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Physico-Chemical Characteristics and Rheolgical Properties of Different Wheat Varieties Grown in Sindh

Mahvish Jabeen Channa[1], Allah Bux Ghanghro*[1], Saghir Ahmed Sheikh[2] and Shafi Muhammad Nizamani[3]

[1]*Institute of Biochemistry, University of Sindh, Jamshoro, Pakistan*
[2]*Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam, Pakistan*
[3]*National Centre of Excellence in Analytical Chemistry, University of Sindh, Jamshoro, Pakistan*

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Abstract

This study was designed to investigate the physico-chemical and rheological properties of 17 wheat varieties (TJ-83, Jouhar, TD-1, Anmool, Mehran, Indus-66, Sindh B-1, Abadgar, Bhittai, Imdad, Mexi-Pak, Soughat, Blue Silver, Moomal, Marvi, Kiran, and Pak-70) commercially grown on experimental field of Agriculture Research Institute, Tandojam. The results revealed that moisture % were in range of 11 to 12 among all varieties, high protein content of about 15.2% was found in Mehran and Blue silver varieties, starch was found high in Maxi-pak (70.6%), high hardness values in Imdad (70.1%) and Jouhar (70.2%). However, zeleny content was found high in Marvi, Abadgaar and Mehran i.e. 71%. Amylographic results showed that among all varieties the Bhittai variety required maximum temperature up to 65.7 ^{o}C for the beginning of gelatinization as compared to other varieties. The highest gelatinization temperature was noted up to 96.7 ^{o}C in Moomal whereas others had temperature from 82.7 to 89.0 ^{o}C. Highest gelatinization maxima (1782AU) acquired by T.J-83 variety. The results of Farinograph showed that highest water absorption was noted in Anmool variety. The highest dough development time and dough stability were found highest in Kiran and Indus-66, respectively. T.D-1 and Jouhar varieties had highest break down time as well as highest Farinograph quality.

Keywords: Wheat varieties; Physico-chemical; Inframatic grain analyser; Amylograph; Farinograph

Introduction

Wheat is the most important staple food of about two billion people (36% of the world population). In Pakistan, wheat is cultivated in almost every part of the country and it contributes 14.4% to the value added in agriculture and 3.0% to Gross domestic product contributing in the economy of Pakistan [1]. Wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally [2]. Besides being a rich source of carbohydrates, wheat contains protein, essential amino acids except lysine, minerals such as phosphorus, magnesium, iron, copper and zinc and thiamine, riboflavin, niacin and vitamin E [3].

Over the past three decades, increased wheat production occurred largely due to the deployment of high-yielding varieties and increased fertilizer use (PARC, 2012) [4]. It is cultivated on an area of about 9039.0 hectares with the production rate of about 25285.6 tonnes and production index of 118.8 (Pakistan Bureau of Statistics, 2014) [5].

In Pakistan different wheat varieties are grown in different climatic conditions. Therefore, the difference in physico-chemical characteristics and rheolgical properties in different varieties of

*Corresponding Author Email: allah.bux@usindh.edu.pk

wheat is expected [6]. Genotypic and non-genetic factors influence various functional and physico-chemical properties of wheat flour [7, 8, 9, 10]. Empirical rheological tests are used to test quality of flour and its usage in specific baked products [11].

The quality of wheat is considered to be the main factor to use in particular product preparation which is dependent on various rheological dough properties, milling, chemical and baking along with cropping year, climatic conditions, quality of cultivar, and process of harvest and storage conditions [12]. Bread, flat breads and various bakery products are prepared from milled wheat and are taken as cheapest source of proteins in Pakistan [13]. The quality of protein gluten is determined to assess flour quality to process into different wheat products and also physical, chemical and biochemical characteristics are mainly examined for the products prepared from the wheat flour [14]. Wheat quality can be improved if both genetic as well as biochemical composition influencing rheological properties are known [15].

Therefore, there is intense need for determination of physico-chemical and rheological properties of wheat varieties grown in Tandojam, Sindh.

Material and Methods

Sample collection

Seventeen (17) commercial varieties of wheat (TJ-83, Jouhar, TD-1, Anmool, Mehran, Indus-66, Sindh B-1, Abadgar, Bhittai, Imdad, Mexi-Pak, Soughat, Blue Silver, Moomal, Marvi, Kiran, Pak-70) were sown in four replications in Randomized complete design layout (a total of 68 sub-plots each measuring 10x10 meters) in 1st week of December 2012 at the experimental field of Wheat Section, Agriculture Research Institute, Tandojam. Wheat crop received good agriculture practices in terms of irrigation, fertilizer, etc as recommended by Sindh Agriculture Department from sowing till harvest, and the crop was harvested during March 2013. Each sub-plot was harvested separately, grains were mixed thoroughly. One kg sample was taken each sub-plot and a total of 68 samples were taken for 17 varieties. The sample grains were packed in properly labeledpaper bags and brought to the Cereals Technology Laboratory of Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam to perform the following experiments.

Sample Preparation

For physico-chemical analysis wheat grain samples was subject to instrument on normal base moisture of grain without any treatment.

For rheological properties wheat grains samples taken free from dockage and foreign matter and were subjected to tempering at a moisture content of 14-15 percent in plastic containers at room temperature for 24 hours and amount of water required for tempering was calculated by following the expression given in AACC (2000) than were milled by using Brabender quadrametic junior mill to yield flour [16].

Analysis procedure

Physico-chemical analysis of wheat grains

The physico-chemical analysis of wheat grain was performed by subjecting the samples to the Perten Inframatic Grain Analyzer (9200) made in Germany. Inframatic Grain Analyzer. Based on Near Infrared (NIR) specifically designed for determination of moisture content (%), protein content (%), zeleny content (%) and starch content (%), with the wavelength 1100-1400 nm. Instruments work in either reflectance or transmittance mode. In both modes measurement recorded that how much oflight is absorbed by the sample.The Inframatic 9200 meets international standards and recommendations such as AACC (2000) method 39-25.

Rheological analysis of wheat flour

Measurement of alpha-amylase activity with the amylograph

Amylase activity and gelatinization temperature of wheat flour were obtained by placing the samples in Brabender amylograph-E (GmbH & Co. Germeny). This method uses the

amylograph to estimate alpha-amylase activity (diastatic activity) in an aqueous suspension of flour as it gelatinizes during heating. The high viscosity of the starch gel is counteracted by the action of alpha-amylase, which liquefies starch granules as the slurry is heated. The amylograph value, or peak viscosity, also called malt index, is therefore inversely correlated with alpha-amylase activity. The method measures alpha-amylase that naturally occurs in flour.

Rheological behaviour of flour by farinograph

The Farinograph measures and records the resistance of dough to mixing. It is used to evaluate the absorption of flours and to determine stability and other characteristics of doughs during mixing. Two different procedures are in common use: the constant flour weight procedure, described herein, and the constant dough weight procedure. Since the two procedures may not yield identical results, the method employed must be specified when absorption and other farinogram values are reported. However, the parameters including water absorption, dough development time, dough stability, mixing index tolerance, breakdown time were obtained through Brabender Farinograph-E (GmbH & Co. Germeny). Quantitative analysis of gluten or protein. Methods used to assess rheological properties were meets standard recomendationes of method by AACC 2000 [16].

Data analysis

All the experiments had three replicates. Data was analyzed for one-way analysis of variance followed by Student-Newman-Keuls multiple test at 0.05 level using compare means procedure of SPSS 16 (17).

Results and Discussion

Wheat (*Triticum aestivum*) is the main diet for people of Pakistan and is a major source of dietary energy and protein also is the predominant cereal produced and eaten in Pakistan. Globally wheat is staple food, consumed in the form of bread, biscuits etc [18].

Maximum and minimum temperature were correlated with climatic conditions of 2013 with past ten years climatic conditions and also the rain fall were also found in correlation among the sample year and previous climatic data of ten years.**Error! Not a valid link.**

Physico-chemical analysis of wheat grains

The results in (Table-2) reveal all varieties containing moisture up to 12, Moisture has effect on grinding time of wheat [19]. Gulzar *et al.* [50] reported that moisture level ranged from 10.17-10.57% in wheat grains of different varieties. High moisture content enhances proteolytic and lipolytic activities leading to loss of nutrients [51]. Similar statement given by Anjum *et al*. that storage time and yield of flour decreases due to increased amount of moisture content in wheat grains [20]. Wheat kernel texture is also known to be affected due to presence of moisture [21] that also helps to measure wheat kernel weight [22]. Due to climatic and agronomic conditions moisture content shows variations among varieties during growth period and genetic make-up of grains [23, 24]. Similar findings reported by Singh and Patel that poor irrigated field affects the plant health which in turn affects grain weight, grain number per spike, spikes and grain falling numbers [25].

Table 1. **Climate Conditions at Tandojam the During Growth Period Until the Harvest of Wheat.**

Month	Dec 2012-Mar 2013				Ten Year Average (Dec – Mar)			
	Temperature (^{0}C)		Rainfall (mm)	Relative Humidity (%)	Temperature(^{0}C)		Rainfall (mm)	Relative Humidity (%)
	Max.	Min.			Max.	Min.		
December	26.775	12.075	0	56.5	26.15	10.99	0	58.91
January	23.525	10.17	0	58.75	22.25	8.15	0	58.83
February	26.05	11.65	0	60.25	26.07	10.63	0	57.76
March	30.875	14.72	0	55.5	30.76	13.38	0	58.75

Y=	**A + βx**	**n**	**r**	**s**	**F**	**Significance**
Max temp =	3.938 + 0.869x	4	0.993	0.454	133.016	0.007
Min temp =	2.775 + 0.869	4	0.982	0.443	52.907	0.018

The important criterion for assessing wheat quality is protein content. It is reported that difference in protein content among different wheat varieties, could be due to genotype, environment and the growing conditions [26, 27]. The results of present study showed that protein content was higher in Marvi, Bhittai and Mehran varieties that are up to 15%. The results of the present study are also in consistent with the results of Anjum *et al.* who reported that variation in protein content among Pakistani wheat varieties that is from 9.68 to 13.45 % [28]. Present results of different wheat varieties are found in variations from 9.71% to 15.42% in protein content that was supported by many researchers [24,29,30]. It was also observed the mean protein content in different wheat varieties was in range of 11.85% and the highest protein in variety Sehar-06 (v-1), while the lowest protein content in Inqalab-91 (v-6) [28].

Belderok *et al.,* reported that Starch is the stored energy of cereals grain. The amount of starch in a wheat grain of themay vary between (60-70%) [31]. The present results revealed that Pak-70, Moomal, Maxi Pak, Imdad, Sindh B-1, Indus and Johar had the highest (up to 70%) starch content. These values are calculated in normal base weight. The results are in agreement with Ciacca and Applonia who studied yam starch and revealed that gelatinization temperature of raw yam was 73.50°C [32]. Whereas it is also reported that the raw sample had 84.20°C peak temperature for gelation, These ranges of values for gelation temperature are higher than that of cocoyam – soybean-crayfish flours (56.88 to 76.25°C) and sweet potato starch samples (67.0 to 73.8°C) [33, 34]. Protein concentration, temperature, time of heating affects the rate of gelling and gel firmness [35]. When gel formed then viscosity increases sufficiently, this is a useful functional property. The gelatinization is useful in food appliances as gels act as a matrix for holding water, lipids, sugars, flavors, and other ingredients in new product development [36].

Hardness of 53% by method AACC (2000) method 39-25 and mesured in percentage (highest) was found in Jouhar, Bhittai and Imdad varieties. Hardness is the important factor that improves the quality of wheat grain, Endosperm texture (Hardness) in wheat is the single most important and defining quality characteristic, as it facilitates wheat classification and affects milling, baking and end-use quality and wheat hardness is also an important milling quality descriptor, according to which wheat is divided into soft, hard, and durum. [37, 45, 46]. Dry land wheat varieties are much harder than those of wet land wheat varieties reported in many studies. No it was not analyzed.

Zeleny Sedimentation test, By method AACC (2000) method 39-25 a test used to measure the total amount of gluten in wheat flour, hence its quality for bread making can be revealed [38], as the protein showed positive correlations with dry gluten and in tern with Zeleny values [47]. Whereas highest zeleny % (71%) was found in the Marvi, Abadgaar and Mehran. The water deficient plants were significantly lower in zeleny % than those of normally irrigated plants. also reported that all wheat varieties showed different behavior towards grain zeleny % [39].

Rheological analysis of wheat flour

Rheological properties were determined by AACC 2000 method no. 45-15A.

The gelatinization properties of starch in wheat depends on alpha amylase activity and can be used to make important predictions about the baking quality of flour, Amylograph enables continuous measurement of changes of viscosity in flour and water suspension during heating, so in (Table-3) different wheat varieties showed difference in all parameters.

Table-3 showed that only Bhittai variety required maximum temperature up to 65.7 ^{o}C for the beginning of gelatinization followed by T.J-83 with temperature 64.0 ^{o}C, while others required less temperature of gelatinization at the beginning. The highest gelatinization temperature was obtained up to 96.7 ^{o}C by Moomal followed by Anmool (96.3 ^{o}C) and Abaadgaar (95.3 ^{o}C) whereas others had temperature from 82.7 to 89.0 ^{o}C. The wheat variety T.J-83 acquired highest gelatinization maxima (1782AU) out of 17 wheat varieties.

The data in table-4 shows results of Farinograph which measures dough properties including a reliable check for mixing phase and water absorption capacity of flour, mixing time and dough stability as indicator parameters of dough quality. The farinographic characteristics such as water absorption, arrival time, dough development time, departure time, dough stability, mixing tolerance index and softening of dough differed significantly due to differences in wheat varieties as shown in (Table-4).

Table 2. **Physico-Chemical Characteristics of Grain of Wheat Varieties.**

S#	Variety	Moiture%	Protien%	Starch%	Hardness%	Zeleny%
1.	T.J-83	$12.0^{de}\pm0.12$	$14.1^{e}\pm0.14$	$69.9^{ab}\pm0.69$	$49^{ab}\pm0.49$	$62^{e}\pm0.62$
2.	Jouhar	$11.9^{de}\pm0.11$	$13.6^{bcd}\pm0.13$	$70.2^{ab}\pm0.70$	$53^{e}\pm0.53$	$63^{e}\pm0.63$
3.	T.D-1	$12.0^{de}\pm0.12$	$13.4^{b}\pm0.13$	$70.3^{ab}\pm0.70$	$52^{de}\pm0.52$	$63^{e}\pm0.63$
4.	Anmool	$12.0^{de}\pm0.12$	$13.5^{bc}\pm0.13$	$70.0^{ab}\pm0.70$	$50^{bc}\pm0.50$	$58^{cd}\pm0.58$
5.	Mehran	$11.4^{b}\pm0.11$	$15.2^{f}\pm0.15$	$68.5^{ab}\pm0.68$	$52^{de}\pm0.52$	$71^{g}\pm0.71$
6.	Indus-66	$11.8^{de}\pm0.11$	$13.8^{cde}\pm0.13$	$70^{ab}\pm0.70$	$48^{a}\pm0.48$	$57^{bc}\pm0.57$
7.	Sindh B-1	$12.0^{de}\pm0.12$	$13.5^{bc}\pm0.13$	$70.2^{ab}\pm0.70$	$50^{bc}\pm0.50$	$59^{d}\pm0.59$
8.	Abaadgaar	$11.5^{bc}\pm0.11$	$13.9^{de}\pm0.13$	$68.3^{a}\pm0.68$	$52^{de}\pm0.52$	$71^{g}\pm0.71$
9.	Bhittai	$11.4^{b}\pm0.11$	$15.0^{f}\pm0.15$	$68.7^{ab}\pm0.68$	$53^{e}\pm0.53$	$70^{g}\pm0.70$
10.	Imdad	$11.9^{de}\pm0.11$	$13.9^{de}\pm0.13$	$70.1^{ab}\pm0.70$	$53^{e}\pm0.53$	$63^{e}\pm0.63$
11.	Maxi Pak	$10.0^{a}\pm0.10$	$12.7^{a}\pm0.12$	$70.6^{b}\pm0.70$	$49^{ab}\pm0.49$	$52^{a}\pm0.52$
12.	Soughat	$12.0^{de}\pm0.12$	$12.6^{a}\pm0.12$	$69.8^{ab}\pm0.68$	$48^{a}\pm0.48$	$56^{b}\pm0.56$
13.	Blue silver	$10.0^{a}\pm0.10$	$15.2^{f}\pm0.15$	$70.4^{ab}\pm0.70$	$49^{ab}\pm0.49$	$58^{cd}\pm0.58$
14.	Moomal	$11.7^{cd}\pm0.11$	$13.4^{b}\pm0.13$	$70.4^{ab}\pm0.70$	$52^{de}\pm0.52$	$57^{bc}\pm0.57$
15.	Marvi	$12.1^{e}\pm0.12$	$15.2^{f}\pm0.15$	$68.6^{ab}\pm0.68$	$51^{cd}\pm0.15$	$71^{g}\pm0.71$
16.	Kiran	$11.7^{cd}\pm0.11$	$13.4^{bc}\pm0.13$	$69.0^{ab}\pm0.69$	$48^{a}\pm0.48$	$66^{f}\pm0.58$
17.	Pak- 70	$11.9^{de}\pm0.11$	$13.5^{bc}\pm0.13$	$70.2^{ab}\pm0.70$	$49^{ab}\pm0.49$	$58^{cd}\pm0.58$
	F-Statistics at df=16	91.463	104.534	3.620	41.340	274.602

*Values followed by the same letter are not significantly different at 0.05 level Student-Newman-Keuls test.

Table 3. **Amylographic Characteristics of Wheat Flour.**

S#	VARIETY	BEGNING OF GELATINAZATION (BG) (^{o}C)	GELTINIZING TEMPERATURE (GT) (^{o}C)	GELATINIZATION MAXIMA (GM) (AU=amylograph unit)
1.	T.J-83	$64.0^{c}\pm0.64$	$86.5^{de}\pm0.86$	$1782^{k}\pm17.82$
2.	Jouhar	$60.2^{a}\pm0.60$	$82.7^{bc}\pm0.82$	$1340^{g}\pm13.40$
3.	T.D-1	$61.7^{b}\pm0.61$	$87.3^{def}\pm0.87$	$698^{a}\pm6.98$
4.	Anmool	$62.7^{bc}\pm0.62$	$96.3^{g}\pm0.96$	$1682^{j}\pm16.82$
5.	Mehran	$62.2^{b}\pm0.62$	$87.0^{de}\pm0.87$	$1488^{i}\pm14.88$
6.	Indus-66	$61.8^{b}\pm0.61$	$87.7^{def}\pm0.87$	$1308^{f}\pm13.08$
7.	Sindh B-1	$62.8^{bc}\pm0.62$	$89.0^{f}\pm0.89$	$1009^{d}\pm10.09$
8.	Abaadgaar	$62.5^{bc}\pm0.62$	$95.3^{g}\pm0.95$	$1662^{j}\pm16.62$
9.	Bhittai	$65.7^{d}\pm0.65$	$87.7^{def}\pm0.87$	$941^{c}\pm9.41$
10.	Imdad	$62.0^{b}\pm0.62$	$85.5^{d}\pm0.85$	$890^{b}\pm8.90$
11.	Maxi Pak	$62.3^{b}\pm0.62$	$86.2^{de}\pm0.86$	$935^{c}\pm9.35$
12.	Soughat	$62.7^{bc}\pm.62$	$83.8^{c}\pm0.83$	$996^{d}\pm9.96$
13.	Blue silver	$62.3^{b}\pm0.62$	$86.3^{de}\pm0.86$	$1064^{e}\pm10.64$
14.	Moomal	$61.8^{b}\pm0.61$	$96.7^{g}\pm0.96$	$1671^{j}\pm16.71$
15.	Marvi	$63.0^{bc}\pm0.63$	$81.5^{bc}\pm0.81$	$1456^{h}\pm14.56$
16.	Kiran	$60.3^{a}\pm0.60$	$72.8^{a}\pm0.72$	$1019^{d}\pm10.19$
17.	Pak- 70	$61.6^{b}\pm0.61$	$88.0^{ef}\pm0.88$	$1472^{hi}\pm14.72$
	F-statistics at df= 16	12.252	127.996	2.009E3

*Values followed by the same letter are not significantly different at 0.05 level Student-Newman-Keuls test.

Table 4. **Farinographic Characteristics of Wheat Flour.**

S#	Variety	WA (%)	DDT (minute)	DS (minute)	MIT FU	BT (minute)	FQ no:
1.	T.J-83	59.2^{e}±0.59	4.5^{i}± 0.45	4.9^{d}±0.49	96^{f}±0.96	5.9^{h}±0.59	59^{h}±0.59
2.	Jouhar	58.3^{de}±0.58	5.6^{n}±0.56	5.0^{d}±0.50	60^{d}±0.60	8.0^{k}±0.80	80^{k}±0.80
3.	T.D-1	59.0^{e}±0.59	5.0^{k}±0.50	6.0^{f}±0.60	60^{d}±0.60	8.0^{k}±0.80	80^{k}±0.80
4.	Anmool	68.5^{h}±0.68	4.2^{g}±0.42	4.2^{c}±0.42	173^{g}±1.73	5.3^{e}±0.53	53^{d}±0.53
5.	Mehran	57.9^{de}±0.57	3.5^{f}±0.35	4.0^{b}±0.40	60^{d}±0.60	6.0^{h}±0.60	60^{h}±0.60
6.	Indus-66	56.2^{bc}±0.56	2.9^{d}±0.29	9.0^{i}±0.90	225^{j}±2.25	7.0^{i}±0.70	70^{i}±0.70
7.	Sindh B-1	57^{cd}±0.57	1.0^{a}±0.10	6^{f}±0.60	50^{b}±0.50	7.5^{j}±0.75	75^{j}±0.75
8.	Abaadgaar	79.0^{i}±0.790	5.2^{l}±0.52	3.4^{a}±0.34	366^{k}±3.66	2.5^{a}±0.25	54^{e}±0.54
9.	Bhittai	57.2^{cd}±0.57	5.8^{o}±0.58	5.2^{e}±0.52	205^{i}±2.05	5.2^{e}±0.52	52^{d}±0.52
10.	Imdad	55.0^{b}±0.55	4.4^{h}±0.44	4.9^{d}±0.49	88^{e}±0.88	6.0^{h}±0.60	60^{h}±0.60
11.	Maxi Pak	63.0^{f}±0.63	3.4^{e}±0.34	4.0^{b}±0.40	62^{d}±0.62	7.9^{k}±0.79	79^{k}±0.79
12.	Soughat	45^{a}±0.45	2.1^{b}±0.21	4.0^{b}±0.40	45^{a}±0.45	5.2^{e}±0.52	52^{d}±0.52
13.	Blue silver	55^{b}±0.55	2.9^{d}±0.29	6.0^{f}±0.60	95^{f}±0.95	5.5^{f}±0.55	55^{f}±0.55
14.	Moomal	65^{g}±0.65	4.8^{j}±0.48	7.1^{h}±0.71	62^{d}±0.62	5.8^{g}±0.58	5.8^{g}±0.58
15.	Marvi	59.0^{e}±0.59	2.2^{c}±0.22	4.0^{b}±0.40	200^{h}±2.00	2.9^{b}±0.29	29^{a}±0.29
16.	Kiran	56.2^{bc}±0.56	9.0^{p}±0.90	7.0^{g}±0.70	89^{e}±0.89	4.5^{d}±0.45	45^{c}±0.45
17.	Pak- 70	57.2^{cd}±0.57	5.5^{m}±0.55	9.1^{j}±0.91	55^{c}±0.55	3.0^{c}±0.30	30^{b}±0.30
	F-statistics at df=16	419.622	4.834E3	2.650E3	1.102E4	2.586E3	1.951E3

*Values followed by the same letter are not significantly different at 0.05 level Student-Newman-Keuls test.

WA= water absorption; DDT= dough development time; DS= dough stability
MIT= mixing index tolerance; BT= breakdown time; FQ=farinograph quality
FU=farinograph unit

The results of Farinograph revealed that highest water absorption was noted in Abaadgaar variety has 79.0 and Anmool variety (68.5).Water absorption in wheat and composite flour is considered to be an important characteristic[40] Water absorption measures the amount of water that can be absorbed by a given quantity of flour. In bread making, it is usually preferable to have flour that can absorb a large amount of water. Measurements of absorption are done to determine the amount of water the dough can absorb, which in turn indicates dough yield and shelf life. Optimum absorption represents the maximum amount of water, as a percent of the flour weight that will produce a high yield of bread during the baking process [48,49]. The highest Dough Development time was obtained in Kiran variety i.e., up to 9, the longer the time to develop the dough the stronger the flour will be obtained. Indus-66 had highest dough stability i.e., 9, the higher the dough stability, longer dough can withstand. Dough with a longer stability can also withstand a longer fermentation period. The lowest mixing index tolerance of 45 was found in Soughat variety, in general, flours that have good tolerance to mixing have low tolerance index. T.D-1 and Jouhar varieties had highest break down time of about 8 as well as highest Farinograph quality of up to 80. The results pertaining to the physical dough properties obtained from farinograms of different wheat varieties are comparable with the early findings [41, 42, 43, 44].

Conclusion

It was concluded that blue silver variety had good nutritional quality i-e protein and starch as compared to other varieties.

Bhittai variety required maximum temperature for the beginning of gelatinization as compare to rest of the varieties. However, the Moomal and anmool were noted with highest gelatinization temperature and T.J-83 acquired highest gelatinization maxima.

The highest Dough Development time and dough stability was obtained in Kiran and Indus-66 varieties. Lower mixing index tolerance was observed in Soughat variety. The T.D-1 and Jouhar

varieties had highest break down time as well as highest Farinograph quality.

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