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EFFECT OF SPECIALTY FLOURS ON PHYSICAL AND SENSORIAL ATTRIBUTES OF COOKIES

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Roller flour milling separates wheat components through series of break and reduction rolls along with different sifting operations. Protein (13.70%) and moisture (13.60%) contents were highest in Inqulab 91 break stream blend. Break flour blend of wheat variety Inqulab 91 had Zeleny value of 41mL and gluten content 33% that was found an equivalent to mean for gluten content and Zeleny value in AS 02 break stream blend. Cookie thickness (7.06mm) was highest in cookies made from AS 02 straight grade flour, diameter (25.77mm) and spread factor (41.48) in AS 02 sizing blend while cookie weight (8.24g) in AS 02 break blend. Among sensory characteristics, mean for cookie colour (7.80) was highest in AS 02 break blend while score for crispness (7.80), taste (7.20), surface characteristics (7.60) and overall acceptability (8.00) was maximum in AS 02 middling blend. It is concluded from results that physical parameters of cookie like diameter, spread factor and weight improved with blending while cookie thickness decreased. Cookies made from blended flours exhibited better color, crispness, taste, surface characteristics and overall acceptability. Cookies made from AS 02 middling stream blend were preferred by judges on overall sensory profile basis.
Keywords: Baking, flour streams, blending, sensorial characteristics

INTRODUCTION

Adequate availability of food to masses depends on certain factors including; climatic vagaries, cultivable area, population size and frequent occurrence of natural disasters (Tanyaradzwa *et al*., 2015). The fluctuated climatic behaviour is infact enforcing the growers to adopt suitable approaches for the enhancement of the growth and reproductive skills of field crops (Hussain *et al*., 2015). The grain production in wheat in turn depends upon its components. Grain milling separates the kernel components with flour extraction as ultimate objective and enhances palatability of wheat grain (Hoseney, 1994). It includes different operations like cleaning, conditioning, size reduction and separation (Posner and Hibbs, 1999). The size reduction facilitates the enzymatic and cooking processes (Marion *et al*., 1998). Separation techniques reduce the level of indigestible bran and remove germ to make flour shelf stable (Cauvain and Tran, 2005). Roller mills gradually reduce wheat kernel through a series of break and reduction rolls to produce different flour streams with endosperm, bran and germ in variable proportions (Rani *et al*., 2001). Numerous milling and sifting processes are repeated in a sequence resulting in a large number of mill streams (Yahata *et al*., 2006). Straight grade flour (SGF) is obtained by combining all flour fractions. Quality of straight grade flour is determined by quality characteristics of wheat and milling parameters. Each bakery item requires specified flour for good quality end products. Stream splitting is valuable process and most useful technique for the production of specific quality flours, where desired quality wheat is not available (Prabhasankar *et al*., 2000). Most of the roller mills in Indian Sub-continent extract farina (wheat meal) and atta in addition to refined flour. The quality of flour fractions thus obtained differ from system where only refined four is separated. Atta is combination of tail end flour, fine bran and germ. It is used for the production of different conventional products like unleavened flat bread chapatti along with its variants as *roti* and *parrota* and leavened flat bread *naan*.

Flour streams of the same wheat cultivar vary in levels of constituents due to their uneven distribution within the kernel (Wang and Flores, 1999). Streams with desired protein content or particular quality trait are blended for specified end use (Amendola and Rees, 2003). Knowledge of quality parameters of mill streams enables millers to select particular fraction for blending to produce a high-quality flour (Dornez *et al*., 2006; Yahata *et al*., 2006). Various flour streams with similar quality characteristics are blended to get specialty or tailor end flour (Okrajkova *et al*., 2007; Miralbes, 2004). Selection of mill stream is based on the extent of variability of different constituents and quality parameters (Ramseyer *et al*., 2011b). This variation is helpful to get precise combinations for blending to satisfy the customer's needs and market demand. Blending improves overall quality of final products (Chen, 1996) like bread (Pojic *et al*., 2004; Yahata *et al*., 2006), noodles, cookies (Yahata *et al*., 2006), pastry and also starch and gluten production (Dornez *et al*., 2006). Proportionate blending of specific mill stream is an alternate measure to prepare flours with desired quality traits (Liu *et al*., 2011). It modifies the dough and end product characteristics (Liu *et al*. 2011; Fustier *et al*., 2009). Optimal blending of functional streams is decisive tool to eliminate or reduce the need for further treatments and hence decrease labeling requirements (Ramseyer *et al*., 2011a).

Soft wheat flour is suitable only for ''Udon'' noodles. However, its blending with extra-strong flour improves its bread making quality (Yamauchi *et al*., 2003). First grade mill streams with bright color and higher protein are used mainly for Chinese noodles while bread is made from their blend. The third grade flour is not suitable for Chinese noodles and bread due to its dark color and lower protein and is destined for buckwheat noodles (Yahata *et al*., 2006). Break flour streams produced firmer, more elastic and chewy noodles (Chen, 1996). The quality and acceptability of parottas made from the first 5 reduction passages was superior to those made from initial 5 break streams (Indrani *et al*., 2003). The 2nd and 3rd break streams of hard wheat produced tortillas with strong stretchability and good foldability while middling stream tortillas were lighter in color with less stretchability (Wang and Flores, 1999).

The present research was planned to develop specialty flours by selecting proper flour streams which is a practical approach to obtain specific flour for different baked products. This information is helpful for millers to establish a milling system for producing high-quality mill streams with a high yield (Yahata *et al*., 2006) and for blending strong flour with soft flour to make good-quality flour suitable for bread. Research has been conducted revealing the effect of blending on quality of parotta (Indrani *et al*., 2003), bread (Gomez *et al*., 2011), noodles (Chen, 1996) and tortillas (Wang and Flores, 1999). However, no such research has been carried out to study the effect of mill stream blending on cookie quality.

MATERIALS AND METHODS

Samples of two commercially available wheat varieties i.e. Inqulab 91 and AS 2002 were purchased from Wheat Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. The wheat grains were tempered following AACC (2000) method No. 26-95 and milled through a Moore Roller Flour Mill (Moore Machine Manufacturer, Inc. Wichita, Kansas) to obtain different streams of break and reduction flour. First break stream was obtained by passing each wheat variety from first roll of mill having 0.25″ gap between the rolls. Milled wheat was then shifted from gyrating sifter (Great Western Co., Leavenworth, KS, USA) for 2 minutes with following sequence of sieves (20W wire mesh of 20 threads per inch with a micron aperture of 1000 (1041µm openings), 50GG (375µm), 70GG (240µm), 10XX (136µm) and pan (<136µm) (Pasikatan *et al*., 2003). Material retained on the sieve 20W was milled from 1st set of rollers with 0.12 inch nip to obtain 2nd break flour and sieved as mentioned above. Material retained on 20W of 2nd passage of 1st break roll was milled from 2nd set of break rolls with 0.06″ nip and sifted as described above to collect 3rd break fraction. Similarly 4th break stream was obtained with gap adjustment of 0.003 inches. All the reduction streams were milled from smooth rolls with nip 0.003″. Fractions of wheat retained on 50GG (375µm) from each break roll were combined to get sizing which was milled from reduction rolls. Arrangement of sieves was same for all break and first reduction fraction.

Flour blending: Specialty flours were made by blending different mill streams (break flour B_1-B_4, middling flour M_1-M_5 and sizing, tailing T_1-T_2 and LG) of each wheat variety (Table 1).

Table 1. Flour blends of different millstreams used for cookie making.

Blends	Flour combinations
AS 02- break	B1- B4
AS 02-middling	M1-M5
AS 02-sizing	Sizing, tailing (T1 andT2) and LG
Inqulab 91-break	B1- B4
Inqulab 91-middling	M1-M5
Inqulab 91-sizing	Sizing, tailing (T1 andT2) and LG

B1= break 1, B2= break 2, B3= break 3, B4= break 4, M1=middling 1, M2=middling 2, M3=middling 3, M4=middling 4, M5=middling 5, T1= tailing 1, T2= tailing 2, LG = Low grade flour

Chemical composition of flour blends: Protein content (39-11), moisture content, ash content, gluten content and zeleny value of blended and straight grade flours were determined according to AACC NIR method (AACC, 2000) on a scanning monochromator Infratec 1241 Grain Analyzer (Foss Tecator, Denmark) with flour module through small ring cup cells. It measured NIR transmittance spectra of flour within the range of 850 to 1048.2 nm with every 2 nm after calibration by adopting AACC (method 39-00).

Cookie baking quality: The cookies were prepared following the procedure described in AACC (2000) method No. 10-50 D with minor modifications. Sodium chloride was excluded and 2% less shortening used than AACC 10-50D. Shortening and sugar were mixed to creamy mass for 1 min at slow speed. Flour, baking powder and dextrose solution were then mixed to homogenous mass. Then distilled water was added to obtain the dough of desired consistency. The resulting batter was rolled out, cut manually and baked at 175°C for 10-12 min.

***Analysis of cookies*:** The weight, diameter and thickness of cookies were measured to calculate average values. The spread factor was calculated by dividing diameter with thickness and multiplying by 10. The sensory characteristics like color, crispness, taste and surface characters were evaluated by a panel of judges using 9-point hedonic scale as described by Meilgaard *et al*. (2007).

***Statistical analysis*:** The data obtained for each parameter were subjected to statistical analysis to work out effect of different flours and flour blends on cookie baking quality by using completely randomized design and mean values obtained for each parameter were compared according to Duncans Multiple Range test as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

Chemical analysis of mill stream blends:

***Protein content*:** The effect of blending was significant on protein content of different stream blends (Table 2). Protein content ranged from 11.00 to 13.70% among different flour blends (Table 3). The protein content was found to be highest in Inqulab 91 break streams blend while lowest in AS 02 sizing. Among the mill stream blends of wheat variety AS 02, break stream blend got highest mean value for protein content while lowest value was found in sizing (Table 3). The results of current studies are in concordance with findings by Prabhasankar *et al*. (2000) who recorded 11-13.3% protein content in break streams and 10.1-11.4% in reduction. Protein content was higher in break stream blend than middling and sizing. Break streams have higher protein content than reduction streams due to greater amount of peripheral endosperm portion rich in protein in break streams (Gomez *et al*., 2010) while lowest in sizing among different reduction streams (Anjum *et al*., 1997).

***Moisture content*:** The moisture content was significantly affected by different flour blends (Table 2) and showed slight variation among different flour blends. Means for moisture content varied from 12.80 to 13.60% (Table 3). Moisture content was found to be highest in Inqulab 91 break streams blend while lowest in Inqulab 91 sizing. Highest mean value for moisture content was found in break streams blends while lowest in sizing of both the wheat varieties. Means for moisture content in present studies are in line with those reported by Gomez *et al*. (2009) 13-14.4% in break streams, 12-13.5% for middling and 12.4-13.6% in sizing. Break flour streams contain higher moisture content than reduction and sizing due to higher separation in break rolls and more grinding and heating in reduction rolls (Gomez *et al*., 2009) which supports results of present study.

***Gluten content*:** The effect of mill stream blends was found to be non-significant on gluten content of different flour blends (Table 2). Gluten content of different flour blends ranged from 25 to 33%. Gluten content was found to be highest in AS 02 break and Inqulab 91 break blends while lowest mean value was observed in AS 02 middling and sizing (Table 3). Indrani *et al*. (2003) reported 9.63% dry gluten in specialty flour, 8.38-10.89% for break and 8.43-9.71% for reduction streams. Mirables (2004) reported NIR gluten content ranged from 17.70-36.76% among different mill streams which is similar to mean values in present investigation.

***Zeleny value*:** The effect of mill stream blends was highly significant on Zeleny value of different flour blends

Table 2. Mean squares for chemical characteristics of specialty flour.

SOV	DF	Mean squares				
		Protein content (%)	Moisture content (%)	Gluten content (%)	Zeleny value (mL)	Ash content (%)
Flours/Blends	7	5.202*	7.50*	32.121^{NS}	14.089**	0.065*
Error	16	1.000	1.00	1.000	1.000	0.100
Total	23	6.202	8.50	33.121	15.089	0.165

Table 3. Chemical characteristics of millstream blends of wheat varieties.

Flour blends	Protein content (%)	Moisture content (%)	Gluten content (%)	Zeleny value (mL)	Ash content (%)
AS 02	11.46±1.41bc	9.52±1.57b	27.02±3.13c	35.00±2.80e	0.50±0.16ab
Inqulab 91	12.45±1.41ab	10.23±1.57b	30.32±3.13b	38.00±2.80bc	0.65±0.16a
AS 02 break	13.40±1.41a	13.50±1.57a	33.00±3.13c	41.00±2.80a	0.55±0.16a
AS 02 middling	10.40±1.41c	13.23±1.57a	25.00±3.13d	37.00±2.80cd	0.31±0.16c
AS 02 sizing	10.30±1.41c	13.00±1.57a	25.00±3.13d	36.00±2.80de	0.28±0.16c
Inqulab 91 break	13.70±1.41a	13.60±1.57a	33.00±3.13a	41.00±2.80a	0.59±0.16a
Inqulab 91 middling	11.00±1.41bc	13.20±1.57a	27.00±3.13c	39.00±2.80b	0.35±0.16bc
Inqulab 91 sizing	11.00±1.41bc	12.80±1.57a	27.00±3.13c	38.00±2.80bc	0.30±0.16c

Note: Values carrying same letters are non-significantly different with each other

(Table 2). Zeleny value varied from 36 to 41 mL among wheat flours and flour blends. AS 02 break and Inqulab 91 break stream blends obtained highest mean value for NIR Zeleny test while lowest value was found in AS 02 sizing (Table 3). The results of the present study are in accordance with the findings of Hruskova and Famera (2003) with NIR Zeleny value 17-66 mL and Zeleny sedimentation value 25 to 67 mL (Zanetti *et al*., 2001).

***Ash content*:** Ash content differed significantly among flours and flour blends due to variation in their composition (Table 2). Mean for ash content ranged from 0.28 to 0.59%. The highest mean value for ash content was recorded in Inqulab 91 SGF which is statistically equivalent to Inqulab 91 break flour blend while lowest score was attained by AS 02 middling (Table 3). The results of the present investigation are in close conformity with the findings of Indrani *et al*. (2003) who reported mean value 0.45% for ash content of blended flour while Mirables (2004) found that NIR ash content varied between 0.37 and 1.54% among different flour streams. The difference in results of the present study may be due to altered milling conditions or due to wheat varieties.

Cookie baking quality:

***Physical parameters of cookies*:** The results regarding physical parameters of cookies are presented in Table 5.

***Cookie thickness*:** The results revealed that the effect of different flours and flour blends was found to be highly significant on thickness of cookies (Table 4). Thickness of cookies ranged from 6.10 to 7.06 mm. Cookie thickness was the highest in cookies made from SGF of AS 02 while lowest in Inqulab 91 break streams blend (Table 5). The results of present study are in accordance with the previous studies conducted by Haque *et al*. (2002) who reported thickness 4.4 to 5.5 mm and Igrejas *et al*. (2002) reported thickness of cookies varied from 4.6 to 5.9 mm.

***Cookie diameter*:** Cookie diameter was significantly affected by different flours and blends (Table 4). Cookie diameter varied from 23.87 to 25.77 mm among cookies made from different wheat flours and flour blends (Table 5). The diameter was found to highest in cookies made from AS 02 sizing blend while lowest in cookies made from the SGF of wheat variety Inqulab 91. Pareyt *et al*. (2010) reported that cookie diameter decreased from the first break to the second reduction fraction which is in contradiction with our results. Straight grade flour produced on an average smaller cookie diameter and lesser cake volumes than patent flour. Flour blend was the greater source of variation in cookie diameter and cake volume. Cookies diameter was higher for cookies made from patent flour (9.5cm) than straight grade flour (9.3cm) (Ramseyer *et al*. 2011b). Haque *et al*. (2002) reported diameter of cookies ranged from 31.0 to 41.1 mm and Igrejas *et al*. (2002) reported width of cookies varied from 57.2 to 58.2 mm.

***Spread factor*:** The effect of different flours and blends on cookie spread factor was found to be significant (Table 4). Spread factor of cookies ranged from 35.82 to 41.48. The mean value for spread factor was the highest in AS 02 sizing while lowest spread factor values were observed in SGF of wheat variety Inqulab 91 (Table 5). The results of the present investigation are in line with the previous findings of different researchers. Cookies with the largest surface area were produced with the patent while clear showed significantly smaller surface area of the cookies made both in wire-cut and laminated recipes (Frustier *et al*., 2009). Parotta prepared from reduction streams speciality flour (C_1-C_5) showed good spread while parottas from first five break passages had a decreased spread ratio (Indrani *et al*., 2003).

Table 4. Mean squares for physical characteristics of cookies.

SOV	DF	Mean squares			
		Thickness (mm)	Diameter (mm)	Spread factor	Weight (g)
Flours/Blends	7	0.372**	0.92**	13.90*	0.79*
Error	14	0.009	0.06	0.35	0.04
Total	21	0.381	0.98	14.25	0.83

*= Significant (P<0.05); ** = Highly significant (P<0.01); NS = Non-significant

Table 5. Physical characteristics of cookies.

Flours/Blends	Thickness (mm)	Diameter (mm)	Spread factor	Weight (g)
AS 02	7.06a	25.30 b	36.50f	7.427b
Inqulab 91	6.65e	23.87e	35.82h	6.683c
AS 02-break	6.13g	24.97bcd	36.37g	8.240a
AS 02-middling	6.32f	24.80cd	39.28c	7.487b
AS 02-sizing	6.87b	25.77a	41.48a	7.637b
Inqulab 91-break	6.10h	24.53d	40.66b	8.217a
Inqulab 91-middling	6.73d	24.90bcd	36.98e	7.600b
Inqulab 91-sizing	6.75c	25.00bc	37.04d	8.047a

***Cookie weight*:** Different flours and blends showed significant impact on weight of cookies (Table 4). Weight of cookies varied from 6.83 to 8.24 g. Cookies made from AS 02 break streams blend got highest mean value for cookie weight while it was lowest in SGF cookies of wheat variety Inqulab 91 (Table 5). Break flour blends of both wheat varieties with equivalent protein and gluten contents and Zeleny value has higher water absorption and retention during baking due stronger gluten network and hence cookies made from these flours showed greater weight.

Sensory evaluation of cookies: The results regarding sensory characteristics of cookies are presented in Table 7.

***Color*:** The color of cookies was significantly influenced by the variation in different flour and flour blends (Table 6). Mean for color of cookies ranged from 5.80 to 7.80. Highest score for color was observed in AS 02 break blend while lowest in Inqulab 91 sizing blend (Table 7). Results of present study are in contradiction to findings by Indrani *et al*. (2003) who prepared creamish white parotta from speciality flour made by blending reduction streams (C_1-C_5) while parottas from first 5 break passages had a dull brown color. First break and reduction streams are the brightest while last break and reduction streams are more reddish and yellowish. Cakes made from final break and reduction streams (B_2 and R_3) exhibited a darker, more reddish and yellowish crumb color due to contamination with the external layers (Gomez *et al*., 2010). Noodles made from top-grade flours had lighter color (Chen, 1996). Middling streams of hard wheat yielded tortillas with lighter color (Wang and Flores, 1999).

***Crispness*:** Results showed that the crispness of cookies was found to be non-significantly influenced by flours and flour blends (Table 6). Crispness of cookies ranged from 6.20 to 7.80 in cookies made from different flours and blends. The mean value for cookies crispness was highest in AS 02 middling while lowest in SGF of wheat variety Inqulab 91 (Table 7). The results of present study are in conformity with findings of Indrani *et al*. (2003) who reported that parottas prepared from speciality flour (C_1-C_5) exhibited excellent pliability, thin, transparent and distinct layers. Noodles made from top-grade flours showed medium softness, elasticity and chewiness whereas those prepared from break flour streams were firmer, more elastic and chewy (Chen, 1996).

***Taste*:** Statistical analysis depicted non-significant impact of different flours and blends on cookie taste (Table 6). Mean values for the taste of cookies varied from 5.60 to 7.20 among the cookies prepared from different flours and blends. Cookies from AS 02 middling streams blend got highest score while lowest in Inqulab 91 break streams blends (Table 7). The results obtained are in line with findings by Indrani *et al*. (2003) who reported that parottas made from reduction streams speciality flour (C_1-C_5) showed good taste, break down easily in the mouth without leaving any residue and typical chewiness. Final break and reduction streams (B_2 and R_3) are contaminated with external layers which a ect odour and taste of cakes (Gomez *et al*., 2010).

***Surface characteristics*:** The effect of different flours and blends was significant on surface characteristics of cookies (Table 6). Mean for surface characteristics of cookies ranged from 5.60 to 7.60. AS 02 middling streams blend got highest mean value while lowest value was found in Inqulab 91 break blend (Table 7). The results of present study are in close agreement with the previous findings of Indrani *et al*. (2003) who reported that speciality flour (C_1-C_5) from reduction streams produce parottas with soft texture while parottas made from the first five break passages had fused layers. Results of present study are also well supported by findings of Gaines *et al*. (1996) who reported lowest hardness values for cookies prepared from patent flour confirmed the view that earlier streams produce softer cookies, whereas later reduction streams produce the hardest cookies. The findings of present investigation are in line

Table 6. Mean squares for sensory characteristics of cookies.

SOV	DF	Mean squares				
		Color	Crispness	Taste	Surface characteristics	Overall acceptability
Flours/Blends	7	2.425*	2.386^{NS}	1.357^{NS}	2.254*	3.082*
Error	28	0.907	1.645	1.063	0.870	1.091
Total	35	3.332	4.031	2.42	3.124	4.173

Table 7. Sensory characteristics of cookies made from flours and flour blends.

Flours/Blends	Color	Crispness	Taste	Surface characteristics	Overall acceptability
AS 02	6.40bcd	6.60a-d	7.00b	6.80abc	7.00c
Inqulab 91	6.00cd	6.00b	6.20e	6.40abc	5.80g
AS 02-break	7.80a	7.20abc	6.60c	6.00bc	7.20bc
AS 02-middling	7.40ab	7.80a	7.20a	7.60a	8.00a
AS 02-sizing	7.00a-d	6.40ab	6.60c	7.20c	6.40d
Inqulab 91-break	7.20abc	6.20ab	5.60g	5.80bc	6.20e
Inqulab 91-middling	6.60a-d	6.20ab	6.40d	6.20bbc	6.00f
Inqulab 91-sizing	5.80d	7.60ab	6.00f	7.00ab	7.40b

with Fustier *et al*. (2009) who reported that higher dough consistency of the clear fraction results in higher cookie hardness values. Last break (B_2) and reduction (R_3) streams produce cakes with lower score for external appearance and highest firmness. First reduction streams showed higher firmness scores than the first break streams while last break and reduction streams showed the highest initial firmness (Gomez *et al*., 2010). The 2nd and 3rd break streams of hard wheat produce tortillas with strong stretchability and good foldability while middling streams showed less stretchability (Wang and Flores, 1999).

***Overall acceptability*:** Overall acceptability was determined on the basis of quality scores obtained from color, taste, crispness and surface characters. The effect of flours and blends were found to be significant on overall acceptability of cookies (Table 6). Mean values for overall acceptability of cookies varied from 5.8 to 8.0. Highest mean value was observed in AS 02 middling blend while lowest value was found in SGF of wheat variety Inqulab 91 (Table 7). Blended flours got higher scores for overall acceptability of cookies. Thus blending flour of different mill streams improved cookie quality. The present study is well supported by the findings of Anjum *et al*. (1998) who stated that color, texture and overall acceptability of cookies differed significantly between wheat varieties. The overall quality score of parotta made from reduction streams (C_1-C_5) specialty flour was highest (93.5) as compared to break and reduction streams (43-79 and 56-92 respectively) and was rated the best as it had all the desirable attributes of a good quality parotta (Indrani *et al*. 2003). Cakes (Gomez *et al*., 2010) and bread (Gomez *et al*., 2011) prepared from last break and reduction streams was lower in quality and obtained the lowest sensory scores with least acceptability. Hence, final break and reduction streams should be eliminated (Gomez *et al*., 2010). Neither first nor second grade of Kachikei 33 flour was suitable for instant Chinese noodles. Blended flour composed of the second-grade mill streams of Kachikei 33 and Hokushin flour indicated same hardness and elasticity values whereas better quality comparable to the specific flour commercially used. In contrast, the first grade mill streams failed to improve the quality when blended with the Hokushin flour (Yahata *et al*., 2006).

***Correlation studies*:** Spread factor was negatively associated with ash (r=-0.23), protein (r=-0.02), gluten (-0.04), Zeleny (r=-0.11) and cookie thickness (r=-0.19) while it showed positive correlation with moisture content (r=0.31), cookie diameter (r=0.43) and cookie weight (r=0.19) (Table 8). Overall cookie score depicted negative correlation with cookie spread factor (r=-0.13), ash (r=-0.25), protein (r=-0.24), gluten (r=-0.29) and Zeleny values (r=-0.25) and positive correlation with cookie thickness (r=0.05), moisture content (r=0.08) and other sensory characteristics. Protein content (r=0.40), moisture content (r=0.52), gluten content (r=0.46), Zeleny value (r=0.53), spread factor (r=0.19) and cookie diameter (r=0.01) showed positive correlation with cookie weight while negative relationship was recorded for cookie weight with ash (r=-0.36) and cookie thickness (r=-0.36) (Table 8). Protein, ash, gluten and Zeleny value exhibited negative correlation with both physical and sensory characteristics of cookies (crispness, cookie diameter, overall acceptability, spread factor, surface characteristics, taste and cookie thickness).

Gaines (1991) and Kaldy and Rubenthaler (1987) showed a negative impact of the protein on spread while Nemeth *et al*. (1994) found no correlation between cookie diameter and protein content for Canadian soft wheat.

***Conclusion*:** Wheat variety Inqulab 91 was less suitable for cookie baking and among mill streams AS 02 middling and

Table 8. Relationship between flour blend's quality characteristics and cookie quality.

	Col	Crisp	Dia	OA	SF	SC	Tas.	Th	Wt	ash	Glu	Moi	Pro
Crisp	-0.16												
Dia	-0.12	0.06											
OA	-0.00	0.98	0.08										
SF	0.48	-0.24	0.43	-0.13									
SC	-0.22	0.64	0.55	0.67	0.14								
Tas	0.35	0.31	0.26	0.40	-0.06	0.60							
Th	-0.64	0.02	0.70	0.05	-0.19	0.49	0.23						
Wt	0.18	0.25	0.01	0.23	0.19	-0.32	-0.52	-0.36					
Ash	-0.06	-0.29	-0.41	-0.25	-0.23	-0.25	-0.05	-0.12	-0.36				
Glu	0.33	-0.31	-0.67	-0.29	-0.04	-0.80	-0.57	-0.73	0.46	0.42			
Moi	0.38	0.09	0.10	0.08	0.31	-0.12	0.09	-0.26	0.52	-0.26	0.27		
Pro	0.31	-0.27	-0.56	-0.24	0.02	-0.68	-0.47	-0.63	0.40	0.49	0.95	0.43	
Zel	0.29	-0.22	-0.60	-0.25	-0.11	-0.78	-0.53	-0.65	0.53	0.19	0.88	0.60	0.88

Col=Color, Crisp=Crispness, Dia=Diameter, OA=Overall Acceptability, SF=Spread Factor, SC=Surface Characters, Tas=Taste, Th=Thickness, Wt=Weight, Glu=Gluten, Moi=Moisture, Pro=Protein, Zel= Zeleny value.

sizing blends were most suitable for cookie baking. It is concluded from the results of the present investigation that middling and sizing streams with lower protein content can be added to streams having higher protein content and strong gluten in order to get flour suitable for cookie making. The results of the present investigation also revealed that flour blending improves overall acceptability of cookies because cookies made from mill stream blends got higher score for overall acceptability than those made straight grade flour of individual wheat varieties. Thus flour obtained from latter reduction passages having lower protein content and ash content is better for cookie making.

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