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EFFECT OF WHEAT VARIETY AND GERMINATION PERIOD SUITABLE FOR MANUFACTURE OF *HALVASAN* – A MILK CEREAL BASED INDIAN SWEETMEAT

Amitkumar Manojbhai Patel[1], Smitha Balakrishnan[2], Ajay Jayantrao Gokhale[1], Jarita Mahadeb Mallik[1], Hasmukhbahi G. Patel[3]

1Assistant Professors (Department of Dairy Processing and Operations), SMC College of Dairy Science, Anand Agricultural University, Anand – 388110, India

2Assistant Professors (Department of Dairy Chemistry), SMC College of Dairy Science, Anand Agricultural University, Anand – 388110, India

3Retired Professor and Head (Department of Dairy Processing and Operations), SMC College of Dairy Science, Anand Agricultural University, Anand – 388110, India

ABSTRACT

Traditional Indian Dairy Products such as Halvasan are manufactured in India using an age old practice. Halvasan is semi-soft, sticky, sweet, caramelized milk-cereal based traditional Indian dairy product. It is heat desiccated sweet prepared from mixture of milk and wheat fada (germinated and dried wheat semolina). It is sweetened and after desiccation, is richly coloured, flavoured and decorated using nutmeg, cardamom, pistachio and saffron. For manufacture of such products industrially, standard quality fada is required. Halvasan is very popular heat desiccated milk product but has not been studied scientifically especially for suitable wheat variety and wheat germination conditions. Present experiment envisages selecting suitable wheat variety and developing a wheat germination protocol for Halvasan manufacture. Three different wheat varieties viz. GW - 496 (T. aestivum), Arnej - 206 (T. durum) and GW - 1 (T. durum) were geminated for 2, 3 and 5 days and dried in vacuum tray drier. The germinated and dried wheat samples were converted into fada (semolina). One market sample of fada (semolina) was also procured for the comparison purpose. All the samples of fada were analysed for various physico-chemical parameters. The average moisture, ash, pH, total soluble sugar and total protein of experimental samples after drying wheat GW-1, Arnej-206 and GW-496 germinated for 2,3 and 5 days, ranged between 9.22-11.72%; 1.92-2.15%; 5.88-6.67; 3.03-19.62%; 10.59-12.90%, respectively. The mean sedimentation value, β-carotene, thousand kernel weight (TKW) and saccharification rate of dried wheat experimental samples ranged between 20-38 ml; 3.49-6.79 ppm; 29.59-55.95 g and 10-60 min, respectively

Keywords: Wheat, T. durum, T. aestivum, Halvasan, Wheat germination

INTRODUCTION

It is now very well recognized that with the steadily changing socio-economic scenario, consumers are becoming increasingly health conscious and are demanding natural, wholesome and health promoting foods. Cereal-based milk foods providing protein, energy, fiber and other nutrients and present themselves as valuable health foods. India is the largest milk producer as well as consumer in the world accounting for ~ 16.3 per cent of the global milk production (Beniwal and Kumaresen, 2015). Historically, surplus milk in the rural areas of India where it is produced has been converted into a

variety of traditional products primarily as a means of preservation. In addition to preservation of milk solids for longer time at room temperature, manufacture of traditional dairy products add value to milk and also provide considerable employment opportunity. *Halvasan* is one such traditional milk-cereal based product which was originated and prepared in Khambhat/Cambay, an ancient sea port of Gujarat. It is a semi-soft, sticky, sweet, caramelized milk-cereal based product popular in central Gujarat region.

Halvasan is heat desiccated milk-cereal based sweet prepared from mixture of milk and wheat fada (germinated and dried wheat semolina). It is sweetened and after desiccation, is richly coloured, flavoured and decorated using nutmeg, cardamom, pistachio and saffron (Patel *et al*. 2010). Traditionally made *Halvasan* is rich source of nutrients derived from milk solids as well as high quality of germinated *Bhalia* Wheat (durum wheat variety) solids specifically grown in the nearby area of Bhal. *Halvasan* is not known in other parts of India due to lack of available published scientific literature and its well-kept secret recipe. Patel *et al*. (2010) has standardized the laboratory scale process for the manufacture of *Halvasan*. However, the process of its manufacture is longer and other important aspects of the product manufacture are unknown.

There are no studies regarding effect of suitable wheat variety and wheat germination period on the manufacture of *Halvasan*. Hence, the objective of this study was to observe changes occurring during various sprouting conditions in different varieties of wheat (*T. aestivum* and *T. durum*) and try to shed more light on the application of germinated wheat semolina for manufacture of *Halvasan* by the dairy industry.

MATERIALS AND METHODS

Raw material

The wheat cultivars (varieties) of *Triticum aestivum* and *Triticum durum* for the present study were procured from the Regional Research Stations of Arnej and Anand, Anand Agricultural University. Out of three varieties of wheat, one variety was *T. aestivum* (GW – 496) and two varieties were of *T. durum* type (Arnej – 206 and GW – 1). High quality of *fada* (Semolina) was also obtained from Khambhat market for comparison purpose.

Wheat germination and drying

Two varieties of *T. durum* (Arnej – 206, GW – 1) and one variety of *T. aestivum* (GW – 496) were germinated and vacuum tray dried. This germinated and dried wheat was converted into *fada* (semolina). All the three cultivars had germination capacity of more than 98%. All three varieties of wheat were soaked in water treated in domestic reverse osmosis plant (Wheat:Water in the proportion of 1:5) at 20°C for 16 h. The soaked wheat were allowed to germinate at 20°C in B.O.D. incubator (Make: Yorko Sales Pvt. Ltd., New Delhi) for 2, 3 and 5 days. Sprout maker (Make: Action Sprout Maker, K.D. Kitchen wares Pvt. Ltd., Rajkot, India) was used to germinate wheat samples. Germinated wheat withdrawn at 2, 3 and 5 days were dried at 45±5°C in vacuum tray dryer (Make: Perfect Engineering and Allied Works Pvt. Ltd., Baroda, India) at the vacuum of 740-760 mm of Hg for 7 h. The dried samples of wheat were converted into *fada* using domestic mixer grinder. These

laboratory made *fada* were compared with the market sample procured from Khambhat market. The percentage distribution of particle size of *fada* is shown in Table 1.

Table 1 Particle size distribution of *fada* from various wheat varieties and market *fada*

Sr. No.	*Name of Cultivar*	*Germination Period (Days)*	*Particle size distribution of fada (semolina), %*		
			+ 2057 µm	**+ 1003 µm**	**+ 75 µm**
1	GW – 496	2	88.6	10.0	1.4
		3	80.8	16.6	2.6
		5	79.4	16.9	3.7
2	Arnej – 206	2	72.4	23.8	3.8
		3	71.2	24.1	4.7
		5	63.5	27.3	9.2
3	GW – 1	2	71.6	23.4	5.0
		3	70.3	25.5	4.2
		5	58.4	35.3	6.3
4	Market *fada*	-	70.3	24.5	5.2

Note: + 2057 µm: B.S.S. 8, A.S.T.M. 10, Microns 2057 (2.057 mm)
+ 1003 µm: B.S.S. 16, A.S.T.M. 18, Microns 1003 (1.003 mm)
+ 75µm: B.S.S. 200, A.S.T.M. 200, Microns 75 (0.075 mm)

Analyses of wheat and sprouted and dried wheat

The cultivars of *Triticum aestivum* and *Triticum durum* wheat used for present study were analyzed for various physico-chemical parameters. Moisture and ash content was determined using the method described by AOAC (1995) and AOAC (1965), respectively. Total soluble sugars were determined using Phenol-sulphuric acid method described by Dubois *et al*. (1956). The method of AOAC (1965) was used for determination of protein content. β -Carotene and sedimentation value was determined using method described by Mishra and Gupta (1998). Thousand Kernel Weight (TKW) was determined by electronic seed counter. 1000 seeds were counted and weighed in grams using electronic digital weighing balance. The method described by AACC (2000) was used to determine saccharification rate. The pH of germinated and dried wheat *fada* was measured using digital pH meter, CH-8603, M/s. Mettler Toledo AG, Schwerzenbach, Model LE438.The homogenate prepared by diluting 50 g of ground sample in 50 ml of glass distilled water was subjected to pH measurement.

Statistical analysis

Ten treatments (three wheat varieties germinated for three different periods; one market wheat fada) were subjected to statistical analyses. The mean values generated from the analyses of duplicate samples, obtained in three replications were subjected to statistical analysis using completely randomized design (CRD) as per Steel and Torrie (1980).

RESULT AND DISCUSSION

The variety of wheat and germination period of wheat *fada* plays a pivotal role in deciding physico-chemical, organoleptic and rheological characteristics of *Halvasan* as well as economics of the

product. Traditionally, *T. durum* type of wheat is used for the manufacture of *Halvasan*. *T. durum* wheat is known for its higher protein content compared to *T. aestivum* and they have different compositional characteristics.

Influence of variety of wheat and germination period on physico-chemical parameters

The average per cent moisture, ash, total soluble sugar, total protein and pH of experimental samples after drying of wheat GW-1, Arnej-206 and GW-496 germinated for 2, 3 and 5 days, ranged between 9.22 - 11.72%, 1.92 - 2.15%, 3.03 - 19.62%, 10.59 - 12.90% and 5.88 - 6.67, respectively (Table 2). The average sedimentation value, β – carotene, thousand kernel weight (TKW) and saccharification rate of dried wheat experimental samples ranged between 20 - 38 ml; 3.49 - 6.79 ppm; 29.59 - 55.95 g; 10 - 60 min, respectively (Table 3).

Moisture

The results of the effect of wheat variety and germination period on moisture per cent of germinated and dried wheat are presented in Table 2. Control wheat *fada* had average moisture of 10.3%. In case of *T. durum* types of wheat (GW - 1 and Arnej - 206), the moisture per cent increased significantly ($P \leq 0.05$) in the wheat samples germinated for 2 days.

GW - 1 variety of wheat samples initially had 10.71% moisture which increased significantly ($P \leq 0.05$) to 11.03% after 2 days germination and decreased significantly ($P \leq 0.05$) to 9.22% after 3 days germination. It subsequently increased to 9.74% in dried wheat samples germinated for 5 days. Moisture content increased from 10.03% initially to 11.49% upon 2 days germination and subsequent drying in Arnej - 206 wheat variety. The moisture decreased to 9.4% and later on increased significantly ($P \leq 0.05$) to 10.47% in dried wheat samples germinated for 3 days and 5 days, respectively. In case of *T. aestivum* wheat variety (GW - 496), moisture content decreased significantly ($P \leq 0.05$) from 11.72% for 0 day, to 10.94% for 2 days and to 9.29% in the dried wheat which were germinated for 3 days. On the fifth day, the moisture increased significantly ($P \leq 0.05$) to 9.66% in the dried wheat samples.

Nasir *et al.* (2003) studied effect of moisture on the shelf life of wheat flour and found that moisture has significant effect on crude protein, crude fat, mould growth and insect infestation. They concluded that 9 and 10% moisture content is suitable for storage stability and longer shelf life of wheat flour. Aalami *et al.* (2007a) evaluated spaghetti making potential of 12 Indian *durum* wheat varieties and 2 *aestivum* wheat varieties and found that moisture content in durum wheat samples varied from 9.0 - 11.5%. The moisture content in the two *aestivum* wheat varieties was marginally lower.

Table 2 Influence of wheat variety and germination period on moisture, ash, pH, total soluble sugar and total protein of dried wheat

Type of Wheat	*Germination Period (Days)*	*Moisture (%)*	*Ash (%)*	*pH*	*Total Soluble Sugar (%)*	*Total Protein (N X 5.7) (%)*
Control (Market	- (T1)	10.3 ± 0.06^{fg}	2.14 ± 0.05	6.22 ± 0.01^{b}	14.64 ± 0.14^{g}	12.86 ± 0.05^{ghi}

Sample)						
GW – 1	0 (T2)	10.71± 0.25^{hi}	1.92 ± 0.07	6.66 ±0.02^{f}	3.23 ±0.17^{a}	10.59 ± 0.09^{a}
	2 (T3)	11.03± 0.24^{j}	1.98 ± 0.11	6.53 ±0.01^{b}	6.46 ±0.19^{c}	10.65 ± 0.08^{a}
	3 (T4)	9.22± 0.20^{a}	2.10 ± 0.13	6.41 ±0.01^{c}	11.3 ±0.15^{f}	11.00 ± 0.07^{b}
	5 (T5)	9.74± 0.29^{de}	1.96 ± 0.13	5.88 ±0.02^{a}	16.15 ±0.26^{i}	10.97 ± 0.07^{b}
Arnej – 206	0 (T6)	10.03± 0.19^{ef}	2.04 ± 0.09	6.60 ±0.02^{e}	3.27 ±0.16^{a}	12.69 ± 0.06^{fg}
	2 (T7)	11.49± 0.08^{k}	2.13 ± 0.11	6.58 ±0.02^{e}	8.17 ±0.19^{d}	12.90 ± 0.04^{i}
	3 (T8)	9.4± 0.23^{abc}	2.15 ± 0.05	6.22 ±0.01^{b}	14.71 ±0.14^{g}	12.74± 0.05^{fg}
	5 (T9)	10.47± 0.07^{gh}	2.10 ± 0.09	5.88 ±0.03^{a}	19.62 ±0.22^{j}	11.84 ± 0.07^{c}
GW – 496	0 (T10)	11.72± 0.09^{k}	1.95 ± 0.07	6.67 ±0.01^{f}	3.03 ±0.16^{a}	12.11 ± 0.08^{d}
	2 (T11)	10.94± 0.12^{ij}	2.03 ± 0.11	6.52 ±0.03^{d}	6.06 ±0.18^{b}	12.63 ± 0.08^{f}
	3 (T12)	9.29± 0.07^{ab}	2.12 ± 0.07	6.20 ±0.01^{b}	10.6 ±0.17^{e}	12.80 ± 0.06^{ghi}
	5 (T13)	9.66± 0.10^{cd}	2.01 ± 0.13	5.90 ±0.01^{a}	15.15 ±0.21^{h}	12.34 ± 0.05^{e}
S.Em.		0.102	0.059	0.012	0.108	0.041
C.D. (0.05)		0.30	NS	0.04	0.31	0.12
C.V.%		1.73	5.00	0.35	1.84	0.589

1. Each observation is a mean ± SD of three replicate experiment (n = 3).
2. Each mean is compared using CD value obtained from statistical analysis of data.
3. Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different ($P \leq 0.05$).
4. NS: Non- significant

Ash

Control wheat *fada* had average 2.14% ash (Table 2). Ash content of different varieties of wheat germinated for various periods ranged non-significantly from 1.92 - 2.15%. However, in all the three varieties, ash content increased up to 3 days of germination and then decreased in the samples which were germinated for 5 days. Dried samples of Arnej - 206 wheat variety had higher ash content as compared to GW - 496 followed by GW - 1 at all the days of germination studied.

Randhawa *et al.* (2002) studied seven wheat varieties and found that ash content ranged from 1.32 - 1.72%. Prabhasankar *et al.* (2002) studied physico-chemical and biochemical characterization of selected nine *T. aestivum* wheat cultivars and reported that the ash content ranged from 1.4 - 2.1%. Aalami *et al.* (2007a) studied spaghetti making potential of Indian durum wheat varieties in relation to their protein, yellow pigment and enzyme contents and reported that the ash content of wheat samples varied between 1.38 - 2.14% in *durum* samples and in the *aestivum* varieties it was within the above range. Plaza *et al.* (2003) in a study recognized that significant increase in minerals content such as Cu, Fe, K and Zn is one of the most important factors in the sprouting seeds. Another study by Ozturk *et al.* (2012) showed an average 2-3 fold increase in minerals especially Mg, Ca, Fe, Na, K and P in two different varieties of wheat.

pH

Control wheat *fada* had average pH of 6.22. All other samples varied significantly ($P \leq 0.05$) in their pH depending upon both variety of wheat and germination period (Table 2). In case of GW - 1 wheat variety samples, pH decreased from 6.66 (0 day) to 6.53, 6.41 and 5.88 respectively for the dried wheat samples which were germinated for 2, 3 and 5 days. Arnej - 206 wheat cultivar had 6.60 pH on 0 day, which decreased significantly ($P \leq 0.05$) to 6.58, 6.22 and 5.88 for the dried wheat samples which were germinated for 2, 3 and 5 days respectively. Similar results were observed in case of GW

- 496 type of wheat cultivar. The initial pH value of 6.67 decreased significantly (P≤0.05) to 5.90 till the 5th day of germination.

Jin *et al*. (2011) suggested that wheat variety is very important with regard to wheat malt qualities and reported pH of six different wheat malt in the range of 6.08 - 6.25. Guo *et al.* (2014) illustrated that the LM21 white wheat variety malt had pH in the range of 5.95 - 6.03.

Total soluble sugar

In the present study, per cent total soluble sugar content in the three different wheat varieties ranged between 3.03-19.62. During germination of all the three wheat varieties, the total soluble sugar increased significantly (P≤0.05) correspondingly with the germination period (2, 3 and 5 days) compared with the native seeds (Table 2). The lowest soluble sugar (3.03%) was found in the sample GW - 496. In case of Arnej - 206 wheat variety which was germinated for five days, the total soluble sugar was found highest (19.62%). Arnej - 206 wheat samples germinated for 3 days was having total soluble sugar 14.71%, which was at par with the total soluble sugar of control *fada* (14.64%).

Gooding and Davis (1997) reported total soluble sugars in the wheat ranging from 1.5 - 2.0%. Gujjaiah and Kumari (2013) investigated changes in the total soluble sugar that occur during germination of rice, wheat, ragi and bajra, in order to understand the changes and biochemical mechanism of cereal germination. During the course of investigation, the total soluble sugar content was found to be significantly increased correspondingly with the germination time in comparison with the dry seed.

Total protein

The total protein content of dry seeds of wheat varieties GW - 1 and GW - 496 increased significantly (P≤0.05) up to 3rd day of germination, whereas in case of Arnej - 206 wheat variety the significant increase (P≤0.05) in the total protein content was found till 2nd day of germination. Later on total protein content decreased in dry seeds of all the three wheat varieties germinated up to 5 days (Table 2).

A significant influence of wheat variety on the crude protein content were observed by Randhawa *et al*. (2002) who reported that the crude protein content ranged from 11.82 - 14.10%. Aalami *et al.* (2007a) also reported the protein content among durum varieties varying between 12.1 - 15.9%. It has been also reported by Ranga Rao *et al*. (1981) that protein content in Indian *aestivum* wheat is relatively lower compared to *durum* varieties.

However, in our study we found that the *aestivum* wheat variety GW - 496 (12.11%) had relatively high protein content than *durum* wheat variety GW - 1 (10.59%). The protein content of Arnej - 206 wheat variety was 12.69% which was the highest and significant (P≤0.05) compared to other two varieties.

Vanderstoep (1981) observed that germination of seeds lead to breakdown of seed reserves and increased enzyme activity leads to a loss of total dry matter and an increase in total protein (Lorenz, 1980). Steve (2012) investigated effects of germination and fermentation on protein quality of the wheat flour and found that, the protein content of the raw wheat flour was 10.77%, which increased significantly to 13.50% in the wheat flour samples which were germinated for four days. Gujjaiah

and Kumari (2013) studied change in the activity of α- amylase, β-amylase and proteases involved in the breakdown of stored carbohydrates, proteins in cereals (rice, wheat, ragi and bajra) during soaking and the 1st week of germination. The total protein value of dry, 0, 2, 4, 6, 8 and 10 days germinated seeds of rice, wheat, ragi and bajra was found to be significantly increased with the increase in the time of germination when compared with dry seed. They observed decline in protease activity in wheat after 4th day of germination and this lead to decrease in total protein content. In the present study also concentration of total protein content of wheat increased up to 2 days of germination compared to untreated samples due to significant increase in the protease activity of the cereals during soaking and germination.

Sedimentation value

In the present study, it was found that sedimentation values decreased significantly ($P \leq 0.05$) in all the three wheat varieties under investigation upon germination compared to their native seeds (Table 3). The highest sedimentation value was found in GW - 1 wheat sample (38 ml), whereas 5 days germinated Arnej - 206 wheat variety had lowest sedimentation value (20 ml).

In case of GW - 1 wheat variety, sedimentation value varied significantly ($P \leq 0.05$) between native seeds and dried wheat samples germinated for 2 days. Sedimentation values of GW - 1 germinated and dried wheat samples were found non-significant on 3rd day. However, 5 days germinated and dried wheat sample's sedimentation value was found significantly different ($P \leq 0.05$) from other samples. Similar results were found for the Arnej - 206 cultivar. Whereas sedimentation value of aestivum wheat variety GW - 496 did not vary significantly up to 3rd day of germination. However, the sedimentation value on the 5th day of germination varied significantly compared to other samples of the GW - 496 variety.

Sedimentation value of dried wheat samples of 3 days germinated Arnej - 206 wheat variety (25 ml) was statistically at par with the sedimentation value of control wheat *fada* (23 ml).

Dexter *et al*. (1978) studied sedimentation test for thirty durum wheat lines to assess gluten strength and reported sedimentation values ranged from 15.8 - 52.5 ml. Prabhasankar *et al*. (2002) studied physico-chemical and biochemical characterization of selected wheat cultivars and their correlation to *Chapati* making quality and found that sedimentation values ranged from 59 - 76 ml. Randhawa *et al*. (2002) studied physico-chemical and milling properties of new spring wheat grown in Punjab and Sind for the production of pizza and found that SDS sedimentation value differed significantly among different wheat varieties. The sedimentation value varied from 18.17 - 28.33 ml. Sayaslan *et al*. (2012) studied 14 durum wheat genotypes and reported SDS sedimentation volumes of the genotypes ranged from 20.5 - 38.0 ml.

The sedimentation values reported in literature are different for different varieties and requirements for product manufacture are also differing. However, the values in the same variety differ on germination which may be suitably utilized for its end use.

β – Carotene (Yellow Pigment)

β – Carotene values increased significantly ($P \leq 0.05$) amongst all the three wheat varieties during entire germination period studied (2, 3 and 5 days). Highest β – Carotene content was found in the samples of 5 days germinated Arnej - 206 wheat variety (6.79 ppm) whereas lowest β – Carotene

content was found in GW - 496 wheat variety (3.49 ppm). β – Carotene values of dried wheat samples of 3 days germinated Arnej - 206 wheat variety (5.07 ppm) was statistically at par with the β – Carotene of control wheat *fada* (5.14 ppm) (Table 3).

Table 3 Influence of wheat variety and germination period on sedimentation value, β – carotene, thousand kernel weight (TKW) and saccharification rate of dried wheat

Type of Wheat	*Sedimentation Value, β – Carotene, Thousand Kernel Weight and Saccharification Rate of wheat*				
	Germination Period (Days)	**Sedimentation Value (ml)**	**β – Carotene Yellow Pigment (ppm)**	**Thousand Kernel Weight (TKW) (g)**	**Saccharification Rate (Minutes)**
Control (Market Sample)	- (T1)	23 ±1.7 ^{bc}	5.14± 0.12 ^{fg}	46.86± 1.05 ^{h}	30±0.0 ^{c}
GW – 1	0 (T2)	38 ±1.0 ^{g}	4.44± 0.13 ^{c}	55.95± 1.04 ^{l}	60±0.0 ^{e}
	2 (T3)	35 ±1.0 ^{ef}	4.71± 0.16 ^{d}	53.88± 0.75 ^{k}	60±0.0 ^{e}
	3 (T4)	34 ±1.7 ^{e}	4.97± 0.14 ^{ef}	48.92± 0.93 ^{ij}	45±5.0 ^{d}
	5 (T5)	21 ±1.7 ^{ab}	5.87± 0.11 ^{h}	44.01± 0.79 ^{f}	30±5.0 ^{c}
Arnej – 206	0 (T6)	35 ±1.0 ^{ef}	3.96± 0.14 ^{b}	49.54± 0.89 ^{ij}	60±0.0 ^{e}
	2 (T7)	32 ±1.0 ^{e}	4.44± 0.12 ^{c}	48.85± 0.99 ^{i}	60±0.0 ^{e}
	3 (T8)	25 ±1.7 ^{c}	5.07± 0.11 ^{fg}	46.76± 1.04 ^{gh}	30±0.0 ^{c}
	5 (T9)	20 ±1.7 ^{a}	6.79± 0.12 ^{i}	38.93± 0.93 ^{d}	20±5.0 ^{b}
GW – 496	0 (T10)	36 ± 1.0 ^{efg}	3.49 ± 0.11 ^{a}	42.15± 0.86 ^{e}	60±0.0 ^{e}
	2 (T11)	34 ±1.0 ^{ef}	4.04± 0.13 ^{b}	36.66± 1.06 ^{c}	45±5.0 ^{d}
	3 (T12)	32 ±1.0 ^{e}	4.67± 0.11 ^{d}	34.21± 0.93 ^{b}	20±0.0 ^{b}
	5 (T13)	28 ±1.0 ^{d}	5.87± 0.13 ^{h}	29.59± 0.88 ^{a}	10±0.0 ^{a}
S.Em.		0.767	0.075	0.545	1.601
C.D. (0.05)		2.23	0.22	1.59	4.65
C.V.%		4.40	2.68	2.13	6.80

1. Each observation is a mean ± SD of three replicate experiment (n = 3).
2. Each mean is compared using CD value obtained from statistical analysis of data.
3. Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different ($P \leq 0.05$).

Miller (1978) found vitamin A, as carotene, to vary from 100 to 400 mg/lb in un-germinated wheat seeds and from 400 to 600 mg/lb in 7-day old germinated wheat. The results of the studies are comparable with those of two Canadian durum wheats, which had pigment content of 5.5 and 6.5 ppm, respectively (Dexter and Matsuo, 1978). Still higher pigment values of 9.93 and 7.54 ppm were reported in two Indian *durum* wheat varieties by Kathuria and Sidhu (1984). Dexter *et al*. (1994) had reported similar values of 7.2 and 9.0 ppm in two Canadian *durum* wheat varieties. These values compare well with 25 Italian *durum* cultivars which had yellow pigment between 3.0 and 6.5 ppm (Borrelli *et al*., 1999). Haridas Rao *et al*. (1976) studied 24 Indian *durum* wheat varieties in which the yellow pigment content ranged from 2.72 - 6.47 ppm. Impiglia *et al*. (1995) studied nine durum wheat landraces and reported wheat flour yellow pigment in the range of 3.5 - 8.0 ppm.

Yang *et al*. (2001) proved that after steeping for 24 or 48 h, β -carotene content in wheat sprouts greatly increased during the germination process. The β -carotene content in dry wheat grain (control) was undetectable. During germination, β -carotene content gradually increased to 3.1µg/g as germination time increased, reaching the peak on day 8. Aalami *et al*. (2007a) reported durum wheat variety DWR-2006 having significantly higher yellow pigment content (7.2 ppm) followed by PDW-233 variety with 6.0 ppm pigment content. Dexter (2008) reported yellow pigment of four cultivars ranging from 8.3 - 9.8 ppm. β-Carotene content ranged from 1.78 - 8.38 ppm. Thus, the germination process tends to increase the β-Carotene content of wheat, higher the period higher the content irrespective of the variety of wheat.

Thousand Kernel Weight (TKW)

The thousand – kernel weight (TKW) is a measure of average kernel size. Since the ratio of endosperm to bran is greater in larger kernels, a higher milling yield can be expected from these kernels. TKW decreased as the germination period progressed for all the three wheat varieties under study. GW -1 wheat variety had highest thousand kernel weight of 55.95 g, whereas lowest TKW was found in case of dried GW - 496 wheat variety which was germinated for 5 days (29.59 g). For varieties GW - 1 and GW - 496, TKW decreased significantly ($P \leq 0.05$) during all the germination periods studied (2, 3 and 5 days), compared to their native seeds (Table 3). However, in case of Arnej - 206 variety, the changes in TKW were found non-significant till the 2nd day of germination, later on the changes were found statistically significant ($P \leq 0.05$).TKW of dried wheat samples of 3 days germinated Arnej - 206 wheat variety (46.76 g) was statistically at par with the value of control wheat *fada* (46.86 g).

Dexter and Matsuo (1978) reported TKW values of 42.0 and 42.5 g for two Canadian durum wheat cultivars. Lorenz (1980) and Plaza *et al*. (2003) reported that during germination, most of the stored nutrients such as carbohydrates, protein and fat were mobilized to supply energy necessary for the growth of the emerging seedling by the action of their endogenous enzymes. These enzymes were already present in the seed or produced upon initiation of sprouting. Germination reduced the amount of dry weight by catabolizing carbohydrates to CO_2 and H_2O and thus led to decrease in TKW of germinated wheat seeds.

Aalami *et al*. (2007b) studied physical characteristics of six Indian *durum* wheat varieties, and reported TKW varying from 40.31 - 48.42 g. In another study Jin *et al*. (2011) studied effects of wheat starch contents on malt qualities and reported thousand grain weight of twelve different wheat varieties ranged from 29.24 g - 42.75 g.

Saccharification rate

Germination had profound effect on starch properties because α-amylase degraded starch granules. The hydrolytic activity of α-amylases during germination of cereal grains caused structural changes in the endosperm due to native starch granule degradation. Most of these proteins were insoluble in water and they could be utilized only after degradation to soluble proteins (Capocchi *et al*. 2000). Increase in amylases and proteases during wheat germination leads to change in saccharification rate. Therefore, it is very important to germinate wheat at optimal level in order to successfully use sprouted wheat semolina as an ingredient in the *Halvasan* manufacture. The analysis for the rate of

saccharification was carried out to estimate the degree of starch conversion in the wheat malt. A drop of mash extract was allowed to react with iodine solution and saccharification rate was determined according to the disappearance of blue starch-iodine colour. The test was repeated at every 5 min until the saccharification was complete. If the saccharification was not complete after 1 h, the test was stopped. Hence, in the present study, saccharification rate of 60 min indicates that the saccharification was incomplete after 1 h.

In the present study, saccharification rate ranged from 10 min - 60 min. In GW - 1 and Arnej - 206 wheat varieties, saccharification rate did not change till 2nd day of germination, however the rate decreased on the 3rd and 5th day. For GW - 496 variety, the saccharification rate decreased significantly ($P \leq 0.05$) for all the germinated wheat samples compared to native wheat seeds (Table 3). Saccharification rate of dried wheat samples of 3 days germinated Arnej - 206 wheat variety (30 min) was statistically at par with the value of control wheat *fada* (30 min).

Jin *et al*. (2011) characterized malt from seven wheat cultivars and found that saccharification time for wheat malt varied from 8.0 - 18.0 min. In another study, Jin *et al*. (2012) studied relationship between Kolbach index and other quality parameters of wheat malt. Eight wheat malts with different Kolbach indices, from the same wheat variety (L-2), were prepared by controlling the steep-out moisture and the germination time. Comparison of the malts indices showed that extract and saccharifying powers of all the malts were comparatively good, and illustrated that the white wheat variety L-2 had good potential as a wheat variety for malting. The saccharification time of all eight wheat malt ranged from 5.0 - 10.0 min.

CONCLUSION

In the present investigation of process optimization for *Halvasan* manufacture, three varieties of wheat were studied. Out of three varieties one variety was *T. aestivum* (GW - 496) and two varieties were of *T. durum* type (Arnej - 206 and GW - 1). Attempts were also made to develop protocol for the wheat germination. All the three varieties were soaked in water at 20°C for 16 h. The soaked wheat were allowed to germinate at 20°C in B.O.D. incubator for 2, 3 and 5 days. Germinated wheat withdrawn at 2, 3 and 5 days were dried at 45±5 °C and 740 - 760 mm Hg vacuum in vacuum tray dryer. The dried samples of wheat were converted into *fada* (semolina) using domestic mixer grinder. These laboratory made *fada* (semolina) were compared with the market sample. Form the results of the above mentioned study, Arnej - 206 wheat variety germinated for three days was found most suitable for the manufacture of *Halvasan.*

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