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IMPACT OF MIXED LACTIC ACID BACTERIAL (LAB) CULTURE ON FLAVORING PROFILE AND QUALITY ATTRIBUTES OF SPRING WHEAT SOURDOUGH BREAD

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Wheat is a main ingredient of the bread, so the suitability of mixed culture of *Lb. casei, Lb. brevis and Candida humilis* was determined for different spring wheat cultivars for the preparation of sourdough bread. Four spring wheat cultivars such as Lasani-2008, Millat-2011, Punjab-2011 and AARI-2011 were analyzed for chemical composition, physical and farinographic parameters. The cultivars were found significantly ($P<0.05$) different in physicochemical and farinographic parameters. Millat-2011 exhibited the highest scores for all these parameters. Breads prepared from these cultivars were analyzed for pH, titratable acidity, organic acids, and volatile compounds. The sourdough bread prepared was also subjected to analysis of essential amino acids and various sensory attributes. Sourdough bread produced from Millat-2011 had the highest sensory scores. Fermentation by LAB improved the flavoring compounds and amino acid profile of the sourdough bread as compared to yeast leavened bread. The value of lysine improved from 0.16g/100g to 0.39g/100g. Ethanol; 1-propanol, 2-methyl; 1-butanol; 2-methyl-1-butanol; 3-methyl ethyl acetate; acetaldehyde; acetic acid; 1-hexanol; benzaldehyde; hexanal; N-hexanal and propanal-2-methyl were found in sourdough bread.
Keywords: Flavoring compounds, functional breads, sourdough, fermentation, microbes.

INTRODUCTION

Cereals in general and wheat, in particular, are principle foods around the world that provide more nutrients than any other single food source. Wheat is the main staple food of the country's population. It contributes 2.2% to GDP and 10.1% to the value added in agriculture (GOP, 2013). Pakistani wheat cultivars on an average contain 8.38-9.67% moisture, 9.15-10.27% crude protein, 1.15-2.55% crude fat, 1.72-1.85% crude fibre and 1.44-2.10% ash (Khan and Zeb, 2007). In Pakistan, about 70% of the total wheat produced is utilized to produce unleavened flat bread and other bakery stuff like cakes, cookies, breads and pastries etc. (Rehman *et al*., 2014).

In recent times, emphasis is given on developing the nutritious bread with more protein and dietary fibre content and low glycemic index. In this regard, sourdough fermented bread is a suitable alternate of yeast leavened bread. It is health promoting and is associated with a decrease risk for certain diseases. It has an important role in improving the quality attributes of bread (Poutanen *et al*., 2009).

The sourdough is a natural process in which flour and water is mixed and fermented with the help of microbes (bacteria and yeast) that are obtained either from starter culture or previous sourdough. As a result, Hetero fermentative lactic acid bacteria produce lactic and acetic acid resulting in sour taste of the bread. Sourdough fermentation has many advantages over the straight dough method that includes prolonged shelf life by delaying staling and improved nutritional status. It also improves various sensory characteristics and inhibits the growth of spoilage bacteria and mold. Moreover, it also improves bioavailability of minerals and reduces the glucose and insulin responses in human. The increase in production of folate (vitamin B) and thiamin and decrease in vitamin E (tocopherol and tocotrienol) content is also associated with the fermentation of sourdough (Banu *et al*., 2011). During fermentation of dough, pH dependent proteolysis takes place and produces significant amount of peptides and amino acids in the sourdough. Consequently, increased concentration of peptides and amino acids in the product may regulate the glucose metabolism in the body (Nielsen *et al*., 2007).

The dough prepared from lactic acid bacteria (LAB) is natural, additive free and is used for leavening purposes in various bakery products. Mostly, *Lb. brevis*, *Lb. plantarum* and *Lb. sanfranciscensis* have been isolated and identified in sourdoughs. Beside this, numerous yeast species, *Sacchromyces cerevisiae* and *Candida humilis* are also used in the fermentation of sourdoughs. Homo-fermentative species play a key role in the production of various flavoring compounds and organic acids. These species are unable to produce CO_2. Homo fermentative LAB have the major function in the production of lactic acid while the production of acetic acid is mainly associated with hetk8ro-fermentative

lactic acid bacteria resulted in the pleasant odor and sour taste of the breads. The sourdough bread is richer in aroma and flavor than yeast leavened bread (Rehman and Awan, 2011). In the present study, *Lb. casei* and *Lb. brevis* which are homo and heterofermentative in nature were the part of mixed culture, respectively and yeast, *Candida humilis* which is synergistic in action had also been used.

Bread and other wheat products are the essential part of daily food intake; so such food items should be safe, healthy and wholesome. Flour processing like milling, refining, bleaching, enriching, and fortification to flour and baked breads cause medical workers and food scientists to question their safety and nutritional quality. So the emphasis should be given on developing the food products especially bread which is not only nutritious but also have the positive effect on the human health. In Pakistan, straight dough development method is generally used for the production of bread which results in inferior quality, flavor and lesser health benefits. In this regard, sourdough fermented bread is a suitable choice to obtain improved nutritional profile and longer shelf stability. So this project is designed to improve the nutritional value, functional properties as well as sensory attributes of the bread by using the sourdough development method.

MATERIALS AND METHODS

Wheat cultivars were purchased from Ayub Agriculture Research Institute, Faisalabad. Analytical grade chemicals were procured from Merck (KGaA, 64271, Darmstadt, Germany).

***Chemical analysis*:** Wheat samples were analyzed for proximate composition including moisture content, crude fat, crude protein, ash content, crude fibre and NFE (AACC, 2006).

***Thousand kernel weight and test weight*:** Thousand kernel weight and test weight of samples were determined by applying methods as described in AACC (2006). Wheat samples were milled after tempering and straight grade flour (72% extraction rate) (SGF) was prepared by mixing two fractions of flour (AACC, 2006). Dry and wet gluten content and falling numbers of flours were determined by applying the methods 38-10 and 56-81, respectively. Pelshenke and Sedimentation values were determined by following the procedures outlined in method 56-61-3 and 56-50, respectively (AACC, 2006).

***Farinographic characteristics*:** Brabender Farinograph (C.W. Brabender, Duisburg, Germany) was used to determine the Rheological characteristics of flour samples by following the method No. 54-21 (AACC, 2006). Dough rheological characters such as water absorption (WA), dough development time (DDT), dough stability (DS), softening of dough (SOD) and tolerance index (TI) were interpreted through farinogram.

***Preparation of sourdough bread*:** For making sourdough bread, a sponge was prepared from flour (200 g), water (200 mL) and starter culture was added to give 10^8 CFU/g of dough bacterial count. Freeze dried culture namely LV-4 was procured from Lallemand Baking Solutions, Montreal, Canada. LV-4 culture containing *Lactobacillus brevis* and *Lb. casei and Candida humilis was* used. This was mixed thoroughly and incubated at 30°C for 20 h. The sourdough was prepared by mixing 200 g flour, 120 mL water and 70 g fermented sponge, incubated for 24 h at 30°C. Then the bread was prepared and baked at 215°C for 25 min.

***pH and titratable acidity*:** pH and total titratable acidity (TTA) of sourdough breads were determined by using pH meter (Inolab WTW Series 720) (Lefebvre *et al*., 2002).

***Organic acids*:** Lactic acid and acetic acid contents of sourdough bread were determined using High Performance Liquid Chromatography (HPLC) according to the method as described by Vernockchi *et al.* (2004). Saq. HPLC (Model 1050, Hewlett-Packard, Waldbronn Germany) equipped with a Bio-Rad Aminex HPX-87H column (300×7.8 mm) was used. For HPLC analysis, sample was prepared by mixing 10 g of bread sample with 100 mL of 0.1 N sulfuric acid solution, the mixture was then homogenized by an Omni Mixer Homogenizer for 5 min (Omni International, Warrengton, VA) and filtered through a 0.22 mm membrane filter. The prepared sample was analyzed according to the following conditions. Mobile phase, 0.08 M H_2SO_4; flow rate, 0.60 mL/min; temperature, 65°C; UV detector (210 nm).

***Amino acid analysis*:** Samples of yeast leavened and sourdough bread were subjected to determination of amino acids composition using an amino acid analyzer according to the method of Dabbour and Takuri (2000).

***Volatile compounds*:** Volatile compounds of wheat sourdough bread and yeast leavened bread were determined by GC-FID (Kam *et al*., 2011). For the extraction of volatile compound, a 70 g sample with 20% w/v of sodium chloride was centrifuged at 4500 rpm at 2°C for 5 min. 25 mL of the supernatant was mixed with the ethyl acetate in a proportion of 1:1 and stirred for 40 min. Then, the mixture was centrifuged again at 2000 rpm at 2°C for 5 min. The organic phase collected in a round-bottom flask was concentrated up to 1.5 mL at 40°C by using a vacuum rotary evaporator (Buchi, Switzerland).

The extracted sample was analyzed and identified with GC-FID (GC-17A, Shimadzu). A 30 m × 0.25 mm (ID) DB-WAX capillary column, with 0.25 µm film thickness, was used. The sample (1 µL) was injected in split mode (1:50) and the injection temperature was 270°C. Nitrogen was used as carrier gas at a constant flow of 30 mL/min. The oven temperature was programmed as 80°C for 1 min, increased to 120°C at 4°C/min, and then increased to 240°C at 15°C/min rate. The data acquisition was performed with CSW32-Chromatography Station, Data Apex, Ltd, 2001.

***Sensory evaluation of sourdough bread*:** Sourdough breads were evaluated for sensory characteristics at ambient temperature by panel of judges using 9-point Hedonic Scale (Land and Shepherd, 1988).

***Statistical Analysis*:** The data collected was subjected to the statistical analysis using Minitab (V.15.1, Minitab Inc., PA 16801-3008, USA). Duncan's Multiple Range test was applied to estimate the level of significance (Steel *et al*., 1997).

RESULTS AND DISCUSSION

***Thousand kernel weight and test weight*:** The mean values for thousand kernel weight and test weight varied from 37.26-44.23 g and 73.29-81.53 $Kg.hL^{-1}$, respectively as shown in Table 1. Results showed the significant ($P<0.01$) differences among wheat cultivars regarding the thousand kernel weight and test weight. The results are supported by Khan and Shewry (2009) who observed that the test weight and thousand kernel weights varied from 66.47-76.90 $Kg.hL^{-1}$ and 25.98-40 g, respectively. In another study, Pakistani wheat cultivar showed the 41g 1000 kernel weight and 79 $Kg.hL^{-1}$ test weight (Pasha *et al*., 2013).

Table 1. Physical characteristics of various spring wheat cultivars.

Cultivars	Test weight ($Kg.hL^{-1}$)	Thousand kernel weight (g)
AARI-2011	77.05±0.45c	42.38±0.32b
Millat-2011	81.53±0.34a	44.43±0.29a
Punjab-2011	79.68±0.30b	37.26±0.37d
Lasani-2008	73.29±0.46d	39.27±0.37c

Means bearing different letters in each column differ significantly ($P<0.01$).

***Dry and wet gluten, falling number, SDS-sedimentation value and Pelshenke value*:** Results regarding dry and wet gluten, falling number, SDS-sedimentation value and Pelshenke value of spring wheat cultivars are presented in Table 2. The mean values for falling number, wet and dry gluten, SDS-sedimentation value and Peleshenke value of cultivars varied between 463.00-518.67 sec, 20.92-28.99%, 6.61-9.90%, 23.28-36.35 mL and 185.00-211.00 min, respectively. Various Pakistani spring wheat cultivars contain dry and wet gluten content in the range of 8.88-10.09% and 27.60-35.15%, respectively (Anjum and Walker, 2000). Pakistani wheat cultivars were found low in amylase activity as indicated by their falling number values (Pasha *et al*., 2007). The results for SDS-sedimentation values were also found in close agreement with the findings of Pederson *et al*. (2004) who concluded that the SDS-sedimentation values varied between 17-32 mL. Pelshenke values below 60, 60-120 and above 120 min depicts soft, medium strong and strong gluten, respectively. The results of current study revealed that Pelshenke values for all wheat cultivars were >120 min depicting the strong gluten quality.

***Proximate analysis*:** The mean values for moisture, crude fat, crude fibre, crude protein, crude ash and nitrogen free extract (NFE) contents are presented in Table 3 and ranged between 10.91-12.93%, 1.28-1.44%, 0.32-0.40%, 11.51-14.70%, 0.44-0.57% and 83.1-86.25%, respectively. The statistical analysis revealed that moisture, crude protein, crude fat and NFE contents of flour differed highly significantly ($P<0.01$) while crude fibre and total ash contents showed the significant ($P<0.05$) results. The results of the present study was found in agreement with the earlier finding of Ahmed (2001) who observed crude protein, crude fibre, ash, crude fat, moisture and NFE content in the range of 10.15-13.76%, 1.32-1.85%, 2.31-2.99, 1.96-2.52, 9.38-

Table 2. Falling number, dry and wet gluten, SDS-Sedimentation value and Pelshenke value of various spring wheat cultivars.

Cultivars	Falling Number (sec)	Wet Gluten (%)	Dry Gluten (%)	SDS-Sedimentation Value (mL)	Pelshenke Value (min)
AARI-2011	463.00±4.58c	24.34±0.37c	7.41±0.08c	23.28±0.31d	203.00±1.15b
Millat-2011	518.67±2.60a	28.99±0.37a	9.09±0.17a	36.35±0.23a	211.00±1.15a
Punjab-2011	511.67±2.40a	20.92±0.23d	6.61±0.15d	29.327±.445c	185.00±1.15d
Lasani-2008	496.67±3.53b	26.31±0.29b	8.56±0.12b	31.400±.444b	192.33±1.45c

Means bearing different letters in each column differ significantly ($P<0.05$).

Table 3. Proximate composition of various spring wheat cultivars.

Cultivar	Moisture (%)	Crude fat (%)	Crude fibre (%)	Crude Protein (%)	Ash (%)	NFE (%)
AARI-2011	12.16±0.05b	1.28±0.006b	0.40±0.006a	11.51±0.14d	0.57±0.003a	86.25±0.13a
Millat-2011	10.91±0.04d	1.44±0.025a	0.32±0.006c	14.70±0.09a	0.44±0.012d	83.10±0.14b
Punjab-2011	12.93±0.03a	1.32±0.009b	0.36±0.007b	13.52±0.16c	0.52±0.009b	84.28±0.13c
Lasani-2008	11.67±0.14c	1.39±0.009a	0.34±0.006b	14.07±0.03b	0.47±0.012c	83.73±0.12b

Means bearing different letters in each column differ significantly ($P<0.05$).

10.43% and 78.71-85.37, respectively among various wheat cultivars.

***Farinographic properties*:** The mean values for farinographic parameters revealed that significant differences (P<0.01) were observed among various spring wheat cultivars (Table 4). The means values regarding WA, SOD, DDT, DS, MIT, AT, DT ranged between 54.73-60.37%, 45.33-141.00 BU, 2.50-6.80 min, 15.64-22.10 min, 22-49 BU, 0.90-1.37 min and 16.59-23.33 min. Millat-2011 was found best for the preparation of sourdough bread, as it showed the better water absorption and dough development time. The result of the present studies were closely related to the findings of Safdar *et al*. (2012) who found the variation for all these parameters between 54.96-58.15%, 33.67-112.33 BU, 2.35-4.06 min, 39.67-106.67 BU, respectively. Variations in WA and AT depend upon protein quality and damaged starch content (Anjum and Walker, 1991).

***pH and titratable acidity*:** The mean values presented in Table 5 indicated that pH and TTA of sourdough breads varied from 4.70 to 5.17 and 3.47 to 4.60% among the treatments, respectively. Relatively lower pH value (4.7) was observed for sourdough bread prepared from Millat-2011 as compared to control (5.17). However, higher TTA 4.60 mL was found in Millat-2011 than control (3.47 mL). Results are comparable to the findings of Sandra *et al*. (2012) who reported that pH and TTA of various sourdough and yeast bread ranged between 4.5-5.7 and 2.0-5.4 mL, respectively. Sourdough fermentation process breaks down the carbohydrates to form the lactic acid resulting in acidity and lowering of pH of bread (Ostman, 2003).

***Lactic acid and acetic acid content*:** The mean values for lactic acid and acetic acid contents (Table 5) of sourdough breads showed that various treatments for sourdough bread produced lactic acid and acetic acid content in the range of 0.013-0.46 g/100 g and 0.001-0.17 g/100 g, respectively. Control has the lowest value for both acids. Chiefly, lactic acid and acetic acids are produced during the sourdough fermentation. The results for lactic acid content produced in sourdoughs may be supported by the findings of Robert *et al*. (2005) who found lactic acid production in the range of 0.30-0.55g/100g and concluded that the rheological characteristics, acidification and metabolic activity of the wheat sourdough bread were affected by using freeze dried starters. With regards to acetic acid, the results of current study are in conformity with the earlier findings that acetic acid content of the wheat sourdoughs lies in the range of 0.003-0.25 g/100 g depending upon the factors such as flour type, starter and fermentation conditions. Sourdough fermentation process breaks down the carbohydrates to form the lactic acid resulting in the lowering of sugar level in the dough. The conversion of sugars to lactic acid in sourdough bread can aid to keep blood glucose level in line, helping to guard against diabetes. The lactic acid produced by the sourdough fermentation has also the ability to modify the macromolecules as it reduces the starch digestability (Ostman, 2003) whereas, acetic and propionic acids delay the gastric emptying rate (Liljeberg *et al*., 1995). The present study suggested that sourdough bread prepared from the freeze dried starter culture produced more organic acids than the yeast which improve the flavor and aroma of the bread.

Table 4. Farinographic characteristics of straight grade flour (SGF) of various spring wheat cultivars.

Parameters	AARI-2011	Millat-2011	Punjab-2011	Lasani-2008
WA (%)	54.73±0.07d	60.37±0.15a	56.23±0.09c	57.60±0.12b
SOD (BU)	141.00±1.15a	54.33±2.33c	84.00±1.53b	45.33±1.86d
DDT (min)	5.96±0.03c	6.80±0.06a	6.34±0.07b	2.50±0.12d
DS (min)	17.70±0.06b	22.10±0.06a	15.98±0.01c	15.64±0.06d
MIT (BU)	49.00±0.58a	29.00±1.73c	38.00±0.58b	22.00±1.15d
AT (min)	0.93±0.04b	1.37±0.03a	1.33±0.03a	0.90±0.06b
DT (min)	18.47±0.15b	23.33±0.12a	17.40±0.06c	16.59±0.06d

Means bearing different letters in each column differ significantly (P<0.01).

WA= Water absorption, SOD= Softening of dough, DDT= Dough development time, DS= Dough stability, MIT= Mixing tolerance index, AT= Arrival time, DT= Departure time.

Table 5. pH, titrable acidity and organic acid contents of sourdough bread.

Cultivars	pH	Titratable acidity (mL 0.1N NaOH)	Lactic acid (g/100g)	Acetic acid (g/100g)
AARI-2011	4.90±0.06b	4.00±0.21c	0.41±0.012a	0.05±0.012c
Millat-2011	4.70±0.06c	4.60±0.12a	0.46±0.018a	0.17±0.015a
Punjab-2011	4.87±0.03b	4.13±0.19bc	0.37±0.012b	0.14±0.006b
Lasani-2008	4.77±0.03bc	4.50±0.06ab	0.33±0.012b	0.12±0.012b
Control (Yeast)	5.17±0.03a	3.47±0.07d	0.013±0.002c	0.001±0.00d

Means bearing different letters in each column differ significantly (P<0.05).

Hence, it is concluded that the LV-4 culture used in the current study produced more acids than that of control.

***Amino acid profile of yeast leavened and sourdough bread*:** Amino acid composition of yeast leavened bread and sourdough wheat bread is presented in Table 6. It is depicted that the bread prepared from the mixed culture showed the higher amino acid content than the yeast leavened bread. Proteolysis during fermentation plays a key role to improve the essential amino acid profile. The value of lysine for yeast leavened bread and wheat sourdough bread was 0.16g/100g and 0.39g/100g, respectively. Generally, dough fermentation with lactic acid bacteria improves the amino acid profile of sourdough bread (Thiele *et al*., 2002). The results are found similar with the findings of Barber and Baquean (1989) who reported that high proteolytic activity was found in sourdoughs as compared to yeast leavened bread and effective amino acid production was observed with sourdoughs fermented with lactic acid bacteria. The LAB starter culture in the present study produced significant amount of essential amino acids especially lysine which can help to improve the level of amino acids in the end product.

Table 6. Essential amino acid content of sourdough bread.

	Yeast leavened bread (g/100g)	Sourdough bread (g/100g)
Methionine	0.04	0.14
Lysine	0.16	0.39
Leucine	0.32	0.78
Iso leucine	0.22	0.40
Histidine	0.09	0.22
Valine	0.16	0.47
Threonine	0.18	0.41

***Volatile compounds*:** Typical sourdough flavors are produced by the bacterial proteolysis during sourdough fermentation as compared to the yeast leavened breads (Hansen *et al*., 1989). In the present study, mixed culture of *Lb. casei* and *Lb. brevis* (homo and hetero fermentative bacteria, respectively) and yeast, *Candida humilis* had been used. Results regarding flavoring compounds of sourdough bread are presented in Table 7 which showed that ethanol; 1-propanol,2-methyl; 1-butanol,2-methyl; 1-butanol,3-methyl; ethyl acetate and acetaldehyde were the main flavoring compounds of yeast fermented bread whereas, in addition to above, acetic acid; 1-hexanol; benzaldehyde; hexanal; N-hexanal and Propanal-2-methyl were present in breads fermented with mixed culture of *Lb. brevis*, *Lb. casei and Candida humilis*.

Flavoring compounds produced by *Lb. brevis* was found more complete among others. However, in combination with yeast, both types of LAB can enhance the generation of volatile compounds of yeast (Gobbetti *et al*., 1995). It has been reported that generation of volatile compounds in sourdough bread may be improved by a mixture of homo and hetero fermentative lactic bacteria. The chief flavoring compounds of dough fermented with *Candida humilis* were 2-methyl-2-propanol and 3-methyl-1-butanol. Moreover, diacetyl may be produced by homofermentative LAB (Spicher *et al*., 1981). Aldehydes and ethyl acetate with some alcohols may be produced by heterofermentative LAB (Spicher *et al*., 1982).

Table 7. Comparison of volatile compounds of yeast leavened and sourdough bread.

	Yeast bread	Sourdough fermented bread
Alcohols		
Ethanol	125	181
1-propanol, 2-methyl	31	-
1-butanol, 2-methyl	182	9
1-butanol, 3-methyl	89	71
1-hexanol	7	9
Esters		
Ethyle acetate	11	22
Ethyl lactate	3	8
Acids		
Acetic acid	9	16
Propionic acid	-	28
Carbonyls		
Acetaldehyde	41	18
Benzaldehyde	2	5
Hexanal	-	10
N. hexanal	-	11
Propanal 2 methyl	4	6

The amounts of volatile compounds are expressed in terms of Relative abundance (%) = (peak area of compound/peak area of standard) × 100.

Table 8. Sensory characteristics of various spring wheat sourdough breads.

Parameters	Control	AARI-2011	Millat-2011	Punjab-2011	Lasani-2008
Crust color	8.00±0.29ab	6.83±0.44b	8.50±0.50a	7.63±0.19ab	7.67±0.44ab
Crumb color	7.83±0.44ab	7.17±0.44b	8.83±0.17a	7.33±0.33b	8.00±0.29ab
Flavor	6.00±0.58e	6.17±0.17c	7.90±0.10a	6.83±0.17bc	7.33±0.33ab
Taste	6.27±0.15d	7.00±0.00c	8.97±0.26a	8.00±0.29b	7.50±0.29bc
Texture	8.67±0.17a	6.57±0.35de	8.50±0.29ab	6.90±0.21cd	7.67±0.44bc
Over all acceptability	7.3±0.18c	6.74±0.13d	8.54±0.20ab	7.33±0.31b	7.63±0.21ab

Means bearing different letters in each column differ significantly ($P<0.05$).

***Sensory evaluation*:** Comparison between wheat sourdough breads and yeast bread (control) showed the highly significant ($P<0.01$) differences among them for flavor, taste, texture and over all acceptability whereas the crumb color was affected significantly ($P<0.05$) and crust color non-significantly ($P>0.05$). The mean values for sensory parameters of various treatments have been presented in Table 8. Fermentation process improves the sensory attributes of the product. It results in the product with increased volume and good texture. The primary and secondary metabolites produced during the fermentation process have positive effects on the sensory and textural properties of bread. The organic acids (acetic and lactic acids) produced by lactobacilli greatly affect the rheological properties of sourdoughs such as the dough gas retention and elasticity of gluten network. Bread flavor is one of the key factors for consumer acceptance. The sensory scores regarding the flavor of sourdough bread have the higher value than that of yeast leavened breads, resulting in the improved flavor of the bread. It may be due to the addition of sourdough in the bread production (Arendt *et al*., 2007).

***Conclusion*:** The cultivars used for sourdough production were subjected to different physicochemical tests. The cultivar, Millat-2011 showed the highest thousand kernel and test weights as well as wet gluten content, pelshenke and SDS sedimentation value. Among the proximate composition and farinographic characteristics, Millat-2011 had the highest crude protein, water absorption, tolerance index and softening of the dough. The sourdough breads prepared from mixed culture showed the improved amino acid and flavor profile of the product. The use of mixed culture in bread production would result in the product with better quality in terms of nutritional, functional and sensory characteristics. Thus the sourdough bread prepared from mixed culture and Millat-2011 was awarded the highest scores for sensory characteristics in terms of quality and overall acceptability.

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