in temperature and humidity. Similar reasons were also quoted by Pomeranz [16]. The damaged starch increased with sprouting treatment and its duration in all the three varieties due to excessive alpha-amylase present in the grains. The storage of sprouted flour for different periods showed an increase in the starch damage up to 90 days but thereafter the values decreased significantly.

Storage of both sound and sprouted flours produced significant changes in proteolytic properties after 135 days in all the samples. Significant decrease in gluten, free amino acids and proteolytic activity was seen in the stored flours from bread, durum and triticale flours. Decrease of gluten and free amino acids was more in sprouted flours. Durum and triticale flours showed more deterioration in gluten as compared to bread wheat. The free amino acids decreased to the extent of 62 and 64 percent, respectively, in sound and sprouted flours during storage. Similar results were reported earlier for the stored sound flours [16, 17].

The free fatty acids increased significantly upon 135 days storage and the increase was more in the sprouted flours showing that sprouted flour deteriorated faster during long storage. The increase in fat acidity may be due to enzymatic breakdown of fats.

Effect of storage on baking properties of flour

Data given in Table 5 revealed the changes in baking properties of flours stored for 0, 45, and 90 days. The 45-day storage period had no effect on bake absorptions of flours; however, after 90 days storage, it decreased. Loaf volume of bread decreased when it was prepared from stored flour. Sound and sprouted wheat flour gave 20% and 13.5% lesser loaf volume, respectively, with increase in storage period, indicating more changes in bread making properties from sound wheat flour. Longer storage (90 days) gave light brown crust and white to creamish yellow crumb breads.

The three varieties differed significantly with respect to spread factor of cookies. Cookie spread factor showed slight increase with storage length. Storage of 45 days had no effect on cookie top score; however, storage beyond 90 days produced cookies having significantly lower top score. This was observed with bread wheat and durum wheat flour; whereas, the cookies made from triticale flour even after storage did not affect the top score.

Table 5. Effect of sprouting and storage on baking properties of flour. The means having the same superscript do not differ significantly from each other

		Storage time (days)		
		0	45	90
Bake absorption (%)	Sound	60.17[a]	60.17[a] (–)	58.83[a] (−2.23)
	Sprouted	56.25[a]	56.17[a] (−0.14)	54.75[b] (−2.67)
Cookie spread factor (width/thickness)	Sound	5.83[a]	5.94[a] (+1.89)	5.79[a] (−0.69)
	Sprouted	6.32[a]	6.37[a] (+0.79)	6.49[a] (+2.69)
Cookie top score (out of 4.00)	Sound	3.00[a]	3.33[a] (+11.00)	2.33[b] (−22.33)
	Sprouted	3.17[a]	3.50[a] (+10.41)	2.58[a] (−18.61)
Cake volume (cc)	Sound	670.00[a]	656.7[a] (−1.99)	700.00[a] (+4.48)
	Sprouted	730.7[a]	675.2[a] (−7.00)	647.5[a] (−11.38)
Cake total score (out of 100)	Sound	86.0[a]	92.7[a] (+7.76)	81.3[a] (−5.43)
	Sprouted	67.0[a]	89.3[b] (+33.33)	88.0[b] (+31.34)
Whole wheat flour water absorption (%)	Sound	56.47[a]	56.47[a] (–)	60.20[b] (+6.61)
	Sprouted	49.90[a]	51.90[b] (+4.01)	57.08[c] (+14.39)

Figures in parenthesis denote % change, + increase, − decrease.

With storage, a decrease in cake volume was observed; however, internal score of cakes improved significantly after 45 days storage showing that flour aging is conducive to the internal characteristics of cakes, however, when storage period exceeded 90 days, there was a slight decrease in the internal score.

The cake prepared from fresh flour of sprouted triticale were having inferior taste, but storage improved taste properties. Johnson & Hoseney [18] reported that flour stored for 2 months at room temperature improved grain characteristics of cakes.

Storage of whole wheat flour (WWF) resulted in an increase in water absorption. Sprouted flour had lesser water absorption than sound samples. Colour, flavour and softness of *chapatis* deteriorated when prepared from stored bread, durum and triticale flour.

The investigation revealed that limited storage of sound as well as sprouted wheat flour for 45 days was beneficial for baking particularly for cake and cookie making, however, *chapati* and bread making potential decreased with the storage of flour.

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The fermentation of trahanas: a milk-wheat flour combination

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Abstract. The fermented food, trahanas (a milk-wheat flour combination prepared in Greece), was studied to determine the microbiological and chemical changes that occur during fermentation. It is a lactic acid bacterial fermentation in which *Streptococcus lactis*, *Streptococcus diacetylactis*, *Leuconostoc cremoris*, *Lactobacillus lactis*, *Lactobacillus casei*, *Lactobacillus bulgaricus* and *Lactobacillus acidophilus* play the major acid- and aroma-producing role. The whole fermentation lasts about 50 hours. The pH of the final dried trahanas was 4.07–4.75, the acidity 0.60–1.00%, the moisture content 8.6–11.5% and the protein content 10.4–13.6%. The product offers possibilities as an increased nutritive value or high-protein food.

Introduction

Fermented foods play an important role in the diets of many people in various countries [1]. The manufacture of fermented dairy products constitutes a major fermentation industry worldwide. Fermented milk-wheat flour products are extremely popular foods in many Balkan, Mediterranean and Middle East countries. They have different names in different areas such as kishk in Syria, Palestine, Jordan, Lebanon and Egypt; kushuk in Iraq and Iran; and tarhana in Turkey [1–7]. The manufacture of these products differs from place to place and even within the same country, but yoghurt and wheat flour or parboiled wheat (bulgur) are generally used [6,7]. In addition, tomato paste, red peppers, onions, turnips and other vegetables may be added [2,7].

In Greece, a similar but rather different product under the name trahanas is manufactured. Trahanas is mainly prepared from wheat flour and a curd which is produced by lactic acid fermentation of cow, sheep or goat milk. Two main traditional preparation methods are followed. According to