SOLVENT RETENTION CAPACITIES OF WHEAT VARIETIES IN RELATION TO COOKIE BAKING QUALITY

Zafar **Iqbal***[1, 2], Imran **Pasha**[2], Muhammad Shakeel **Hanif**[3], Atta Muhammad **Arif**[4], Muhammad **Rafiq**[5], Sharoon **Masih**[4]

[1] Mango Research Institute, Multan, Pakistan
[2] National Institute of Food Science and Technology, Uni. of Agri. Faisalabad, Pakistan
[3] Department of Dairy Technology, Uni. of Veterinary and Animal Science, Lahore, Pakistan
[4] Oilseeds Research Institute, AARI, Faisalabad, Pakistan
[5]Food Technology Section, Post-Harvest Research Centre, AARI, Faisalabad, Pakistan
*E-mail: zafarft@yahoo.co.in

ABSTRACT
Two wheat varieties AS-2002 and Inqulab 91 were analyzed for solvent retention capacities and cookie baking quality at National Institute of Food Science and Technology, University of Agriculture, Faisalabad during 2013. Wheat variety AS 2002 depicted less means for SDS sedimentation (25.32mL), Zelney value (59.81mL), AWRC (73.17mL), water absorption (55.03%) and all solvent retention capacities (59.50, 81.00, 70.64 and 100.95% WSRC, SUCSRC, SODSRC and LASRC respectively) values than Inqulab 91 (27.51mL, 64.98mL, 79.49%, 59.78%, 67.62%, 94.12%, 75.01% and 121.12% SDS, Zelney value, AWRC, WA, WSRC, SUCSRC, SODSRC and LASRC respectively). Wheat variety AS 2002 showed higher mean for physical characteristics of cookies (7.06mm, 25.30mm, 36.50 and 7.43g thickness, diameter, spread factor and weight) than Inqulab 91 (6.46mm, 23.87mm, 35.82 and 6.68g thickness, diameter, spread factor and weight). Mean for sensory characteristics were higher for wheat variety AS 2002 (6.40, 6.67, 7.00, 6.80, 7.00) as compared to Inqulab 91 (6.00, 6.00, 6.20, 6.40, 5.80) respectively for cookie color, crispness, taste, surface appearance and overall acceptance. Break flour yield is good predictor of cookie quality and exhibit direct relationship with physical and sensory parameters of cookies. SDS sedimentation, Zelney value, AWRC, water absorption and SRC values revealed inverse association with physical and chemical characteristics of cookies and significant with each other.

Keywords: SRC, cookie quality, AWRC, Zelney value, sensory evaluation

Submitted: 17.11.2015 Reviewed: 18.02.2016 Accepted: 30.03.2016

1. INTRODUCTION

Wheat (*Triticum aestivum* L.), the principle cereal grain produced, consumed and traded across the globe (Dhaka et al., 2012) is staple food of Pakistani people which contribute 60% in their total protein and calorie requirement (Khan et al., 2009) by a consumption of 80% of total dietary intake in daily diet (Bostan and Naeem, 2002). Genetics and environmental effects make end use quality attributes of wheat difficult for their estimation (Li *et al*. 2009). Prabhasankar (2002) suggested certain physical, chemical, rheological and baking analysis for grain quality. Technical performance of flour is outcome of delicate and intricate interactions evaluated on the basis of quality attributes like protein content, wet gluten content, gluten strength, Zeleny value, fall/decrease index, extensibility and resistance (Constantinescu et al., 2011), sodium dodecyl sulphate (SDS) sedimentation volumes, the mixograph and the farinograph test (McDermott and Redman, 1977).

Unique chemical and physical parameters are valuable in expression of wheat and flour quality. However, no single test itself or independent of other variables provides sufficient prediction (Baslar and Ertugay, 2011). Zeleny sedimentation test estimates gluten strength (Zhi-ying et al., 2013) and helps in deciding wheat quality as food and a constituent in baking (Ozturks et al. 2008). SDS test evaluates the sedimentation volume of a flour suspension in dilute lactic acid. Its value is linked with swelling of glutenins and reveals the quantity and quality of gluten protein (Zhi-ying et al., 2013). Damaged starch, pentosans, gluten proteins and ash affect water absorption of flour (Buckley, 2013). Flour with low water absorption capacity develops sticky, slack dough difficult to process in a commercial bakery while flours with high water absorption are more robust and produce machinable dough with more stable handling properties. Flours with a high water absorption tolerance reduce waste during processing, are need of automated commercial bakeries. Such strong wheat varieties are of great concern for breeders and commercial bakers due to limited differences in final product quality (Buckley, 2013).

American association of cereal chemists (AACC, 2000) proved that solvent retention capacity (SRC) measures the ability of flour to retain a set of four solvents (water, 50% sucrose, 5% sodium carbonate and 5% lactic acid) expressed as percent of flour weight corrected to 14% moisture after centrifugation (Al-Dmoor, 2013). Retention of these solvents forecasts a practical and functional flour quality and predicts commercial bakery performance better than traditional sugar snap cookie test (Slade and Levine, 1994). Each solvent evaluates certain chemical and physical aspects of flour (Buckley, 2013). Lactic acid SRC is linked to gluten proteins particularly glutenin attributes and predicts strength of flour and loaf volume in relation to protein quality. Sodium carbonate SRC delineates the levels of damaged starch and pentosans while sucrose SRC differentiates with water soluble arabinoxylans (pentosans) and distilled water shows the ability of flour to hold water and interworking of all polymer networks (Kweon et al., 2011; Buckley, 2013). SRC predicts flour performance and hence useful for breeders, millers and bakers in modifying a specific functional components for improving dough handling and end product quality (Xiao et al., 2006).

The technological quality of wheat includes many attributes of kernel and flour important in the production of different baked products (Zghal et al., 2001). Soft wheats are best adapted for making cookies, pastries, cakes and other derived products while hard wheats better suited for bread baking (Giroux and Morris, 1997). Wheat varieties with greater protein content, wet and dry gluten, SDS sedimentation value, damaged starch, strong gluten and superior rheological attributes are suitable for making bread and its variants like chappati, roti and naan while those with low protein content, fragile gluten network with less wet and dry gluten, SDS sedimentation value, damaged starch and poorer rheological parameters are best suited for the production of cookies, cakes, pastries and crackers (Iqbal et al., 2015). Sugar-snap cookie making is best technique for analyzing baking quality of soft wheat (Ohm et al., 2009). Preparation of quality cookies and crackers requires specific quality flour (Anjum et al., 2002). Soft wheat flour with low protein content, smaller particle size and low alkaline water retention capacity produce cookies with better quality.

Grain hardness is one of the most important element for selection of wheat for cookie quality (Ohm et al., 2009). Wheat grain texture influence break flour yield, flour particle size index and damaged starch (Wade, 1988). Soft wheats has higher yield of break flour with a smaller particle size distribution, and lower protein and starch damage. All these attributes are desired for cookie and cake baking (Faridi et al 2000). Wheat varieties with soft grain texture yield considerably higher flour, break flour and lower ash content than hard wheats (Martin et al. 2007). Hard wheat produces relatively little flour from the break rolls compared with soft wheat (Ziegler and Greer 1978). Wheat flour is main ingredient in cookies and crackers and its quality assessment is imperious. Wheat cultivars could be selected for cookie baking on the basis of sodium carbonate and sucrose SRC and SDS-sedimentation volume (Kang et al., 2014). Each wheat genotype has different flour quality which may affect the quality of cookies. Current studies were therefore planned to assess the association between physical and sensorial cookie characteristics and chemical and functional characteristics of flour from two commercially available wheat varieties.

2. MATERIALS AND METHODS

Two commercially available wheat varieties i.e. Inqulab-91 and AS-2002 were used as medium of experiment at National Institute of Food Science and Technology University of Agriculture Faisalabad during 2013. Clean wheat grains tempered to 15.50% moisture content kept in plastic containers at room temperature for 24 hours. Water quantity was calculated by AACC (2000) method No. 26-95. Wheat was milled through Brabender Quadrumate Senior Mill (C.W. Brabender Instruments, Inc.) according to AACC (2000) method No. 26-95 to obtain break and reduction flour which were combined to get straight grade flour. All tests were conducted on straight-grade flour.

CHEMICAL CHARACTERISTICS AND SOLVENT RETENTION CAPACITIES

The straight grade flour was tested for alkaline water retention capacity (AWRC) and SDS sedimentation test following procedures outlined in AACC (2000) method No. 56-10 and No. 56-70 respectively. The water absorption capacity and Zelney value of flour samples was estimated through near infrared reflectance (NIR) instrument, IM 9100. The solvent retention capacities of straight grade flour samples were recorded using four water-based solvents following procedure described in AACC (2000) method No. 56-11 modified by Guttieri *et al*. (2001) and Ram *et al*. (2005) employing the following formula

$$\% SRC = \frac{\text{Weight of residue}}{\text{Flour weight}} \times \frac{86}{100 - \%\text{ flour moisture}} - 1 \times 100$$

COOKIE BAKING QUALITY

The cookies were prepared from straight grade flour of each wheat variety adopting AACC (2000) method No. 10-50 D. The weight, diameter and thickness of six cookies were recorded and spread factor was calculated by dividing diameter with thickness. The sensory characteristics such as color, crispness, taste and surface characteristics were evaluated by a panel of judges on 9-point hedonic scale described by Meilgard et al. (2007).

STATISTICAL ANALYSIS

The data obtained for each parameter were subjected to statistical analysis to work out effect of flour samples on chemical, SRC and cookie baking quality by using completely randomized design and mean values were compared according to Duncans Multiple Range test (Steel *et al*., 1997).

3. RESULTS AND DISCUSSION

FUNCTIONAL PROPERTIES

Effect of wheat varieties was found to be highly significant on water absorption and alkaline water retention capacity. Wheat variety Inqulab 91 possessed considerably higher water absorption (59.78±2%) and AWRC (79.49 mL) values than AS 02 (55.50%, 73.17mL respectively) (Fig 2). Wheat varieties showed significant variation for Zelney value. Wheat variety Inqulab 91 revealed substantially higher mean score (64.98mL) for Zelney sedimentation value than AS 02 (59.81mL) (Fig 1).

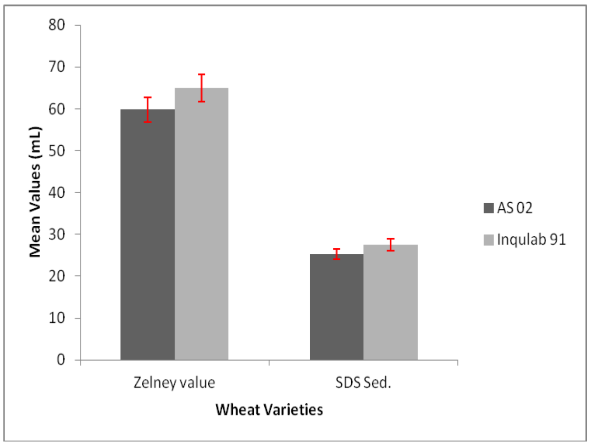

Fig. 1. Zelney value and SDS sedimentation volume of wheat varieties

AWRC is conducted to select flours of good cookie quality. Good cookie flours have low AWRC values and produce cookies with large diameters (Ohm et al., 2009). Water absorption is important due to the producing dough of workable consistency (Simmonds, 1995) and important consideration in all types of baked products (Mutlu et al. 2011). Soft wheats have lower water absorption capacity than hard wheats because soft wheats contain less damaged starch (Oshorne *et al*., 2001).

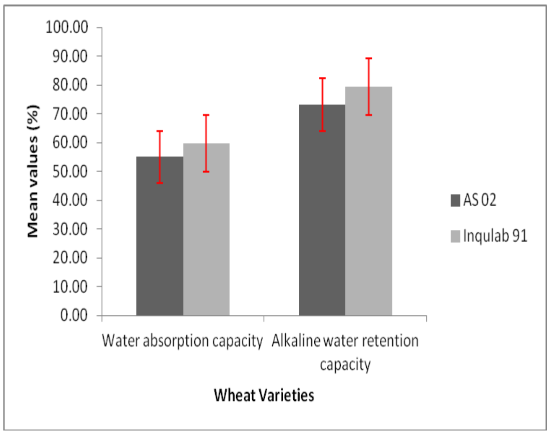

Fig 2. Water absorption capacity and alkaline water retention capacity of wheat varieties

Mutlu et al. (2011) and Pasha et al. (2006) reported NIR water absorption value ranged from 50.0 to 66.6% and 59.64 to 63.64 mL respectively. The Zeleny sedimentation test is used as a screening tool in wheat breeding and milling applications (Trajkovic et al., 1983) and it provides information on the protein quantity and quality of ground wheat and flour samples (Keran et al., 2009). Zelney value in current studies is in conformity with Mutlu et al. (2011) and Pasha et al. (2006) reported NIR Zelney value 24.50 to 56.00 mL and 50.67 to 80.34 mL respectively. Both higher gluten content and a better gluten quality give rise to slower sedimentation and higher Zeleny test values (Shewry and Tatham, 2000). Wheat variety Inqulab 91 having strong gluten showed higher volume of the sediment in Zelney sedimentation and SDS tests than AS 02 having weak gluten.

SOLVENT RETENTION CAPACITY (SRC)

Effect of wheat varieties was found to be highly significant on WSRC. Wheat variety Inqulab 91 possessed higher (67.62%) WSRC than AS 02 (59.50%) (Table 1). Effect of wheat varieties was found to be highly significant and significant on SUCSRC and SODSRC, respectively. The wheat variety Inqulab 91 exhibited the higher SUCSRC and SODSRC as compared to AS 02. Results showed that Inqulab 91 had 94.12% SUCSRC and 75.01% SODSRC while AS 02 displayed 81.00% SUCSRC and 70.64% SODSRC (Table 1). Effect of wheat varieties on LASRC was found to be highly significant. Mean scores for LASRC was higher in wheat variety Inqulab 91 (121.12%) than AS 02 (100.95%) (Table 1). WSRC is a general indicator of base absorption and included in the SRC profile as a summary solvent that is affected by all hydrophyllic flour components (Guttieri and Souza, 2003). The results of the present study are in agreement with the findings of other researchers as 69.20 to 81.40 % (Bettege *et al*., 2002) and 53.40 to 70.60 % (Ram *et al*., 2005) in different wheat varieties. The findings of the present study are in concordance with the results observed by Ram and Singh (2004) who reported SODSRC in the range of 65 to 114% in different wheat varieties. The results further showed that wheat variety Inqulab 91 possessing higher SUCSRC (high pentosans) and SODSRC (high starch damage) is suitable for bread production. Ram *et al.* (2005) reported LASRC ranged from 72.0 to 122.8 % in 150 wheat varieties and observed that LASRC was positively correlated with grain protein content. Guttieri and Souza (2003) added that the LASRC is an indicator of gluten strength and it varies due to genotypic differences in different wheat varieties and observed LASRC ranged from 81.6 to 108.0 %.

Table 1: Solvent retention capacity of wheat varieties

Wheat varieties	Solvent retention capacities (%)			
	WSRC	SUCSRC	SODSRC	LASRC
AS 2002	59.50b	81.00b	70.64b	100.95b
Inqulab 91	67.62a	94.12a	75.01a	121.12a

Table 2: Physical characteristics of cookies

Wheat varieties	Thickness (mm)	Diameter (mm)	Spread factor	Weight (g)
AS 2002	7.06a	25.30 a	36.50a	7.43a
Inqulab 91	6.48b	23.87b	35.82b	6.68b

Table 3: Sensorial characteristics of wheat varieties

Wheat varieties	Color	Crispness	Taste	Surface characteristics	Overall acceptability
AS 2002	6.40a	6.67a	7.00a	6.80a	7.00a
Inqulab 91	6.00b	6.00b	6.20b	6.40b	5.80b

It may be concluded that wheat variety Inqulab 91 possessing higher LASRC may have better gluten quality and should be used for bread production.

The SRC profile including the flour absorption level in each solvent indicates adequacy of flour for certain baked product applications (Buckley, 2013).

For bread production, high water absorption, good gluten strength, sufficient damaged starch and arabinoxylan contents are required (Kweon et al 2011). Flour having 51% water SRC, 89% sucrose SRC, 87% lactic acid SRC and 64% sodium carbonate SRC is best suited for cookie preparation while sponge and dough system perform better for flour with water SRC 57%, sucrose SRC 96%, lactic acid SRC 100% and sodium carbonate SRC 72% (Al-Dmoor, 2013).

COOKIE BAKING QUALITY

PHYSICAL CHARACTERISTICS

Effect of wheat varieties was significant for physical characteristics of cookies. Wheat variety AS 02 showed mean values 7.06mm, 25.30mm, 36.50, 7.43g respectively for cookie thickness, diameter, spread factor and weight which are higher as compared to Inqulab 91 (6.48mm, 23.87mm, 35.82, 6.68g respectively) (Table 2).

Wheat variety AS 02 has lower water absorption capacity and release moisture rapidly during baking to produce cookies with higher spread ratio while Inqulab 91 produce cookies with smaller diameter because of higher water absorption during mixing and retain water for long time during baking. Hence wheat variety AS 02 with less water absorption, lower AWRC, SDS and Zelney sedimentation values is more suitable for cookie baking as compared to Inqulab 91. Wheat varieties and growing environment showed significant influences on flour characteristics and cookie baking quality (Souza *et al.*, 2004). Cookie diameter was mainly influenced by cultivars (Kang *et al.*, 2010b, 2014), but thickness of cookie was influenced by genotypes and environmental conditions in Korean wheat cultivars and experimental lines (Kang *et al.*, 2010b).

Wheat lines with larger cookie diameters can be selected on the basis of combined values from sodium carbonate SRC and SDS sedimentation volume of wheat flour (Guttieri et al., 2004). AWRC, SCSRC, LASRC and protein content account for 87 % variation in cookie diameter in Indian Wheats (Ram and Singh, 2004) while in Chinese Wheats SUSRC and flour particle size contributed 83% in cookie diameter (Zhang et al., 2007). Soft wheat flours assure unique characteristics like large, tender and less-dense products (Gaines et al., 1996). Good cookie flours hold less water (Faridi et al. 1994). Higher cookie diameter and spread ratio are considered desirable quality attributes (Baltisvas, 1996). Technological quality parameters of cookies and crackers like specific volume and overall sensory score showed positive correlation with weak gluten content (Osella et al., 2008). Flour suitable for most soft wheat products except crackers produces superior quality sugar-snap cookies with larger diameters and uniform cracking pattern on the top surface with improved softness (Wade, 1988).

Cookie spread is a consistent indicator of genet ic characteristics of wheat varieties within a location. Cookies prepared from soft wheat flours exhibit more width or diameter, lesser height and lower bulk density than from hard wheat flours (Baltiavas, 1996). Wheat varieties with larger cookie spread liberate moisture efficiently during baking due to lower water absorption while cultivras with smaller cookies diameter have higher water absorption and hold moisture for extended time (Abboud et al., 1985).

SENSORY EVALUATION

Mean values for sensorial characteristics varied significantly among wheat varieties. Average sensorial scores for color, crispness, taste, surface characteristics and overall acceptability of cookies were higher (6.40, 6.67, 7.00, 6.80, 7.00 respectively) for wheat variety AS 02 than Inqulab 91 (6.00, 6.00, 6.20, 6.40 and 5.80) (Table 3). Wheat variety AS 02 produced cookies with better sensory profile than Inqulab 91.

Cookies made from soft wheat flours have better appearance, soft bite and more tenderness than those made from hard wheat flour (Baltiavas, 1996). Wheat varieties exhibited substantial impact on all sensory parameters of cookies (Pasha, 2006). Results of current studies are in concordance with Anjum et al. (1998) who observed substantial impact of wheat varieties on color, texture and over all acceptance of cookies. Surface characteristics of cookies and flour protein content showed inverse relationship (Igrejas et al., 2002). Wheat varieties showed significant influence on surface appearance of cookies (Pasha, 2006).

CORRELATION STUDIES

Break flour yield showed significant positive correlation with cookie spread (r=0.71), cookie diameter (r=0.93) and thickness (r=0.99) (Table 4). Flour protein content did not show notable association with physical and sensory characteristics of cookies (Table 4). Non-significant correlation between SDS sedimentation volume and cookie characteristics showed that flour with higher SDS and WA (Table 4). Lactic acid SRC showed significant positive correlation with flour protein content (r=0.88) and SDS sedimentation volume (r=0.99), while negative correlation with thousand kernel weight (r=-0.73) (Table 4). SODSRC showed positive correlation with NIR hardness (r=0.67) (Table 4). SUCSRC showed significant inverse relationship with break flour yield (r=-0.52) and thousand kernel weight (r=-0.7) while weak correlation with cookie diameter and thickness (Table 4). WSRC exhibited high inverse relationship with break flour yield (r=-0.66), cookie thickness (r=-0.54) and TKW (r=-0.81) while significant positive correlation with protein content (r=0.81), SDS value (r=0.97), Zelney value (r=0.96) and water absorption capacity (r=1.0) (Table 4). Test weight depicted weak association with all SRC values but strong relationship with physical characteristics of cookies (r=0.82, 0.98, 0.66 cookie diameter, spread factor and thickness respectively) (Table 4). Spread factor of cookies was significantly correlated with break flour yield, NIR hardness, TKW, TW and surface score of cookies (Table 4). Cookie diameter showed significant positive correlation with break flour (r=0.93), NIR hardness (0.82), cookie spread (0.92), surface characteristics (1.00), TKW (0.82) and cookie thickness (0.97) (Table 4). AWRC, WSRC, SODSRC, SUCSRC, LASRC, WA, PC, SDS sedimentation and Zelney values were highly interrelated with each other but showed no significant association with physical and sensorial characteristics of cookies (Table 4). LASRC (r=-0.2, -0.43, -0.26), SUCSRC (r=-0.16, -0.39, -0.22) and WSRC (r=-0.33, -0.54, -0.38) showed insignificant negative correlation with cookie diameter, cookie thickness and surface characteristics of cookies significant negative correlation with overall acceptance (r=-0.66LARC, -0.63, SUCRC and -0.76WSRC).

Table 4. Correlation coefficients for association of cookie baking with physic-chemical characteristics of wheat varieties

Parameters	AWRC	BF	CD	LARC	NIR Hard	OA	PC	SDS	SODRC	SUCRC	CSF	SC	TKW	TW	CT	WA	WSRC
Break Flour	0.43																
Cookie Diameter	-0.06	0.93**															
LASRC	0.99**	-0.55	-0.20														
NIR Hardness	0.53	0.55	0.82*	0.40													
Overall Acceptance	-0.55	0.99*	0.87*	-0.66	0.42												
Protein Content	0.94*	-0.08	0.29	0.88*	0.79	-0.22											
SDS Sed.	1.00	-0.44	-0.08	0.99**	0.51	-0.57	0.93*										
SODRC	0.98**	-0.25	0.12	0.95**	0.67*	-0.39	0.98**	0.98**									
SUCRC	0.99**	-0.52*	-0.16	1.00**	0.44	-0.63*	0.90*	1.00**	0.96*								
Cookie Spread	0.33	0.71*	0.92*	0.19	0.98**	0.60	0.64	0.31	0.50	0.23							
Surface Characters	-0.12	0.95*	1.00**	-0.26	0.78	0.89*	0.24	-0.13	0.07	-0.22	0.90*						
TKW	-0.62	0.97*	0.82*	-0.73*	0.34	1.00**	-0.31	-0.63	-0.47	-0.70*	0.54	0.85*					
TW	0.53	0.54	0.82*	0.40	1.00**	0.42	0.79*	0.51	0.67	0.44	0.98*	0.78*	0.34				
Cookie Thickness	-0.29	0.99**	0.97**	-0.43	0.66	0.96**	0.06	-0.31	-0.11	-0.39	0.80*	0.98**	0.93*	0.66*			
WA	1.00**	-0.48	-0.12	1.00**	0.48	-0.60	0.92*	1.00**	0.97*	1.00**	0.28	-0.17	-0.66	0.48	-0.35		
WSRC	0.96*	-0.66*	-0.33	0.99**	0.27	-0.76	0.81*	0.97*	0.90*	0.98*	0.06	-0.38	-0.81*	0.28	-0.54*	0.98*	
Zelney Value	1.00**	-0.42	-0.05	0.99**	0.53	-0.54	0.94*	1.00	0.98**	0.99**	0.34	-0.11	-0.61	0.54	-0.29	1.00**	0.96*

AWRC=Alkaline water retention capacity; BF=Break flour; CD=Cookie diameter; LASRC=Lactic acid retention capacity; NIR Hard. =NIR hardness; OA=Overall acceptance
PC=Protein content; SDS=SDS sedimentation volume; SODRC= Sodium carbonate retention capacity; WA=water absorption; SUCRC=Sucrose retention capacity

There is general perception that wheat with higher break flour yield produces cookies with better quality (Faridi et al 2000). Results of current studies are in line with Ohm et al. (2009) who reported significant positive correlations of break flour yield with sugar-snap and wire-cut cookie diameters. However correlation between break flour yield and cookie thickness in current studies is contrary to results reported by Ohm et al. (2009). Earlier studies revealed insignificant correlation between protein content and cookie diameter (Fustier et al 2008). Insignificant relationship between SDS volume and cookie characters shows poorer cookie baking quality as oxidative gelation or development of gluten network during baking upsurges viscosity resulting in retardation or shrinkage in cookie spread (Bettge and Morris 2000; Pedersen et al 2004).

Xiao et al. (2006) reported LARC showed significant positive correlation with wheat protein content (r = 0. 66****) and negative correlations 1,000 kernel weight (r = 0. 52****) which might be due to inverse relationship between flour protein and kernel weight. Xiao et al. (2006) recorded significant positive correlation of SODSRC with SKCS hardness index (r 0.49****) as it reacts with damaged starch and hard wheats possess higher levels of starch damage. SUCSRC predicts the level of pentosans in wheat flour (1.5-2.0%DB) coming from cell wall (Michniewicz et al 1990) .This might be due to direct relation of TKW with break flour yield (r=0.97). Wheat kernels larger in size exhibit proportionately less cell wall materials comprised of pentosans and relatively more endosperm (Xiao et al., 2006). This is due to high level of damaged starch, higher protein and strong gluten, all of which help in absorbing and retaining water (Xiao et al., 2006). Guttieri et al (2002) also observed negative correlations between test weight of soft white spring wheat and 5% Na_2CO_3 and 50% sucrose SRC tests.

Barak et al. (2013) reported significant positive correlations among different SRC values. Break flour yield was found to be a relatively good predictor of cookie diameter (Morris et al., 2004). Higher break flour yield and larger cookie diameter are due to variation in pentosan content or composition (Bettge and Morris, 2000). Wheat meal sodium carbonate SRC was negatively correlated with flour extraction and sugar snap cookie diameter (Guttieri et al., 2004). Sucrose SRC is single best predictor of cookie diameter and showed strong negative correlation cookie diameter (r=0.66. p<0.0001) in most of the samples for baking (AACC, 2000). AWRC values exhibit significant negative correlation with cookie spread (r=-0.844) and texture. The flours with higher SDS sedimentation value also produced cookies with lower spread ratio and harder texture (Barak et al., 2013). The water absorption had a significant positive correlation with sucrose SRC and LASRC (Kaur et al., 2014).

4. CONCLUSIONS

Wheat variety AS 2002 exhibit less mean for SDS sedimentation, Zelney value, AWRC, water absorption and all SRC values than Inqulab 91. Cookies prepared from AS 2002 flour showed better physical and sensorial characteristics in comparison to cookies made from Inqulab 91. SDS sedimentation, Zelney value, AWRC, WA and all SRC values showed negative correlation with physical and sensorial characteristics except surface appearance of cookies. Break flour yield showed direct association with physical and sensory parameters of cookies, NIR hardness, TKW, TW and inverse relation with all SRC values, SDS sedimentation, Zelney value, AWRC, water absorption. Wheat variety AS 2002 is with less SDS sedimentation, Zelney value, AWRC, water absorption and lower mean for SRC values is best suited for preparation of cookies than Inqulab 91.

5. REFERENCES

[1] AACC. 2000. Approved Methods of the American Association of Cereal Chemists, 10th Ed. American Association of Cereal Chemists, Inc. St. Paul, MN.

[2] Abboud, A. M., R. C. Hoseney and G. L. Rubenthaler. 1985. Factors affecting cookie flour quality. Cereal Chem. 62:130-133.

[3] Al-Dmoor, H. M. 2013. Cake flour: functionality and quality (review). Euro. Scientific J. 9(3). 166-180.

[4] Anjum, F. M., M. Niaz, M. A. Randhawa and M. S. Bhatti. 2002. Suitability of different wheat flours for the commercial production of crackers. Pak. J. Food Sci. 12(3-4): 1-6.

[5] Anjum, F. M., W. Butt, M. S. Butt and S. Wahab. 1998. Protein composition and technological properties of some old and new wheat varieties. Sarhad J. Agric. 14(3):253-257.

[6] Baltiavas, A. 1996. Mechanical properties of short doughs and their corresponding biscuits. Ph.D. Thesis, Wageningen Agricultural University.

[7] Barak, S., D. Mudgil and B. S. Khatkar. 2013. Effect of composition of gluten proteins and dough rheological properties on the cookie-making quality. British Food J. 115(4):564-574.

[8] Baslar, M. and M. F. Ertugay. 2011. Determination of protein and gluten quality-related parameters of wheat flour using near-infrared reflectance spectroscopy. Turk. J. Agric. For. 35:139-144.

[9] Bettge, A. D. and C. F. Morris. 2000. Relationships among grain hardness, pentosan fractions, and end-use quality of wheat. Cereal Chem. 77:241-247.

[10] Bostan, N. and M. Nadeem. 2002. Evaluation of resistance in some wheat cultivars to Tribolium castaneum under laboratory conditions. Asian J. Plant Sci. 1: 95-98.

[11] Buckley, E. 2013. Factors in hard winter wheat affecting water absorption tolerance. M.Sc. Thesis, Deptt. Grain Sci., College of Agriculture, Kansas State University, Manhattan, Kansas, USA.

[12] Constantinescu, G., A. Dabija, A. Buculei and I. Rebenciuc. 2011. Evaluation of wheat quality using

modern methods. J. Agroalimentary Processes and Technologies. 17(4):469-472.
[13] Dhaka, V., N. Gulia and B. S. Khatkar. 2012. Application of Mixolab to Assess the Bread Making Quality of Wheat Varieties. Open Access Scientific reports. 1(3):1-8.
[14] Faridi, H., C. Gaines and P. Finney. 1994. Soft wheat quality in production of cookies and crackers. In: Wheat: Production, properties, and quality. (Bushuk, W. and V.F. Rasper Ed.): Glasgow, Scotland. Chapman and Hall, pp. 154-168.
[15] Faridi, H., C. S. Gains and B. L. Strouts. 2000. Soft wheat products. In: Handbook of Cereal Science and Technology. K. Kulp and J. G. Ponte, Jr., eds. Marcel Dekker 2nd Ed.: New York. pp. 575-614.
[16] Fustier, P., F. Castaigne, S. L. Turgeo and C. G. Biliaderis. 2008. Flour constituent interactions and their influence on dough rheology and quality of semi-sweet biscuits: a mixture design approach with reconstituted blends of gluten, water solubles and starch fractions. J. Cereal Sci. 48:144-158
[17] Gaines, C. S., A. Kassuba and P. L. Finney. 1996. Using wire cut and sugar-snap formula cookie test baking methods to evaluate distinctive soft wheat flour sets: implications for quality testing. Cereal Food World. 41:155-160.
[18] Giroux, M. J. and C. F. Morris. 1997. A glycine to serine change in puroindoline b is associated with wheat grain hardness and low levels of starch-surface friabilin. Theor. Appl. Genet. 95: 857-864.
[19] Guttieri, M. J. and E. Souza. 2003. Sources of variation in the solvent retention capacity test of wheat flour. Crop Sci. 43:1628-1633.
[20] Guttieri, M. J., C. Becker and E. Souza. 2004. Application of wheat meal solvent retention capacity tests within soft wheat breeding populations. Cereal Chem. 81:261-266.
[21] Guttieri, M. J., D. Bowen, D. Gannon, K. O'Brien and E. Souza. 2001. Solvent retention capacities of irrigated soft white spring wheat flours. Crop Sci. 41:1054-1061.
[22] Guttieri, M. J., R. McLean, S. P. Lanning, L. E. Talbert and E. J. Souza. 2002. Assessing environmental influences on solvent retention capacity of two soft white spring wheat cultivars. Cereal Chem. 79:880-884.
[23] Igrejas, G., H. Guedes-Pinto, V. Carnide, J. Clement and G. Branlard. 2002b. Genetical, biochemical and technological parameters associated with biscuit quality II. Prediction using storage proteins and quality characteristics in a soft wheat population. J. Cereal Sci. 36:187-197.
[24] Iqbal, Z., I. Pasha, M. Abrar, S. Masih and M.S. Hanif. 2015. Physico-chemical, functional and rheological properties of wheat varieties. J. Agri. Res. 53(2): 253-267.
[25] Kang, C.-S., C. S. Park, J.-C. Park, H.-S. Kim, Y.-K. Cheong, K.-H. Kim, K.-J. Kim, K.-H. Park and J.-G. Kim. 2010b. Flour characteristics and end-use quality of Korean wheat cultivars. I. End-use properties. Korean J. Breeding Sci. 42: 75-86.
[26] Kang, C.-S., J.U. Jung, B.-K Baik and C. S. Park. 2014. Relationship between physicochemical characteristics of flour and sugarsnap cookie quality in Korean wheat cultivar. Inter. Food Res. J. 21(2): 617-624.
[27] Kaur, A., N. Singh, S. Kaur, A. K. Ahlawat and A. M. Singh. 2014. Relationships of flour solvent retention capacity, secondary structure and rheological properties with the cookie making characteristics of wheat cultivars. Food Chem. 158:48-55.
[28] Keran, H., M. Salkic, A. Odobašic, M. Jašic, N. Ahmetovic and I. Šestan. 2009. The importance of determination of some physical-chemical properties of wheat and flour. Agriculturae Conspectus Scientificus. 74(3):197-200.
[29] Khan, M. R., F. M. Anjum, T. Zahoor and H. Nawaz. 2009. Biochemical and technological characterization of Pakistani spring wheat. Pak. J. Agri. Sci. 46, 271-279.
[30] Kweon, M., L. Slade and H. Levine. 2011. Solvent retention capacity testing of wheat flour: principles and value in predicting flour functionality in different wheat-based food processes and in wheat breeding-a review. Cereal Chem. 88:537-552.
[31] Li, Y., Y. Song, R. Zhou, G. Branlard and J. Jia. 2009. Detection of QTLs for bread-making quality in wheat using a recombinant inbred line population. Plant Breeding. 128:235-243.
[32] McDermott, E. E. and D. G. Redman DG. 1977. Small-scale tests of bread making quality. FMBRA Bulletin, Mill Baking Res Assoc. 6:200-213.
[33] Meilgard, M., G. V. Civille and B.T. Carr. 2007. Sensory Evaluation Techniques. 4th Ed: Boca Raton: Florida. CRC Press. pp. 43-57.
[34] Michniewicz, J., C. G. Biliaderis and W. Bushuk. 1990. Water-insoluble pentosans of wheat: Composition and some physical properties. Cereal Chem. 67:434-439.
[35] Morris, C. F., K. G. Campbell and G. E. King. 2004. Characterization of the end-use quality of soft wheat cultivars from the eastern and western US germplasm 'pools'. Plant Genetic Resources 2(1): 59-69.
[36] Mutlu, A. C., R. Ozturk, I. H. Boyaci and N. Basaran-Akgul. 2011. Prediction of wheat quality parameters using near-infrared spectroscopy and artificial neural networks. Eur. Food Res. Technol. DOI 10.1007/s00217-011-1515-8.
[37] Ohm, J. B., A.S. Ross, C. J. Peterson and C.F. Morris. 2009. Relationships of Quality Characteristics with Size-Exclusion HPLC Chromatogram of Protein Extract in Soft White Winter Wheats. Cereal Chem. 86(2):197-203.
[38] Osella, C. A., J. Robutti, H. D. Sánchez, F. Borrás and M. A. de la Torre. 2008. Dough properties related to baking quality using principal component analysis. Cienc. Tecnol. Aliment. 6(2) 95-100.

[39] Oshorne, B. G., K. M. Turnbull, R. S. Anderssen, S. Rahman, P. J. Sharp and R. Appels. 2001. The hardness locus in Australian wheat lines. Aust. J. Agric. Res. 52:1275-1286.
[40] Ozturk, S., K. Kahraman, B. Tiftik and H. Koksel. 2008. Predicting the cookie quality of flours by using Mixolab. Eur. Food Res. Technol. 227: 1549-1554.
[41] Pasha, I. 2006. Biochemical characterization of Pakistani wheats in relation to grain hardness. Ph.D. Thesis, Inst. Food Sci. and Tech., Univ. Agric., Faisalabad, Pakistan.
[42] Pasha, I., F. M. Anjum and M. S. Rashid. 2006. Near Infrared Spectroscopic techniques to predict different wheat quality characteristics. Pak. J. Agri. Sci. 43(3-4): 146-151.

[43] Pedersen, L., K. Kaack, M. N. Bergsøe and J. Adler-Nissen. 2004. Rheological properties of biscuit dough from different cultivars, and relationship to baking characteristics. J. Cereal Sci. 39:37-46.
[44] Prabhasankar, P. 2002. Electrophoretic and immunochemical characteristics of wheat protein fractions and their relationship to chapati-making quality. Food Chem. 78:81-87.
[45] Ram, S. and R. P. Singh. 2004. Solvent retention capacities of Indian wheats and their relationship with cookie-making quality. Cereal Chem. 81(1):128-133.
[46] Ram, S., V. Dawar, R. P. Singh and J. Shoran. 2005. Application of solvent retention capacity tests for the prediction of mixing properties of wheat flour. J. Cereal Sci. 42:261-266.
[47] Shewry, P. R. and A. S. Tatham. 2000. Wheat. The Royal Society of Chemistry. Cambridge CB4 OWF, UK: 335-339.
[48] Simmonds, N. W. 1995. The relation between yield and protein in cereal grain. J. Sci. Food Agric. 67:309-315.
[49] Slade, L. and H. Levine. 1994. Structure–function relationships of cookies and cracker ingredients. In: The Science of Cookies and Cracker Production. Faridi, H. Ed: New York. Chapman & Hall. pp. 23-141.
[50] Souza, E. J., J. M. Martin, M. J. Guttieri, D. K. Habernicht, S. P. Lanning, R. McLean, G. R. Carlson and L. E. Talbert. 2004. Influence of genotype, environment, and nitrogen management on spring wheat quality. Crop Sci. 44: 425-432.
[51] Steel, R. G. D., J. H. Torrie and D. A. Dickey. 1997. Principles and procedures of statistics. A boimeterical approach. 3rd Ed: New York. McGraw Hill Book Co. Inc.
[52] Trajkovic, J., J. Baras, M. Miric and S. Šiler. 1983. Analyses of Food Products, Beograd.
[53] Wade, P. 1988. Preparation of biscuit doughs. In: Biscuits, Cookies and Crackers. The Principles of the Craft. Elsevier Applied Science, London. Vol. 1 pp 18
[54] Xiao, Z. S., S. H. Park, O. K. Chung, M. S. Caley and P. A. Seib. 2006. Solvent retention capacity values in relation to hard winter wheat and flour properties and straight-dough bread making quality. Cereal Chem. 83(5):465-471.
[55] Zghal, M. C., M. G. Scanlon and H. D. Sapirstein. 2001. Effects of flour strength, baking absorption, and processing conditions on the structure and mechanical properties of bread crumb. Cereal Chem. 78:1-7.
[56] Zhang, Q., Y. Zhang, Y. Zhang, Z. He and R. J. Pena. 2007. Effects of solvent retention capacities, pentosan content, and dough rheological properties on sugar snap cookie quality in Chinese soft wheat genotypes. Crop Sci. 47: 656-664
[57] Zhi-ying, D., Z. Liang, L. Bin, Z. Kun-pu, C. Jian-sheng, Q. U. Hou-lan, S. Cai-ling, Z. Yong-xiang and T. Ji-chu. 2013. Conditional QTL mapping of sedimentation volume on seven quality traits in common wheat. J. Integrative Agric. Advanced Online Publication: 2013. 13: 1-13.
[58] Ziegler, E. and E. N. Greer. 1978. In: Wheat chemistry and technology. Y. Pomeranz Ed. American Association of Cereal Chemists, St. Paul, MN. pp.115.