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The effect of different flour extraction rates on physiochemical and rheological characteristics

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Abstract

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The objective of this study was to evaluate the effect of different flour extraction rates (78% as a control, 79%, 80%, 81%, 82%, 83%, and 84%) on flour chemical, physiochemical and rheological properties on the flour quality. The results indicated that the moisture content, gluten index, zeleny sedimentation values, color, and falling number started to decrease gradually with an increase in extraction rate, whereas, ash, crude fiber, crude protein, wet and dry gluten were increased with each increase in flour extraction rate. Farinograph characteristics such as water absorption and dough development time were increased with an increase in flour extraction rate, but for dough stability, dough elasticity and weakening of the dough characteristics were reduced. Furthermore, the results of water absorption, dough development time, and dough elasticity gave significant differences, while, dough stability only with 81% and 82% flour extraction rates gave significant differences, whereas, for weakening of the property only with 81% flour extraction rate showed significant differences. The results of extensograph illustrated that when the flour extraction rate was increased, the characteristics of resistance to extension, extensibility and the area under the extensogram curves were reduced except the ratios of resistance to extension / extensibility.

Keywords: physiochemical; rheological properties; flour quality

Introduction

Bread is an important staple food, the consumption of which is steadily increasing in the Middle East in general and Jordan in particular. Nutritionally, bread contains a high percent of carbohydrate which is needed for energy production. It also contains other nutrient, such as protein, lipids, fibers, minerals and vitamins (Faridi & Finney, 1980; Alvarez-Jubete et al., 2010). Cornell and Hovelling (1998) were of the view that wheat quality could be usually assessed on the basis of the ability of the wheat flour to produce a high standard loaf of bread (yeast leavened bread). The baker requires wheat flour suitable for baking e.g., bread, biscuits or cakes (Kent & Evers, 1994). The overall bread making quality of wheat depends on several factors such as water absorption, loaf volume, internal and external loaf characteristics and tolerance to mixing and fermentation and these characteristics are correlated to the physical and chemical characteristics of wheat flour and dough (Pomeranz, 1988; Deleour & Hoseney, 2009). The chemical characters include protein content, protein quality (gluten content), sedimentation test and other tests such as farinograph, extensograph, and which can assess the mixing or viscoelastic properties of the dough (Bushuk, 1985; Faridi & Faubion, 1990). The important quality criteria which save attributes for describing wheat and flour quality are flour extraction rate, protein content, gluten content, gluten index, zeleny sedimentation, amylase activity, ash content, crude fiber content and etc. which are affected by varieties, environments in which they are grown and the environment/ genotype interactions (Finney et al., 1987). On the other hand, the objective of milling is to separate the endosperm from the wheat kernel and gradually grind the endosperm into more than 30 flour streams (Posner, 2009). Flour extraction rate is a key factor in determining milling efficiency and profitability and can be used in planning flour output for a mill (Gwirtz, 2005).

The importance of knowing the physiochemical properties of wheat and flour is contributed to the need of miller, baker, and consumer to recognize the quality and type of flour which is produced after milling process in order to determine the suitable final baking product of that flour (Deleour & Hoseney, 2009; Pyler & Gorton, 2009). However, based on the obtained results in this work, it is good to notice too, that the control sample for all the study was 78% flour extraction rate.

Based on above the main of objectives were to investigate the effect of different flour extraction rates on physiochemical and rheological characteristics.

Materials and Methods

Methods

Preparation of Flour Samples

The wheat was cleaned in the cleaning system of the mill and conditioned at appropriate moisture content by adding additional 5 to 6% of moisture. Then the wheat was milled regularly in the milling section of a commercial mill (South Amman Mill-Jordan) with milling capacity of 320 t/day. Ten kilograms of flour samples of different flour extraction rates were drawn according to the computer program which was established in advance based on the experiment requirements, under the supervision of the head miller of the mill. All samples were kept in a refrigerator until the time of analysis (Pomeranz, 1988; Hoseney, 1994).

Chemical Analysis

Gross Chemical Analysis

The moisture, ash, crude fiber, and protein contents and wet and dry gluten content of flour samples were determined according to the AACC procedures (2000).

Physiochemical Characteristics

Zeleny Sedimentation Value

The sedimentation value was determined by applying the procedure outlined in method No. 5529 as described in ISO (2007) by using Zeleny instrument (produced by ERKAYA Co., Turky).

Falling Number (FN)

Falling number were determined using Pertin Falling Number Apparatus Type 1900 (Pertin Instruments Sweden) by following the AACC (2000) Method No. 56-81.

Color Grade Measurement

All wheat flour samples of different extractions were tested and categorized according to the AACC (2000), Method No. 14-22.01 using Minolta Chroma Meter series CR-410 (Japan) and recorded in CIE (1976) L* a* b* color systems.

Rheological Characteristics

Farinograph

The farinograph measurement which includes: water absorption, development time, stability, and breakdown (weakening of the dough) were carried out according to the AACC (2000) Method No. 54-21 in which 50 g sample was placed in a farinograph bowl. After 1 min of dry mixing sufficient water was added to the center of the graph at maximum dough consistency and the test was run for 10 min beyond the point of maximum development. Information provided by the farinogram was divided into the following categories: water absorption which was carried out and results reported on 14% flour moisture basis because the weight of tested sample (300 gm) was modified to 14%; development time is the interval in minutes from the first addition of water to the point of maximum consistency; stability is the time minutes in between the point where the top of the curve first intersected the 500 BU line and the point where the top of the curve falls below the 500 BU line; and breakdown (weakening of dough) which is the degree of softening and was measured at the difference (in BU) from the center of the curve at peak and the center of the curve at 10 min after the peak.

Extensograph

The extensograph measurements which include: extensibility, maximum height, and area were carried out in accordance to the AACC (2000), method no. 54-10. A flour-salt-water dough was prepared under standard conditions in the farinograph (except the water absorption is 1-4% less than the farinograph water absorption depending on the strength of the flour) and molded on the extensograph into 150 g standard shape. After 45 min the dough was stretched and a curve was drawn recording the extensibility and resistance of the dough to stretching. These three parameters were used including extensibility measured as total length of the extensogram base in mm; maximum height achieved by the curve is expressed in BU; and the area which indicated the surface in cm^2 outlined by the curve indicates the total force used in stretching the dough.

Statistical Analysis

Data of research were statistically analyzed by applying the general linear model (GLM) procedure with JMP statistical package (JMP Institute Inc., Carry, NC). Least significant difference (LSD) test was used for means comparison. All analysis was performed at level of $p < 0.05$.

Results and Discussion

Chemical Analysis

The Effect of Flour Extraction Rates on Moisture Content

The results of moisture content for different wheat flour extraction rates are shown in Table 1. The moisture values for the flour extraction rates indicated significant differences at $p \leq 0.05$. This is mainly because the rule of composite flour has been applied in this research to create different flour extraction rates. The moisture contents of different extraction rate flours ranged from 13.06 to 13.86. The highest moisture level 13.86% was found in 78% flour extraction rate. Then, moisture content started to decrease gradually with an increase in flour extraction rate. Many researchers also showed the same trend when they discussed this kind of relation (Prabhasankar et al., 2000; Miric & Pejin, 2008; Mueen-ud-Din et al., 2010). The reduction in flour moisture with the increase in the flour extraction rate is due to the presence of more wheat bran and aleurone particles in flour which has less moisture compared with endosperm flour (Azizi et al., 2006). This also affects flour water absorption and the storage quality of this flour (Prabhasankar et al., 2000; Azizi et al., 2006).

The Effect of Flour Extraction Rates on Ash Content

Results of ash contents for different flour extraction rates are shown in Table 1. The ash contents ranged from 0.64 to 0.94%. The lowest value 0.64% was found in 78% (control) flour extraction rate which increased gradually as long as the flour extraction rate was increased. All ash values showed significant differences at $p \leq 0.05$. This increase might be due to the higher proportion of pericarp and aleuronic layer as reported by Ramirez-Wong et al. (2007). The results which are mentioned above come in agreement with findings of (Prabhasankar et al., 2000; Miric & Pejin, 2008, Aprodu et al., 2010, Muradi et al., 2013).

The Effect of Flour Extraction Rates on Crude Fiber Content

As it is shown in Table 1, the results of crude fiber content were ranged from 1.03 to 1.63%. The lowest value (1.03) was found in 78% flour extraction because wheat bran was removed during milling process which decreased the amount of fiber in flour (Mueen–ud-Din et al., 2010); whereas, the highest value was given by 84% flour extraction rate. As endosperm extraction rates approach the theoretical maximum of 81–84%, the flour becomes increasingly contaminated with bran (Campbell, 2007). In other words, if the extraction rate exceed 80%, the flour will contain bran particles (Dewittnick et al., 2008), in which crude fiber of wheat flour is concentrated (Pomeranz, 1988). Looking at Table 1, it can be noticed that all the results had shown significant differences at $p < 0.05$.

The Effect of Flour Extraction Rates on Protein Content

Results of protein content have been shown in Table 1. The results were ranged from 12.02 to 13.30. The highest value was 13.30 and obtained with 84% flour extraction rate. While, the lowest value of protein content was 12.02 and observed with 78% flour extraction rates. On the other hand, the statistical analysis gave significant differences at p

Table 1. The effect of wheat flour with different extraction rates on chemical composition

Extraction Rates	Moisture, %	Ash, %	Fiber, %	Protein, %	Wet Gluten, %	Dry Gluten, %
78% (control)	13.86± 0.04 [a]	0.64 ± 0.01 [f]	1.03 ± 0.02 [g]	12.02± 0.04 [g]	27.47 ± 0.25 [f]	9.44 ± 0.12 [g]
79%	13.74 ±0.03 [b]	0.70 ± 0.02 [e]	1.10 ± 0.01 [f]	12.33 ± 0.11 [f]	28.70 ± 0.20 [e]	9.81 ± 0.10 [f]
80%	13.65 ± 0.05 [c]	0.79 ± 0.04 [d]	1.23 ± 0.04 [e]	12.57 ± 0.10 [e]	29.80 ± 0.35 [d]	10.19 ± 0.14 [e]
81%	13.57 ± 0.01 [d]	0.81 ±0.05 [d]	1.32 ± 0.05 [d]	12.80 ± 0.13 [d]	30.70 ± 0.29 [c]	10.54 ± 0.13 [d]
82%	13.42 ±0.06 [e]	0.84 ±0.07 [c]	1.40 ± 0.03 [c]	12.95 ± 0.08 [c]	31.27 ± 0.38 [b]	10.62 ± 0.09 [c]
83%	13.21 ± 0.04 [f]	0.90±0.10 [b]	1.51 ± 0.06 [b]	13.16 ± 0.09 [b]	31.80 ± 0.21 [a]	10.81 ± 0.05 [b]
84%	13.06 ± 0.02 [g]	0.94 ±0.06 [a]	1.63 ± 0.07 [a]	13.30 ± 0.12 [a]	32.10 ± 0.26 [a]	10.92 ± 0.07 [a]

* Mean ± SD of three determinations
* Means in the same column with the same letter are not significantly different (P < 0.05)
* All data are calculated on dry basis

≤ 0.05. This is may be due to the presence of the sub aleurone layers which are higher in protein than the inner endosperm (Orth & Mander, 1975; Pomeranz, 1988). In addition, also they reported that they found a significant difference between protein content and Farinograph water absorption, both were increased with extraction rate.

The Effect of Different Extraction Rates on Wet and Dry Gluten Content

The results of wet and dry gluten contents have been shown in Table 1. There were significant effects of flour extraction rates on the wet and dry gluten contents. It was noticed that as far as the flour extraction rate was increased both wet and dry gluten contents increased too. Differences in wet and dry gluten were clearly significant at $p < 0.05$. The results of wet gluten ranged from 27.47 to 32.10 and for dry gluten range from 9.44 to 10.92. The lowest values for wet and dry gluten were found in 78% flour extraction rate and they were 27.47 and 9.44 respectively. While the highest values were obtained in 84% flour extraction rate and they were 32.10 and 10.92 respectively.

This trend of increase is due to two reasons. Firstly, the results previously showed that there was an increase in crude protein contents. Which was attributed to the higher proportion of aleuronic layer and peripheral endosperm that flours contained, when, the flour extraction rate was increased (Prabhasankar et al., 2000). Secondly, gluten proteins represent 80-85% of the total crude protein and have the capability to absorb water 2.5-3 times as it weights (Pomeranz, 1988; Hoseny, 1994, Shewry & Halford, 2002).

Physiochemical Characteristics

The Effect of Flour Extraction Rates on Gluten Index

The data in Table 2 showed that there was a clear trend of decreasing of gluten index values joined the increase in flour extraction rates. The differences were statistically significant at $p < 0.05$. The results of gluten index were ranged from 55- 96.4% indicated stronger gluten network in flour with lower extraction rate (Moradi et al., 2013). The highest value of gluten index 96.4% and it was given by 78% flour extraction rate while the lower value 55% was given by 84% flour extraction rate. This parameter considers being very important by many researchers because gluten index provides information on both quantity and quality of gluten based on the ratio high / low molecular weight proteins (Banu et al., 2012). In addition, gluten index is the only method to determine gluten quality without the need to extract flour first because the method is suitable for both wheat meal and flour (Deleour & Hoseney, 2009).

Table 2. The effect of wheat flour with different extraction rates on physiochemical characteristics

Extraction Rates	Gluten Index, %	Zeleny, ml	Falling Number, sec
78% (control)	96.4 ^{a}	30.4 ^{a}	516.0 ^{a}
79%	92.1 ^{b}	30.0 ^{ab}	485.0 ^{b}
80%	86.0 ^{c}	29.2 ^{b}	461.0 ^{c}
81%	80.0 ^{d}	28.0 ^{c}	442.0 ^{d}
82%	73.0 ^{e}	26.5 ^{d}	431.0 ^{e}
83%	64.7 ^{f}	25.0 ^{e}	416.0 ^{f}
84%	55.0 ^{g}	23.1 ^{f}	404.0 ^{g}

* All values are calculated means of three replicates
* Means in the same column with the same letter are not significantly different ($P < 0.05$)
* All data are calculated on dry basis

High gluten index shows greater proportion of high molecular weight – proteins present in gluten (Collar et al., 2007). On the other hand gluten index usually depends on the amount of wet gluten that passes through a sieve under centrifugal force, and a higher proportion of gluten that remains on the sieve after centrifugation indicated stronger gluten and gives high gluten index value. Therefore, many researchers concluded on the basis of obtained data that gluten index is a good and reliable measure for the technological quality of different flours (Curic, 2001; Dowell et al., 2008). Also the result comes in agreement with Moradi et al. (2013).

The Effect of Flour Extraction Rates on Zeleny / Sedimentation Test

Results in Table 2 have shown that the values of Zeleny – sedimentation were ranged from 23.1 ml to 30.4 ml. The highest value was obtained from 78% flour extraction rate and the lowest value was obtained from 84% flour extraction rate. Furthermore, most of the results showed statistical significant differences. In Table 2 the general trend of the test was illustrated that as long as the flour extraction rate increased, the Zeleny sedimentation value was decreased. These results were confirmed Azizi et al. (2006) previously concluded the sedimentation test shows that the quality of gluten will be reduced and this causes the weaker baking quality of high extraction rate compared to lower extraction rate flour.

The Effect of Flour Extraction Rates on Falling Number

Data in Table 3 showed that results were range between 404 – 516 s. The highest value was 516 s and obtained from 78% flour extraction rate and the lowest value was 404 s which was obtained from 84% flour extraction rate. However, all the results showed statistical significant differences at $p < 0.05$. Those results were concurred with the findings of Azizi et al. (2006) who justified the reduction in the falling numbers to the increase in alpha – amylase activity of flours with higher extraction rate, which was due to an increase in wheat germs and bran in flours. However, Prabhasankar et al. (2000) indicated the same trend regarding the relationship between flour rate extractions and falling number values.

The Effect of Flour Extraction Rates on Flour Color

Results of lightness or whiteness (L*), redness (a*), and yellowness (b*) for all seven different flour extractions rates are shown in Table 3. The whiteness values are ranged from 70.48 to 80.75 and the highest value was 80.75 and observed with flour extraction at 78%, whereas the lowest value was 70.48 and obtained from the flour extraction 84%. Meanwhile the redness values are ranged from -0.51 to 0.66 and the maximum value was 0.66 and obtained from flour extraction 84%, while the minimum was -0.51 and observed with flour extraction 78%. On the other hand the maximum of yellowness was 9.05 and given by 78% flour extraction, whereas the minimum value was 7.67 and given by 84% flour extraction.

Table 3. The effect of wheat flour with different extraction rates on color values

Extraction Rates	L*	a*	b*	ΔE	Chroma
78% (control)	80.8 [a]	- 0.51 [g]	9.0 [a]	12.0 [f]	9.0 [a]
79%	79.0 [b]	- 0.15 [f]	8.9 [b]	13.8 [e]	8.9 [b]
80%	77.7 [c]	0.10 [e]	8.8 [c]	15.1 [d]	8.8 [c]
81%	75.3 [d]	0.22 [d]	8.3 [d]	17.5 [c]	8.3 [d]
82%	73.1 [e]	0.40 [c]	8.0 [e]	19.6 [b]	8.0 [e]
83%	72.9 [e]	0.54 [b]	7.9 [f]	19.9 [b]	7.9 [f]
84%	70.5 [f]	0.66 [a]	7.7 [g]	22.2 [a]	7.7 [g]

* All values are calculated means of three replicates
* Means in the same column with the same letter are not significantly different (P < 0.05)
* All data are calculated on dry basis

The Δ*E* value is defined as the size of the total color difference and expressed the color difference between a sample and a standard and defined by the following equation:

$$\Delta E = [(\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2]^{1/2}$$
$$chroma = [(a)^2 + (b)^2]^{1/2}$$

In Table 3 the larger the ΔE value, the larger the color difference. The results were ranged from 12.09 to 22.24. The lower flour extraction rate (78%) gave the lowest ΔE value also as it was illustrated in Table 3 which means that the sample was having the best whiteness among other flour extraction rates while the higher flour extraction rate (84%) obtained the highest Δ*E* value. This showed that the sample had the darkest color.

In the meantime the chroma values in Table 3 indicated opposite results because when flour extraction rate was increased the chroma values were reduced. All the obtained results of color grade and for all the extraction rates gave significant differences at $P < 0.05$.

The results of whiteness color decreased gradually with an increase in flour extraction rate. These results had been agreed and concluded by many researchers (Azizi et al., 2006; Mueen–ud–Din et al., 2010; Banu et al., 2012) whom all were attributed the main cause to the presence of wheat bran and eleurone particles which increased with each increase in flour extraction rate. Conclusions can be made based on the above data which had clearly shown that the control sample (78%) flour extraction rate was having the highest values of whiteness and yellowness color and lowest value for redness, whereas, the highest flour extraction sample (84%) obtained the lowest values of whiteness and yellowness color and the highest value for redness color increased, the whiteness of flours decreased.

Rheological Characteristics

The Effect of Flour Extraction Rates on Farinograph Properties

All the results are shown in Table 4. The observed results indicated that there were significant differences ($P< 0.05$) among the flour extraction rates in water absorption, development time, dough stability, dough elasticity and weakening of the dough.

Water Absorption

The observed results in Table 4 ranged between 62.4 and 67%. Water absorption of 84% flour extraction rate gave the highest value (67%) while the sample of 78% flour extraction rate gave the lowest value (62.4%). It was also noticed that the water absorption increased as long as extraction rate increased. The result comes in agreement with result of Orth and Mander (1975) who indicated that the additional milling required producing high extraction flour which causes more starch damage by physical abrasion and consequently higher water absorption. Also they found that protein content and farinograph water absorption both increased with increase in flour extraction rate. While other researchers presumed that the increase in water absorption is due to the higher protein and complex carbohydrate contents from bran (Pomeranz et al., 1977; Pomeranz, 1988). In addition, Sliwinski et al. (2004) indicated that this means by increasing the flour ex-

Table 4. The effect of wheat flour with different extraction rates on farinograph properties

Extraction Rates	(wa)% Water Absorption	(B) Development Time (mint)	(C) Dough Stability (mint)	(D) Elasticity (B.U)	(E) Weakening of the Dough (B.U)
78% (control)	62. 4 g	2.0 f	11.0 c	120.0 a	45.0 a
79%	63.0 f	2.0 f	11.0 c	110.0 b	45.0 a
80%	63.6 e	2.5 e	11.0 c	100.0 c	45.0 a
81%	64.4 d	2.8 d	11.5 b	100.0 c	40.0 b
82%	65.3 c	3.2 c	12.0 a	95.0 d	35.0 c
83%	65.9 b	3.5 b	10.5 d	90.0 e	35.0 c
84%	67.0 a	4.0 a	10.5 d	80.0 f	35.0 c

* All values are calculated means of three replicates
* Means in the same column with the same letter are not significantly different (P < 0.05)
* All data are calculated on dry basis

traction rate, the bran content of flour is higher and water absorption will increase. However, the results of this research agreed with results found by Azizi et al. (2006) and Mueen-ud-Din et al. (2010).

Development Time

A similar trend was obtained for development time and as it has shown in Table 4. Significant differences (P< 0.05) were observed in the development time for different flour extraction rates as it has been illustrated in Table 4 and the results were ranged from 2 to 4 min. The lowest value (2 min) was observed with 78% flour extraction while the highest (4 min) was noticed with 84% flour extraction rate. However, the increase in development time may be due to the presence of increased amount of bran particles in high extraction flours which interfere in the quick development of gluten and hydration of endosperm (Mueen-ud-Din et al., 2010).

Dough Stability and Elasticity

The results in Table 4 indicated that both dough stability (DS) and dough elasticity (DE) were reduced with an increase in flour extraction rates. The DS values were in range of 11 to12 (mint), whereas, DE values were found in range of 80 to 120 BU. On the other hand regarding the effect of the extraction rate on Farinograph characteristics significant differences (P < 0.05) in dough stability and elasticity were observed as it has been shown in Table 4. The variation in the Farinographic characteristics might be due to difference endosperm portion among different extraction rates (Vetrimani et al., 2005).

Weakening of the Dough

Same trend was noticed with weakening of the dough (dough breakdown) values when obtained results in Table 4 were reduced with the increase in flour extraction rate. The flour extraction (78, 79 and 80%) gave the highest values whereas; the extractions (82, 83 and 84%) gave the lowest values (35 B.U.). However, data in Table 4 also showed that Farinograph weakening of the dough increased significantly (P < 0.05) with the increase in flour extraction rate. Orth and Mander (1975) found the same trend and they believed that was due to the pronounced decrease in gluten strength with an increase in extraction rate. This decrease in strength occurred despite the increase in flour protein. They added that those flours produced dough with gluten network more easily disrupted by prolonged mixing and offered less resistance

Table 5. The effect of wheat flour with different extraction rates on extensograph properties

Extraction Rates	Relative resistance to Extension (B.U)	Extensibility (mm)	Ratio	Total area
78% (control)	600.0 g	155.0 a	3.9 g	154.0 a
79%	670.0 f	150.0 b	4.5 f	144.0 b
80%	690.0 e	145.0 c	4.8 e	143.0 c
81%	700.0 d	140.0 d	5.0 d	132.0 d
82%	760.0 c	120.0 e	5.8 c	130.0 e
83%	800.0 b	120.0 e	6.7 b	124.0 f
84%	940.0 a	100.0 f	9.4 a	116.0 g

* All values are calculated means of three replicates
* Means in the same column with the same letter are not significantly different (P < 0.05)
* All data are calculated on dry basis

to extension than those of the lower extraction flours. Our results obtained are in agreement with (Vitrimani et al., 2005; Mueen-ud-Din et al., 2010).

The Effect of Flour Extraction Rates on Extensograph Properties

The effect of flour extraction rate on extensogram characteristics has been shown in Table 5 although there were significant differences among the increasing in flour extraction rates and the extensogram characteristics. That means, when the flour extraction rate was increased; resistance to extension, extensibility and the area under the extensogram curves were reduced. This negative effect of higher extraction rate flour on dough rheological characteristics was attributed to the reduction in the gluten network and quality because of the presence of a larger amount of wheat bran in flour that results in weaker resistance to mechanical force (Azizi et al., 2006). The same trend of results had been reported by (Orth & Mander, 1975; Lai et al., 1974; Rao & Rao, 1991; Azizi et al., 2006).

Conclusions

The obtained results indicated that the moisture content, gluten index, zeleny sedimentation values, color grade, and falling number started to decrease gradually with an increase in extraction rate, whereas ash content, crude fiber, crude protein, wet gluten and dry gluten were increased with each increase in flour extraction rate. On the other hand Farinograph characteristics such as water absorption and dough development time were increased with an increase in flour extraction rate, but for dough stability, dough elasticity and weakening of the dough characteristics were reduced. Furthermore, the results of water absorption, dough development time, and dough elasticity gave significant differences, while dough stability with only 81% and 82% flour extraction rates gave significant differences, whereas for weakening of the property with only 81% flour extraction rate showed significant differences. On the other hand, the results of Extensograph illustrated that when the flour extraction rate was increased, the characteristics of resistance to extension, extensibility and the area under the Extensograpm curves were reduced except the ratios of resistance to extension/extensibility which were increased.

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