INT. J. BIOL. BIOTECH., 16 (2): 425-431, 2019.

ALVEOGRAPH RHEOLOGICAL PARAMETERS IN RELATION TO PHYSICOCHEMICAL ATTRIBUTES AS AN INDICATOR OF WHEAT FLOUR QUALITY

Shahid Yousaf*, Hafiza Mehwish Iqbal, Saqib Arif, Salman Khurshid and Qurrrat ul Ain Akbar

Food Quality & Safety Research Institute, SARC, PARC, Karachi University Campus, Karachi, Pakistan.
**Corresponding author's Email: shahidyousaf160@yahoo.com,*
Mobile- 0333-3899489, Fax- 922199261561, 99261558

ABSTRACT

Wheat flour is largely reflected by physicochemical parameters (i.e. moisture content, ash content, wet gluten, dry gluten, gluten index and falling number), influence quality of intended product. This study was aiming to evaluate relationship between physicochemical and alveographic properties of wheat flour by selecting thirty six composite wheat samples with wide range of gluten index (GI: 20-98). Different quality attributes were significantly ($p<0.05$) correlated with alveographic values. Wet gluten (WG) and dry gluten (DG) have been shown a significant correlation (r: 0.61, 0.68, 0.47, 0.50, 0.62, 0.64 0.77 and 0.82) with baking strength (W), extensibility (L), index of swelling (G) and elasticity index (Ie) respectively. Gluten index reflected moderate correlation with P (tenacity) and Ie values. Baking strength and extensibility were increased with increase in gluten content. Falling number illustrated significant correlation with W, P, P/L and Ie values. Moisture content showed moderate correlation with P and P/L value. Ash had moderate correlation with W and significantly correlated with Ie value of alveograph. This research demonstrated significant ($P<0.001$) correlation of gluten and falling number with most of rheological parameters of wheat flour; therefore suitability of flour for intended use can be predicted by alveographic parameters.

Key words: Wheat, rheological parameters, physicochemical properties, correlation.

INTRODUCTION

Rheology is expressed in term of deformation or flow under applied force. To evaluate rheological characteristics, the flour is placed under control, define and irrefutable force for specific time and characteristics i.e. firmness, stickiness, solidity, potency or robustness were evaluated by recording the strain (Dobraszczyk and Morgenstern, 2003). Physical characteristics of dough are predicted by rheology. Rheological parameters are used to determine for expressing mechanical properties of flour in quantitative term, estimation of flour composition and to access the response of flour during processing (Dobraszczyk, 2003).

Wheat flour dough exhibit cohesiveness and viscoelastic characteristics which help to retain gas produced by fermentation and improve the texture and volume of baking products. Rheology of dough is influenced by different factors; gluten is main contributor in this regard. Gluten develops as a result of kneading and effect rheological properties of dough. Physico-chemical and rheological analysis of wheat are carried out to determine end use suitability of flour (Hruskova and Smejda, 2003).

Rheology of wheat flour plays vital role in baking sector. Range of instruments are used to determine the quality of flour for baking purpose. Alveograph is one of instrument used for the prediction of baking products quality. It gives the idea of extensibility and flexibility of wheat flour dough; expansion of dough takes place by air flow in presence of water and salt. The resultant values demonstrate the baking strength of wheat flour, on these basis wheat can be categorized for specific end use (Codina *et al*., 2010; Mirsaeedghazi *et al*., 2008; Hruskova and Smejda, 2003; Miralbes, 2003).Rheology of food represent flow of food and its behaviour under different conditions of processing and impact on structural characteristics. Understanding of flour composition and rheology of ingredients during production is an important tool to maintain ratio of ingredients for desire quality end product (Fischer and Windhab, 2011).

Various testing procedures are developed to determine the quality of wheat flours, on the basis of these tests, behaviour of flour is studied for technical purposes. This behaviour reflects strong interaction between different flour qualities attributes. Studies shows that flour constituent (protein, gluten and falling number) do not always result in high quality end products. Few research works have made clear sense to improve the quality of some products by decreasing the proportion of specific constituent (Popa *et al*., 2009). Therefore the interaction between physicochemical and rheological parameters is important to evaluate, it will assist to determine the impact of specific wheat component on quality of end product. By determining correlation of flour quality components with rheology, it would be easy to standardize the flour for end use suitability.

This study was designed to evaluate relationship between rheological parameters and quality attributes (moisture, ash, wet gluten, dry gluten, gluten index and falling number) of wheat to predict quality of flour for intended purpose.

MATERIAL AND METHODS

Wheat samples were collected from Wheat Research Institute Sakrand. Selection of thirty six wheat samples was made on the basis of gluten strength (GI: 20-98). All samples were analysed by following standard methods of AACC (1994) (Table 1). Standard procedures were adopted for moisture (AACC 44-15A), wet gluten, dry gluten, gluten index (AACC 38-12), ash (AACC 08-01), falling number (ICC- Standard Method No. 107/1) and alveographic parameters (AACC-54.30). Statistically test results were taken in triplicates and data were interpreted by SPSS software (IBM SPSS Statistics 21).

RESULTS AND DISCUSSION

Physico-chemical attributes of different wheat samples were analyzed and variation in results was recorded for same parameter as shown in Table 2.These characteristics (moisture, ash, wet gluten, dry gluten, gluten index and falling number) were correlated with alveographic parameters (W, P, L, P/L, G and Ie values) to evaluate interaction between these values. Correlation between these parameters is given (Fig. **1**, **2**).

Wheat samples were analyzed by Alveograph to measure the resistance of dough toward extensibility. Maximum resistance of dough have been determined in form of tenacity, which decreased by increasing gluten content (Table 3). Extensibility increased with decrease in tenacity; baking strength is the area under curve formulated by tenacity and extensibility of dough which increased by increasing gluten content.

Gluten

Gluten (including WG, DG and GI) contents reflected broad ranges of samples Table 2. Wet gluten and dry gluten have been shown a significant correlation (r= 0.6, 0.5, 0.6, 0.7 and 0.7, 0.5, 0.6, 0.8, respectively) with W, L, G and Ie values Fig. 1, 2. Extensibility, tenacity and baking strength of dough was dependent upon gluten content of flour and establishment of gluten network during kneading. Therefore resistance to extensibility of dough enhanced under the air pressure of alveograph. This behaviour of dough demonstrated the relation between gluten, P, L, G, W and Ie values; results have reflected increase in L and W value with increase in gluten content (Table 3).

Impact of vital gluten was investigated on dough rheology. Vital gluten was added in medium and week strength flour to strengthen gluten network. Stiffen gluten network developed by vital gluten, increased P value and reduced extensibility of dough (Codina and Paslaru, 2008). A study was designed to evaluate correlation of gluten content and alveograph parameters with pan loaf volume of finish product made by wheat flour. Significant correlation (r= 0.51, 0.52 and 0.63, respectively) found between wet gluten (%), W, L value and pan loaf volume (Vazquez and Veira, 2015).

Table 1. List of tests, methods and equipments for determination of physicochemical and rheological attributes of wheat.

Parameters	Method	Equipment
Moisture	AACC (1994)	memmert-Hot air oven
Wet gluten, dry gluten and gluten index	AACC (1994)	Glutomatic, Perten-Glutomatic
Ash	AACC (1994)	CARBOLITE-Muffle Furnace
Falling number	AACC (1994)	Perten-Falling Number
Alveographic parameters	AACC (1994)	CHOPIN- Alveographic

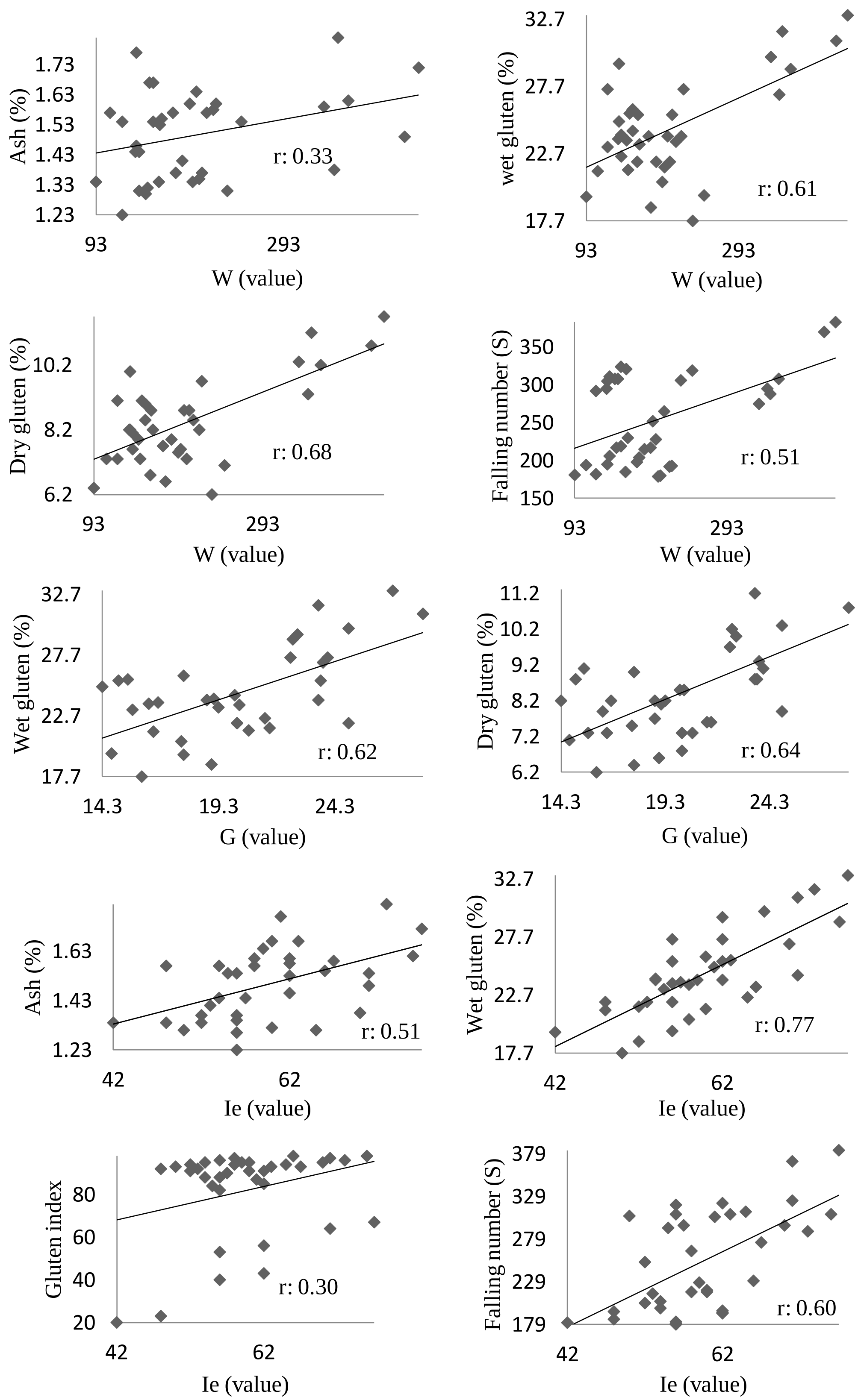

Fig. 1. Correlation between alveographic values and physicochemical parameters.
W: Baking strength 10^{-4}J, G: Index of swelling (mm), Ie: Elasticity index (%), r: correlation.

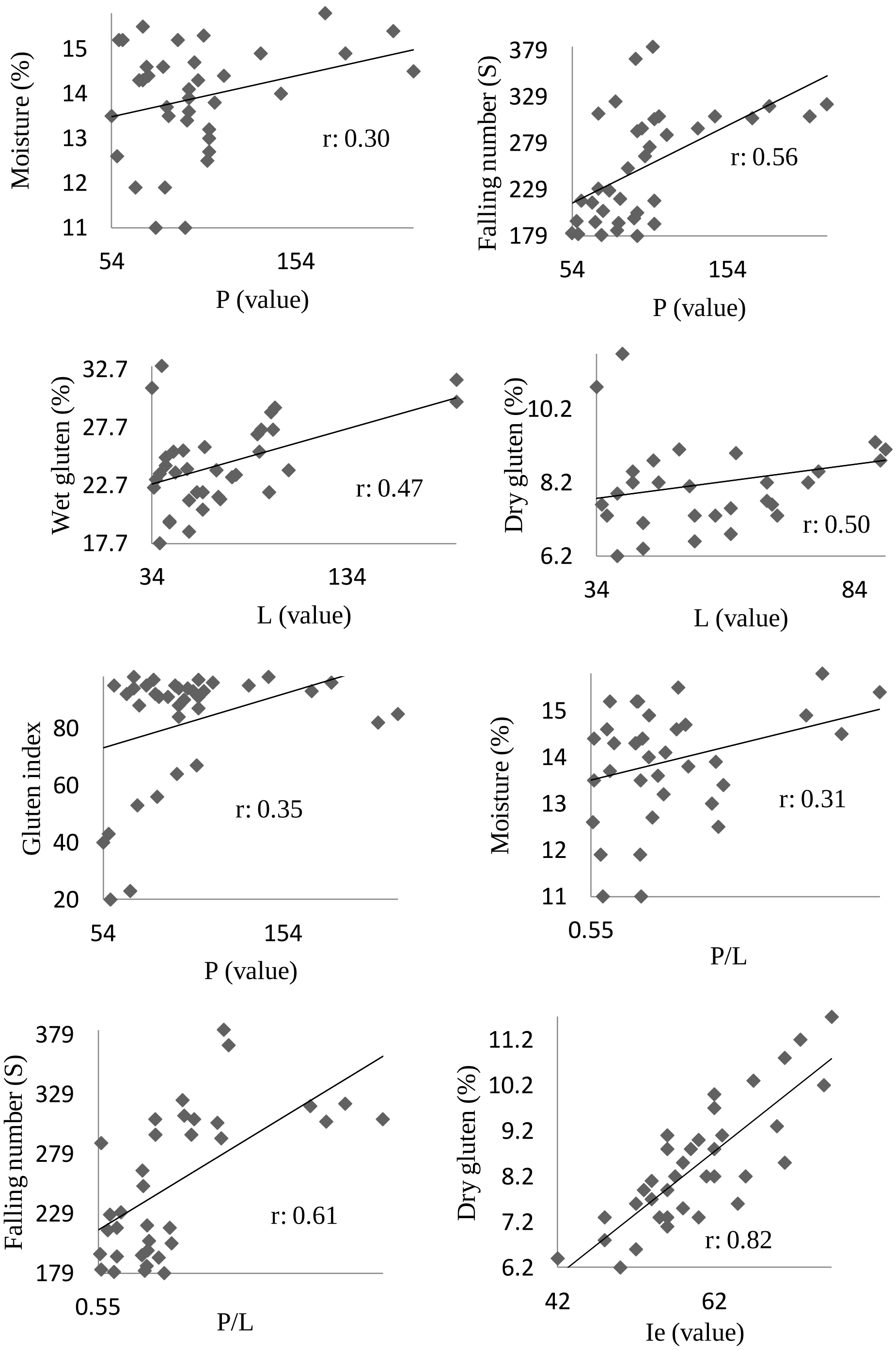

Fig. 2. Correlation between alveographic values and physicochemical parameters.
P: Tenacity (mm), L: Extensibility (mm), P/L: Configuration ratio, Ie: Elasticity index (%), r: correlation.

Falling Number Index (FN)

In this study, wheat samples were analyzed having wide range of falling number (Table 2). Higher values of falling number have been shown a significant correlation (r= 0.51, 0.55, 0.60 and 0.60 respectively) with W, P, P/L and Ie values (Fig. **1**), (Fig. **2**). Higher FN had lower Alveograph L and G values resulted in reduction of dough stretch ability. Alpha-amylase activity had an impact on development of gluten network and ultimately resulted in lower extensibility of dough. In previous study similar results were reported, FN was correlated (r = 0.409, r =

0.587) with P and P/L values, respectively. Lower P value of the dough made by flour of lower FN could be the indication of low molecular weight dextrin formation by hydrolyses of starch (Codina *et al.* 2011).

Table 2. Ranges, means and standard deviation of physicochemical parameters of wheat.

Sample ID	MC	Ash	WG	DG	GI	FN
W1	13.5efgh	1.67abcd	26lmn	9hijkl	91lm	219f
W2	13.6fghi	1.35abc	22.1efhg	7.3abcde	88k	179a
W3	14.6mno	1.37abc	25.6klmn	8.8ghijk	53e	180ab
W4	11.9b	1.34abc	22.1efgh	6.8abcd	92mn	185b
W5	13.9ghij	1.54abcd	23.2fghij	7.3abcde	84j	292kl
W6	15.2pqr	1.34abc	21.7efg	7.6cdef	91lm	252h
W7	13.8ghij	1.67abcd	25.7klmn	9.1ijklm	93no	308mn
W8	14.9opq	1.38abcd	27.1mno	9.3jklmn	95pq	295l
W9	14.5lmno	1.53abcd	25.6klmn	8.8ghijk	85j	321o
W10	13.4efg	1.49abcd	31.1rs	10.8opq	64g	370p
W11	13cde	1.77cd	25.1jklm	8.2efghij	87k	305m
W12	12.6c	1.46abcd	29.4pqr	10lmno	43d	195cd
W13	15.5rs	1.31ab	22.5efgh	7.6cdef	94op	311n
W14	14.3jklmn	1.57abcd	21.4cdef	7.3abcde	23b	194cd
W15	14.4klmno	1.44abcd	24.1hijkl	8.1efghi	88k	206e
W16	15.2pqr	1.32ab	21.5def	7.3abcde	95pq	217f
W17	14.1ijklm	1.37abc	18.7ab	6.6abc	94op	204e
W18	15.4qrs	1.3ab	23.7ghijk	7.9defgh	82i	308mn
W19	12.5c	1.72bcd	33t	11.7q	67h	383q
W20	11.9b	1.41abcd	22.1efgh	7.9defgh	92mn	215f
W21	11a	1.57abcd	24hijkl	7.7cdefg	95pq	198d
W22	15.8s	1.31ab	17.7a	6.2a	93no	306mn
W23	14.3jklmn	1.55abcd	23.4fghij	8.2efghij	98s	230g
W24	13.7fghi	1.6abcd	27.5nop	9.7klmn	56f	193cd
W25	14.7nop	1.44abcd	23.8ghijk	8.2efghij	90l	295l
W26	12.7cd	1.58abcd	24hijkl	8.2efghij	91lm	192c
W27	14hijkl	1.61abcd	29opq	10.2mnop	98s	308mn
W28	15.3qrs	1.59abcd	29.9qr	10.3nop	93no	275j
W29	14.3jklmn	1.57abcd	23.6ghijk	8.5fghij	94op	265i
W30	13.5efgh	1.23a	27.5nop	9.1ijklm	40c	182ab
W31	11a	1.64abcd	24hijkl	8.8ghijk	95pq	228g
W32	15.2pqr	1.34abc	19.5abc	6.4ab	20a	181ab
W33	14.9opq	1.54abcd	19.6abcd	7.1abcde	96qr	319o
W34	14.4klmno	1.82d	31.8st	11.2pq	96qr	288k
W35	13.2def	1.6abcd	20.6bcde	7.5bcdef	97rs	217f
W36	14.6mno	1.54abcd	24.4ijkl	8.5fghij	97rs	324o
Range	11-15.8	1.23-1.82	17.7-33	6.2-11.7	20-98	179-383
Mean	13.9±1.2	1.50±0.14	24.5±3.6	8.4±1.3	82±21	254±59

MC: Moisture (%), Ash: Ash (%), WG: Wet gluten (%), DG: Dry gluten (%), GI: Gluten index, FN: Falling number (S).

Table 3. Ranges, means and standard deviation of alveographic parameters of wheat.

Samples ID	W	P	L	P/L	G	Ie
W1	154f	85g	61h	1.39cd	17.8fgh	60ijkl
W2	203lm	96ij	57gh	1.68de	20.1ijkl	56efgh
W3	206m	73e	89kl	0.82ab	23.7pqr	56efgh
W4	160g	83g	60h	1.38cd	20.1ijkl	48b
W5	121c	96ij	36ab	2.67h	15.6bcde	55defg
W6	196jk	90h	68i	1.32c	21.5lmn	52cd
W7	150ef	110n	50ef	2.20g	15.4abcd	63lmn
W8	347s	135p	88k	1.53cde	23.8qr	70pq
W9	161g	218u	45de	4.80j	15abc	62klm
W10	422u	95i	34a	2.79h	28.1t	71q
W11	136d	107mn	41bcd	2.60h	14.3a	61jkl
W12	136d	57ab	97n	0.58a	22.7nopq	62klm
W13	139d	71de	35a	2.03fg	21.3klm	65mno
W14	108b	69cd	53fg	1.30c	16.5de	48b
W15	139d	74e	52fg	1.42cd	19.1ij	54def
W16	148e	60b	69i	0.87ab	20.6	60ijkl
W17	178h	96ij	53fg	1.81ef	19hij	52cd
W18	146e	207t	38ab	5.45k	16.3de	56efgh
W19	437v	106m	39ab	2.71h	26.8s	77s
W20	185i	67c	94lmn	0.71ab	24.9r	53cd
W21	175h	94i	67i	1.40cd	18.8ghi	54def
W22	233p	170r	38ab	4.47i	16cde	50bc
W23	163g	71de	75j	0.94b	19.3ij	66no
W24	221o	84g	96n	0.87ab	22.4mno	62klm
W25	135d	99jk	46de	2.15g	16.7ef	57fghi
W26	2180	107mn	67i	1.59cde	18.8ghi	62klm
W27	362t	146q	95mn	1.53cde	22.5mnop	76rs
W28	336r	104lm	190p	0.55a	24.9r	67op
W29	211n	101kl	77j	1.31c	20.2jkl	58ghij
W30	121c	54a	90klm	0.60a	24r	56efgh
W31	200kl	78f	104o	0.75	23.6opqr	59hijk
W32	93a	58b	43cd	1.35cd	17.8fgh	42a
W33	248q	181s	43cd	4.20i	14.7ab	56efgh
W34	351s	115o	190p	0.60a	23.6opqr	73qr
W35	193j	107mn	60h	1.78ef	17.7fg	58ghij
W36	154f	82g	41bcd	2.0fg	20ijk	71q
Range	93-437	54-218	34-190	0.55-5.45	14.3-28.1	42-77
Mean	202 ± 86	101± 39	69 ± 36	1.84 ± 1.20	20.1 ± 3.5	60 ± 8

W: Baking strength 10^{-4}J, P: Tenacity (mm), L: Extensibility (mm), P/L: Configuration ratio, G: Index of swelling (mm), Ie: Elasticity index (%).

Correlations were determined between physico-chemical (ash, moisture, protein, wet gluten, gluten deformation index, gluten index, falling number index, maltose index and damaged starch) and rheological (including extensograph and amilograph) properties of wheat flour. Falling number and rheological parameters were significantly correlated ($p<0.05$) with each other (Zaharia,*et al.,* 2014). A study was conducted to find correlations between falling number and other physico-chemical parameters (test weight, protein content, sedimentation volume and wet gluten) with Mixolab properties; FN was significantly correlated with mixolab parameters (Vazquez and Veira. 2015). Investigation reported significant correlations between protein, zeleny, falling number and alveographic parameters (Konopka *et al.,* 2004).

Moisture and Ash

Moisture and ash content which were analyzed to determine correlation with rheological parameters of dough (Table 2). Moisture content showed moderate correlation (r= 0.29 and 0.31) with P and P/L; ash percentage reflected moderate correlation (r= 0.33) with W and significantly correlated (r= 0.50) with Ie value (Fig. **1**), (Fig. **2**). In previous study moisture and ash contents were close to each other, existed in centre of principal component and reflected insignificant correlation with dough rheological characteristics (Mironeasa and Codina, 2013).

Flour quality and rheological parameters were studied to evaluate correlation, findings revealed insignificant correlation (r=-0.244, 0.141, -0.187 and -0.151) of moisture content with P, L, P/L and W value of alveograph (Szabo *et al.* 2016).

Conclusion

This study demonstrated significant correlation of gluten and falling number with most of rheological parameters. Quality parameters like moisture and ash had moderate correlation with rheological properties of wheat flour. Therefore deformation of dough can be correlated with two quality parameters, mainly gluten and falling number. Flour can be recommended for intended purpose by considering rheological parameters like baking strength (W), extensibility (L), index of swelling (G) and elasticity index (Ie) as an indicator of gluten content and W, P, P/L and Ie values for falling number.

REFERENCES

AACC (1994). *Approved methods*. American Association of Cereal Chemists, Inc., Minnesota.

Codina, G. G. and V. Paslaru (2008). Effect of gluten vital on the alveograph charactersitics and bread quality of flour wheat dough with a weaker potential for bread making. *Lucrari Ştiinţifice, Seria Agronomie*, (51):106-111.

Codina, G.G., S. Mironeasa, D. Bordei and A. Leahu (2010). Mixolab versus alveograph and falling number. *Czech Journal of Food Sciences,* 28:185-191.

Codina, G.G., S. Gutt, G. Gutt and S. Mironeasa (2011). Alveograph as a rheological tool topredict the quality characteristics of wheat flour. Annals of DAAAM for 2011 and Proceedings of the 22nd *International DAAAM Symposium*, pp. 1027-1028.

Dobraszczyk, B.J (2003). Measuring the rheological properties of dough. In: Breadmaking Improving Quality. *Woodhead Publishing. Cambridge, UK*. pp. 375-400.

Dobraszczyk, B.J. and M.P. Morgenstern (2003). Rheology and the bread making process. *Jouranl of Cereal Science*, 38(3):229-245.

Vazquez, D. and M. C. Veira (2015). Applicability of mixolab test with local wheat flours. *International Journal of Food Studies,* 4: 78-87.

Fischer, P. and E.J. Windhab (2011). Rheology of food materials. *Current Opinion in Colloid and Interface Science,* 16:36-40.

Hruskova, M. and P. Smejda (2003). Wheat flour dough alveograph characteristics predicted by NIR systems 6500. *Czech Journal of Food Science,* 21(1): 28-33.

Konopka, I., L. Fornal, D. Abramczyk, J. Rothkaehl and D. Rotkiewicz (2004). Statistical evaluation of different technological and rheological tests of Polish wheat varieties for bread volume prediction. *International Journal of Food Science and Technology,* 39(1): 11-20.

Mironeasa, I. and G. G. Codina (2013). Alveograph dough rheological parameters related to wheat flour analytical characteristics using principal component analysis. *Advances in Environment Technologies, Agriculture, Food and Animal Science,* 188 (3): 241-246.

Mirsaeedghazi, H., E. Z. Djomeh and S.M.A.Mousavi (2008). Rheometric measurement of dough rheological characteristics and factors affecting it. *International Journal of Agriculture and Biology,* 10:112-119.

Miralbes, C. (2003). Prediction of chemical composition and alveograph parameters on wheat by near-infrared transmittance spectroscopy. *Journal of Agriculture and Food Chemistry,* 51:633-633.

Popa, N.C., T. B. Radiana, P. Stela, V. Mioara, C. G. Gabriela (2009). Predictive model of the alveografic parameters in flours obtained from Romanian grains. *Romanian Biological Latters,* 14(2):4234-4242.

Szabo, B. P., E. Gyimes, A. Veha Z. H. Horvath (2016). Flour quality and kernel hardness connection in winter wheat. *Acta University. Sapientiae, Alimentaria,* 9(1):33-40.

Zaharia, D., I. Danciu, G. G. Codina, S. Mironeasa and C. Mironeasa (2014). Use of principal component analysis in assessment of relationship between technological and rheological parameters of wheat flour. *Journal of Food, Agriculture and Environment,* 12 (1): 29-32.

(*Accepted for publication February 2019*)