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The Analysis of Momentary Behavior for Pasta Dough Inside the Dough-Mixer

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ABSTRACT

Diversity and high quality in pasta manufacturing ensure continuous development in production. One of the most significant stages of pasta manufacturing is the kneading process, which is the initial stage of production and upon which the quality of manufacturing is inducting during successive stages. A worthy process of mixing the ingredients helps the pasta dough to produce a homogeneous consistency with perfect properties. Therefore, the research goal is to scoop analysis about the momentary behavior of pasta dough inside the horizontal dough-mixer using the analysis methods and design of experiments in examining or achieving the temperature of water added (TW) and the mixer shaft turn number (N, rpm) on the dough qualities because the kneading process is affected by the raw and auxiliary materials used. The experiments were conducted in one of the pasta factories located at Dakahlia Governorate. The performance of the mixer kneading through the properties of dough moisture content and dough elasticity was identified. The concluded results were applied by the regression analysis at 37.8°C TW and the mixer shaft was adjusted to operate at 82.5±1.0 rpm. However the concluded suitable results by surface response system were 38.0°C and 80 rpm.

Keywords: Shaft rotation number, Horizontal-mixer, Quality, Kneading elasticity, Analysis methods

INTRODUCTION

The pasta-related industry has become the second-largest worldwide, followed by the bread industry (Heo et al., 2013). At least twelve percent of global wheat production is used for processing Asian Pasta products [Hou (2001) and FAO (2005)]. Widely, pasta is consumed due to its different types and recipes. Global consumption of pasta products has risen dramatically due to simple cooking methods. The main processes of making pasta are weighing the raw material, mixing the dough, resting the dough, covering the dough, and cutting the dough sheet into pasta threads [Cuq et al., (2002), Ren et al., (2012), Li et al., (2014), Hou (2020), Liu et al., (2021), and Iacovin et al., 2024)]. The short line in pasta production of the short cut-pasta takes about 3,0 h, while the long line to produce the long cut pasta and spaghetti which takes about 5.0 h in the production process (Bühler, www. buhlergroup. com.). Mixing process upshots has the highest impact on the subsequent processes and the quality of the final product. A good mixing effect is the basis for ensuring the production of noodles with stable quality (Li et al., 2012). During the formation of the dough structure, physicochemical processes of a very diverse nature develop (Bayramov and Nabiev, 2014). No one has studied the analysis of momentary behavior for pasta dough inside the mixer.

The mixing time ranges from 10 to 15 min (Hou, 2020) depending on the amount of water added (Liu et al., 2015). According the recommendation from (Gong et al., 2016) the temperature of added rater was around 50°C. The double-shaft of dough-mixer has a better effect of mixing because of the larger contact areas with the shaft. They also cleared that the optimum speeds of pin-shaped blade mixer were about 80 rpm (Bühler, 2011 and Liu et al., 2013). Thus, dough mixing control is the chief step in achieving superior efficiency in the noodle industry. Wheat flour is the primary raw material used to produce pasta. The flour quality is the primary factor determining pasta quality [Liu et al. (2015) and Cappelli et al. (2020)]. The protein content and quality of wheat are closely related to the quality of flour and its products. The percentage of protein content in flour varies greatly among different wheat varieties. The content of gluten is an important factor that determines the quality of protein. Its increase will improve the stability of dough quality, dough viscoelasticity, rubbery of dough and the processing quality of flour products [Kim et al., (2008) and Chen et al., (2020)]. Horizontal mixers are often used in noodle factories because they can carry out large-scale automatic noodle production and their mixing effect is better than that of vertical mixers (Fu, 2008). Accurate assessment of dough kneading is pivotal in pasta processing, where both under-kneading and over-kneading can detrimentally impact dough quality. The identification of this peak point enables the achievement of optimal dough consistency, thereby enhancing the overall quality of both the dough and subsequent pasta products. After the final product quality assessment (Wang et al., 2024). In the tests, they found that the higher protein and fiber in flour results in more water to obtain the perfect dough. Also, the flour extraction rate impacts the stability of dough in the direct relationship (Iacovin et al., 2024).

Therefore, the goal of our research is to use the methods of analysis and design of experiments in examining the analysis of momentary behavior for pasta dough inside the horizontal mixer, the quality of the dough product, and the importance of employing these methods in achieving the

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temperature of water adding and the number of mixture shaft revaluation on the dough qualities.

MATERIALS AND METHODS

The experiments were in one of the pasta factories located at Dakahlia Governorate in 2022-2023. The materials include the transactions affecting the dough mixer and pasta components.

The dough mixer

The horizontal dough mixer in short-line production is prepared for use in the experimental studies. The mixing hopper is made from stainless steel. The specification and structural diagram of dough mixer are in Figs (1 and 2). The dough mixer manufactured by BUHLER with a capacity of 2000 kg consists of two horizontal axises.

The main axes are about 127 mm in diameter and 6780 mm in length. The revolution of the axis can regulate to an up/down of 87 rpm. On each axis are supported 15 paddle arms in five groups (3 paddles in each one) at 45° on the circumference of the main shaft for each group. The paddle dimensions are 2145 × 150 × 10 mm in length, width and thickness. The power source of each axis is a motor with about 75 kW. The electrical motor of three-phase (380 voltage) and 50 HZ is located at the side of the dough mixer. The main parts and dimensions of the dough mixer are in Fig 2.

Fig. 1. The inside view of the dough mixer

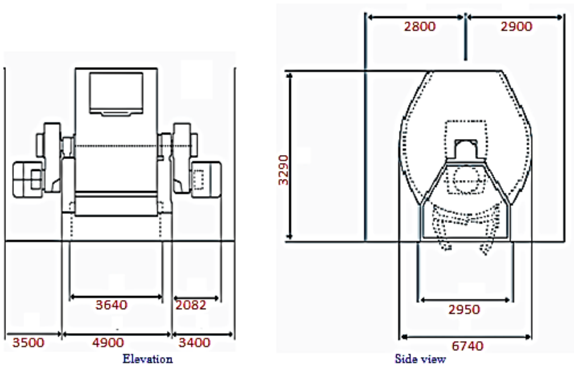

Fig. 1. The structural and dimensions of the horizontal dough mixer

Pasta components

a- The flour

The flour standard specification is 3418/2006. Its extraction rate does not exceed 72%, its moisture content does not exceed 14%, and its color must be natural, creamy yellow, non-smell, and free of impurities and foreign bodies.

b- The water

The water standard specification is 1589/2005. Water is used in the kneading process and it is used in hot form depending on the quality of the flour. It is free of impurities. The water adding temperature was about 37 °C.

Experimental Procedures

The pre-experimental tests were done to determine some of the components in the flour used for the five pasta types under study (Table 1).

Table 1. The flour components suitable for each type of pasta

Types of pasta "M"	Flour properties				
	M, %	P, %	G, %	A, %	I, %
Makossa "M1"	13.1	10	28	0.60	95
Elbow "M2"	14	12	26	0.53	94
Penn "M3"	15	13	27	0.4	93
Spiral "M4"	13	14	26	0.45	95
Sharia "M5"	13.8	13	29	0.50	92

N.B.:
M: Moisture content. P: Protein content. G: Glutamic content.
A : Ash content. I : Glutamic index.

The recommended amount of flour and water was adjusted to be added simultaneously in the dough mixer, as shown in Table 2 for each type of pasta (Buhler Company - Personal communication).

Table 2. The recommended amount of flour and water suitable for each type of pasta

Types of pasta "M"	Flour, kg	Adding water, %
Makossa "M1"	1600	24.8
Elbow "M2"	1500	27.9
Penn "M3"	1700	25.6
Spiral "M4"	1550	27.6
Sharia "M5"	1500	27.9

During the test, the dough was mixed for approximately 15 minutes. After 12 minutes of the mixing process, dough samples of 100g were taken from various positions in the mixer, resulting in 126 samples of each type. The samples were taken from the different positions of the dough mixer. The mixing dough was analyzed according to several variables. The studied variables of the mixing dough were:

1- Temperature of water added (TW) of about 33 to 38°C.
2- Mixing shaft rotation number (N) of about 80 to 86 rpm.

The experiment was conducted to assess the quality of the mixing production and dough qualities by identifying the best dough moisture content (DMC, %) and dough elasticity (KE, N/mm^2).

The samples were analyzed in the factory laboratory. The experimental tests include 42 tests in three replicates. The results of the laboratory analysis were statistically analyzed in the computer programs Excel as regression and Minitab as response surface methodology.

The measurements to determine the specifications of flour, water and dough according to the Draft Kenya Standard (2009) using the sensitive balance has an accuracy of ± 0.01 kg, and the moisture electronic device has an accuracy of ±0.05 to measure a quick moisture content. The device samples of about 5.0 g for flour and/or dough were tested. The device adjusts at a temperature of 135°C for 15 minutes. The elasticity device has an accuracy of ±0.05.

RESULTS AND DISCUSSION

Temperature of added water (TW, °C) via dough moisture content (DMC, %)

One of the minor treatments affecting kneading quality is the temperature of water added (TW, °C) during preparing the dough. Fig (2) indicates the two types of pasta having the approximately characteristic of dough (Makossa

"M1" and the Elbow "M2") operating under the number of mixer shaft revolutions of 83.5± 3.5 rpm. From the figure, increasing the water-added temperature (TW, ºC) decreases the dough moisture content (DMC) for both materials (M1 and M2) during the kneader process. The decreasing rate of DMC for M2 is much lower than for M1. It is regarding the inclination angle of the sloping curve for M2 being minor than for M1. Regarding Fig (2), the inclination angles are 30.15 and 20.17 degrees for M1 and M2, respectively, during increasing TW from 33 to 38ºC.

A simple polynomial regression analysis is applied for the relationships of the above treatments and the obtained regression equations were in the form of:

DMC, % = 0.074 (TW)^2 – 5.82 (TW) + 137.02 R^2 = 0.85 for M1 (1)

DMC, % = 0.045 (TW)^2 – 3.43 (TW) + 88.09 R^2 = 0.74 for M2 (2)

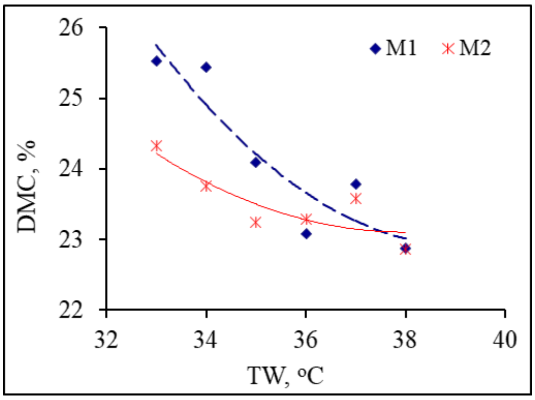

Fig. 2. Effect of TW°C on DMC for M_1 and M_2 doughs

By differentiating equations (1 and 2) and equaling the results to zero, the TW values are 39.32 and 38.11ºC for M1 and M2, respectively, recording the minimum DMC values of 23.08 and 22.86%. The intersection point for two curves lies in between the two above values. Regarding the graph, the intercept of the two curves is 37.8ºC TW and 23.1% DMC. This intersection point is the optimal position for operating the types M1 and M2 at the time without resetting the device programming.

Figs (3 to 5) indicate the three pasta types having the approximately characteristic of dough (Penne "M3", Spirals "M4", and Sharia "M5") affect the DMC under several mixer shaft turns of 83.5± 3.5 rpm. The effect of TW for three dough materials on the DMC represents the sin/cos relationships. Regarding the mathematical methods, the above relationship tends to sin/cos equation with the following shape;

$$\boldsymbol{DMC}\% = \boldsymbol{a}\cos[\,\boldsymbol{b}\,(\,\boldsymbol{x} - \boldsymbol{c}) + \boldsymbol{D} \qquad (3)$$

Where a = amplitude = $\frac{Max.-min}{2}$ c = phase shaft right or left D = is the vertical shaft

b = $\frac{2\pi}{period}$, and the period is the distance between the two consecutive topes.

Substituting equation (3) on the data at Figs (3 to 5), the constants of equation 3 are shown in the Table (3).

Table 3. The values constants of Eq 3 for M3, M4 and M5 pasta types

Pasta types	x	a	b	c	D
M3	TW	0.75	2π/3.9	0.6	0.50
M4	TW	0.65	2π/2.98	0.8	0.33
M5	TW	0.55	2π/2.79	0.9	0.28

Regarding Fig (3), increasing the TW of water added in a mixer increases the DMC, and the curve goes up until the maximum value of 24.7%. After that, the relationship inverses, and the curve decreases until the minimum value of 23.06%. Another side is that the above relation increases by increasing the TW temperature to 24.35 for M3. The above behaviors were the same for M4 (Fig 4) and M5 (Fig 5) dough materials take the above sequence but with different values.

At the end of the mixing operation, it is easy to see the mixture of flour and worm water at the end of mixing contains homogeneous dough moisture content. Other than it differs from one mixture to another. The steady states of DMC were 23.8%, 22.85%, 24.3%, 23.8, and 24.6% for M1, M2, M3, M4, and M5 respectively.

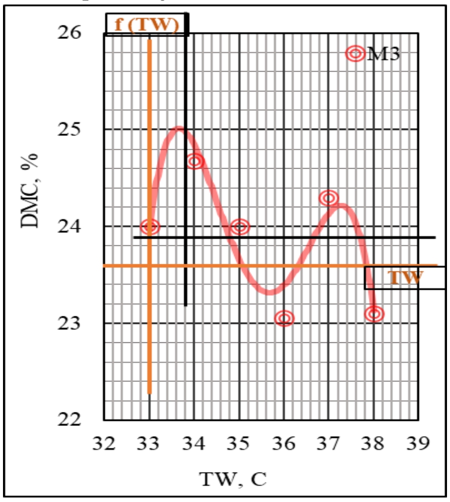

Fig. 3. The DMC, % Via TW, ºC

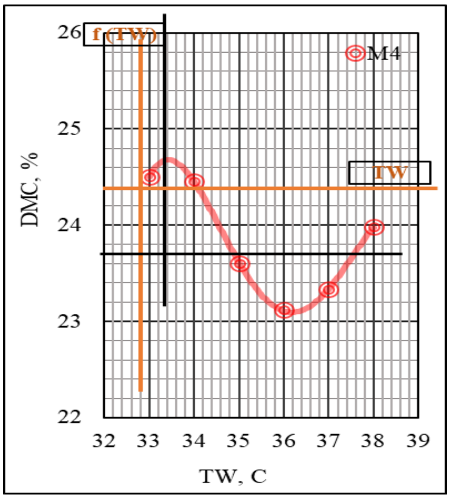

Fig. 4. The DMC, % Via TW, ºC

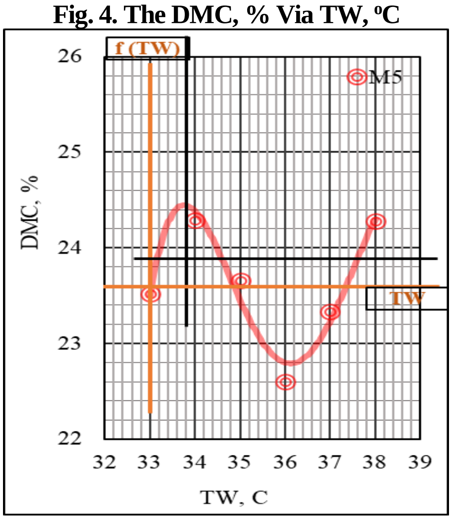

Fig. 5. The DMC, % Via TW, ºC

Temperature of added water (TW, ºC) via dough elasticity (*N/mm²*)

Fig (6) indicates the two types of pasta (Makossa "M1" and the Elbow "M2") for an average number of auger turns of 83.5± 3.5 rpm as the relationship between the TW, °C and the dough elasticity (KE, *N/mm²*). From the figure, increasing the water-added temperature slightly increases the dough elasticity until 79.9 *N/mm²*, then "KE" goes down to 78.7 *N/mm²*, and then the "KE" goes up to 80.12 N/mm² for Makossa dough (M1). Otherwise, for M2, increasing the water-added temperature from 33 to 37°C slightly increases the dough elasticity until 79.9 *N/mm²*, and then "KE" goes down to 78.3 *N/mm²*.

The changes in dough elasticity relate to the amount of warming water and the revolution shaft number of mixtures per time. The change in the degree values of the elasticity for the dough is due to the failure to complete mixing inside the mixer. The fluctuation in elasticity values should be uniform when the dough is transferred to the dryer unit.

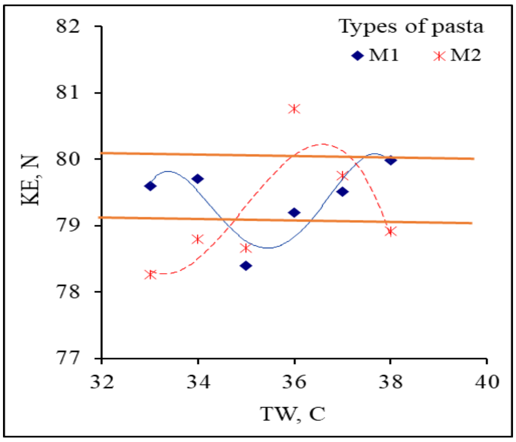

Fig. 6. The behavior of KE, *N/mm²*

Regarding Fig (6), there are two levels for the intersection of behavior curves between the two dough types of M1 and M2. The upper intersection level is at a water temperature of 37.5°C, producing a dough elasticity of 79.9 *N/mm²*. The lower intersection level is at 34.4°C for generating a dough elasticity of 79.0 *N/mm²*. From the above, it easy to save the energy used for heating added water to the dough process from 37.50°C to 34.40°C, as it achieves or reaches the same dough elasticity from 79.9 to 79.0 *N/mm²*.

As shown in Fig (7), the same trend for the above relationship was found at M3, M4, and M5 pasta types. Increasing the TW degree increases the dough elasticity until the maximum elasticity values, after that, they decrease until the minimum values and then go up. The max reversal point for curves of the above relation was 34 °C for M3, M4, and M5 types. Other side, the lowest reversal points were 36.2, 37.1, and 37.3 °C, respectively, for M3, M4, and M5. At TW of 34°C, the max dough elasticity recorded 80.7, 80.8, and 80.9 *N/mm²*, for M3, M4, and M5 pasta types, respectively. While, the lowest points of the elasticity relation were 78.02, 77.3, and 77.4 *N/mm²*, for TW of 33, 37, and 37.1°C, respectively.

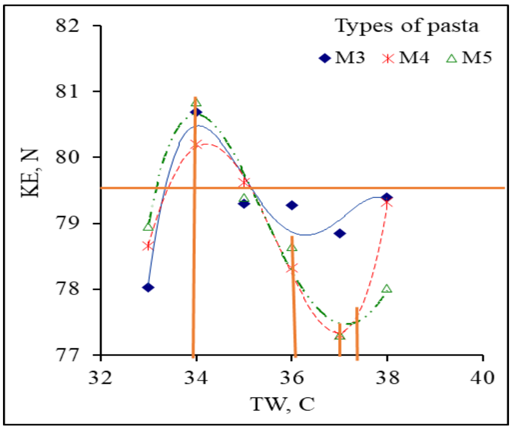

Fig. 7. The behavior of KE, *N/mm²*

The curve equations from the relationships between water-added temperature and dough elasticity as in Figs (6 and 7) are as follows:

$$KE = e\,TW^4 + f\,TW^3 + g\,KW^2 + h\,KW + i \quad (4)$$

The constants of equation (4) tabulates in Table (4).

Table 4. The values constants of Eq. 4 for M1, M2, M3, M4 and M5 dough types

Dough types	Variables	e	f	g	h	i	R^2
M1	TW	0.010	- 1.19	69.3	- 1765	16802	0.73
M2	TW	-0.06	8.48	- 451.04	10648	- 94079	0.78
M3	TW	-0.084	12.05	- 650.97	15615	- 140246	0.89
M4	TW	0.029	- 3.77	186.76	- 4076.9	33205	0.99
M5	TW	-0.029	4.28	- 239.34	5927.4	- 54813	0.95

The dough-mixer shaft rotation number (N, rpm) Via dough moisture content (DMC, %)

Fig (8) indicates the two types of pasta (Makossa "M1" and the Elbow "M2") as the relationship between the mixing shaft rotation number (N, rpm) and the dough moisture content (DMC, %) under the average temperature of water added (TW) of 35±1.5°C. From the figure, increasing the mixing shaft rotation number (N) slightly decreasing dough moisture until 23.8 % at 83 rpm, then DMC goes up to 24.8% at 87.5 rpm, for Makossa dough (M1). Otherwise, for M2, slightly decreasing dough moisture until 23.1 % at 83 rpm, then DMC goes up to 25.8% at 87.5 rpm. The decreasing rate of the DMC for pasta type M1 (0.9%) is nearly equal to the increasing rate (1.0%) On the other hand, the decreasing rate of the DMC for M2 type recorded the lowest values (0.2%) against the increasing rate (1.0%).

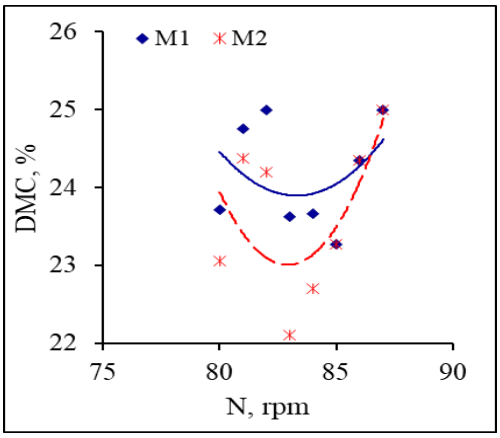

Fig. 8. Effect of N, rpm on M_1 and M_2 dough

As shown in Fig (9), the same trend for the above relationships were for M3, M4, and M5 pasta types under the average temperature of water added (TW, ºC) of 35±1.5°C. Increasing the mixing shaft rotation number (N) for the M3, from 80 to 83.2 rpm, decreases the dough moisture content from 25.2 to 23.8% values. After that, they increase until the maximum values of 25.7 % at 87.3 rpm.

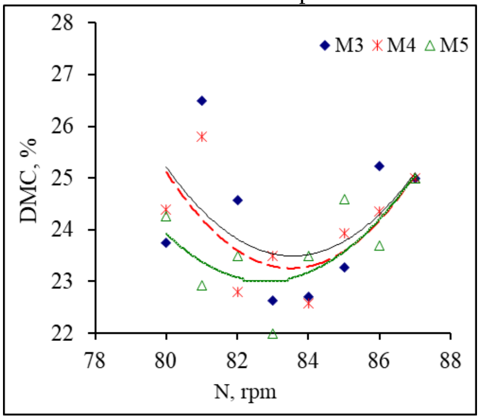

Fig. 9. Effect of N, rpm on M_3, M_4 and M_5

For M4, increasing the mixing shaft rotation number (N) from 80 to 83.4 rpm decreases the dough moisture content values from 25.1 to 23.2%. After that, they increase until the maximum values of 25.2 % at 87.3 rpm. The trend was for M5, which increases the mixing shaft rotation number (N) from 80 to 83 rpm, and dough moisture content decreases from 23.9 to 23%. After that, they increase until the maximum values of 25.2 % at 87.0 rpm. The variation of different values of mixing shaft rotation number (N) for M3, M4, and M5 is almost very close. Therefore, it may be recommended that the mixer shaft be adjusted to operate at 82.5±1.0 rpm.

The mixing shaft rotation number (N, rpm) Via dough elasticity (*N/mm^2*)

Fig (10) indicates the two materials of pasta (Makossa "M1" and the Elbow "M2") under the average temperature of water added (TW, °C) of 35±1.5°C as the relationship between the "N" and the dough elasticity "KE". Increasing the mixing shaft rotation number (N), the dough elasticity (KE) slightly decreases until 79.5 *N/mm^2*, then KE goes up to 80.6 *N/mm^2*, and then the KE goes down to 79.1 *N/mm^2* and retain to go up 82.9 *N/mm^2* for Makossa dough (M1). On the other hand, for M2, the same trend was found and the change values for M2 are very nearly for M1.

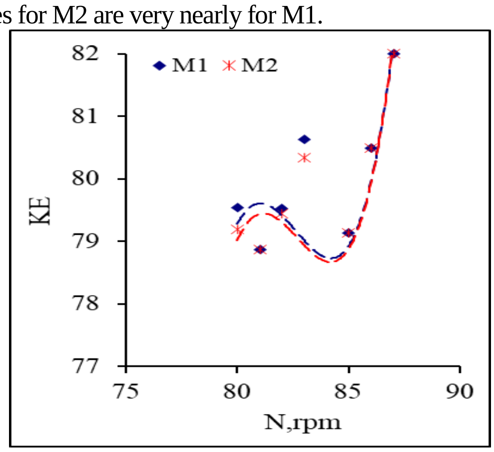

Fig. 10. The behavior of KE, *N/mm^2*

As shown in Fig (11), the same trend for the above relationship was for M3, M4, and M5 pasta materials. Increasing the mixing shaft rotation number (N, rpm) to 80 rpm decreases the dough elasticity until the maximum KE of 79.1 *N/mm^2* values. After that, they decrease until the minimum values and then go up. The max reversal point for curves of the above relation was 80 rpm for M3, M4, and M5 to79.1 *N/mm^2*.

Other side, the lowest reversal points were79.2 *N/mm^2* for M3, 79.1 *N/mm^2*for M4, and 79.2 *N/mm^2* for M5, respectively. At N of 82 rpm, the KE goes up to 79.5 *N/mm^2*, 79.9 *N/mm^2* for M3, M4 and then the KE goes down to78.4 *N/mm^2* for M5 pasta materials, respectively. While, the Max points of the KE relation was 80.4 *N/mm^2* forM3 to 83 rpm, and then the KE goes down to 78 *N/mm^2* to 83 rpm for M4, M5pasta materials, and the Max points of the KE of 82 *N/mm^2* for 87 rpm respectively, for M3, M4, and M5, respectively.

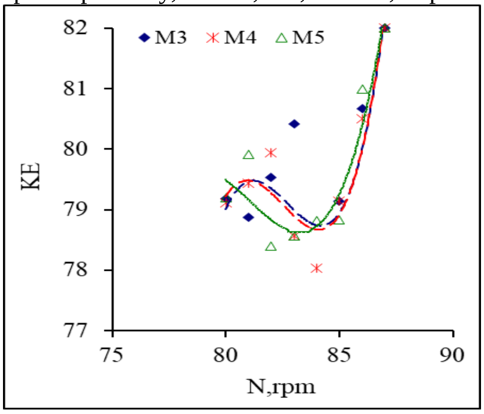

Fig. 11. The behavior of KE, *N/mm^2*

The combination effect of N, rpm and TW, °C on DMC and KE

The results of the combination factors analyzed using the Response Surface Methodology (Box–Behnken design) in the Mini-Tab program are illustrated in Figs (12 to 21). For the Maksosa dough (M1), Fig (12) indicates the behavior effect of a response surface for the effect of N, rpm, and TW, °C on the DMC, %. The maximum, minimum, and average of DMC were 27.4% (at 80 rpm and 38°C), 21.0% (at 87 rpm and 33°C), and 24.28% (at 83.5 rpm and 35.5°C), respectively. From the above analyses, the water-added temperature (TW, °C) is directly proportional to dough moisture content (DMC, %) and vice versa for increasing the mixing shaft rotation number (N, rpm). From Fig (13), the maximum, minimum, and average of KE were 81.8 N/mm^2 (at 83.5 rpm and 35.5°C), 77.0 N/mm^2 (at 83.5 rpm and 38°C), and 79.43 N/mm^2 (at 83.5 rpm and 35.5°C), respectively. So, under the same applied water temperature (TW, °C) and increasing the mixing shaft rotation number (N, rpm), the values of dough elasticity was decrease.

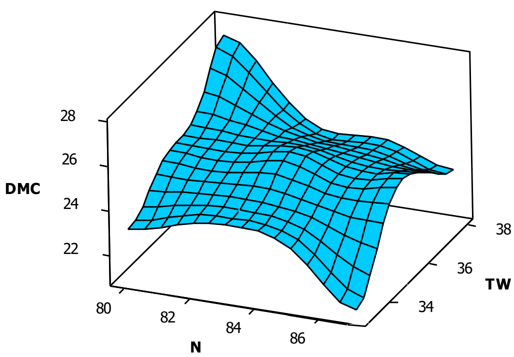

Fig. 12. The behavior of DMC, % Via "N" and TW

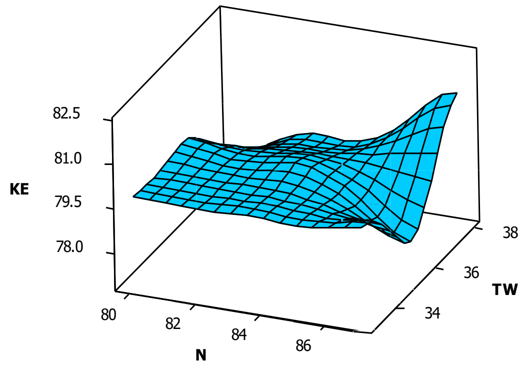

Fig. 13. The behavior of KE, N. mm^2 Via "N" and TW

For the Elbow dough (M2), Fig (14) indicates the behavior effect of a response surface for the effect of N, rpm, and TW, °C on the DMC, %. The maximum, minimum, and average of DMC were 27.0% (at 82.5 rpm and 35.5°C), 20.0% (at 82.5 rpm and 33°C), and 23.5% (at 82.5 rpm and 35.5°C), respectively. It means that increasing both of the water-added temperature (TW, °C) and N, rpm increasing the DMC, %. From Fig (15), the maximum, minimum, and average of KE were 81.8 N/mm^2 (at 82.5 rpm and 35.5°C), 77.0 N/mm^2 (at 82.5 rpm and 38°C), and 79.2 N/mm^2 (at 82.5 rpm and 35.5°C), respectively.

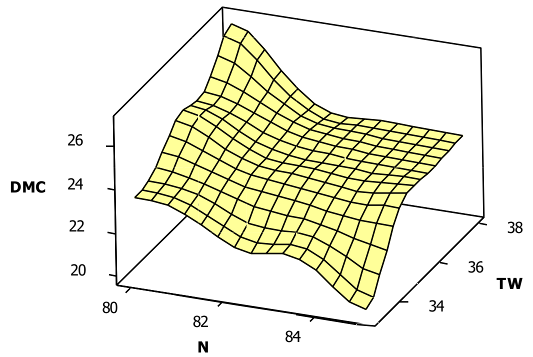

Fig. 14. The behavior of DMC, % Via "N" and TW for Elbow (M2)

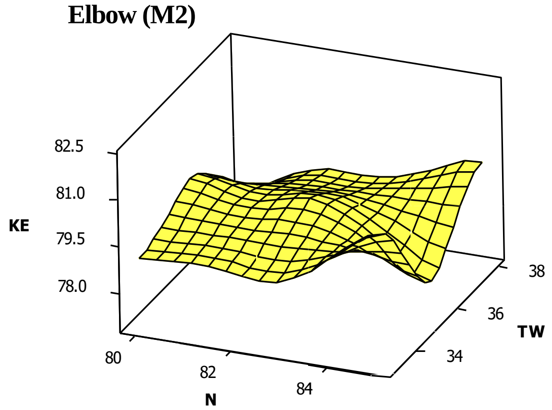

Fig. 15. The behavior of KE, N. mm^2 Via "N" and TW for Elbow (M2)

For the Penne dough (M3), Fig (16) indicates the behavior effect of a response surface for the effect of N, rpm, and TW, °C on the DMC, %. The maximum, minimum, and average of DMC were 28.6% (at 86 rpm and 35.5°C), 22.6% (at 83 rpm and 33°C), and 24.86% (at 82.5 rpm and 35.5°C), respectively. Otherwise, from Fig (17), the maximum, minimum, and average of KE were 83.0 N/mm^2 (at 83 rpm and 38°C), 76.8 N/mm^2 (at 80 rpm and 38 °C), and 79.24 N/mm^2 (at 82.5 rpm and 35.5°C), respectively. From the above results, at N of 80 rpm and TW at 38°C, maximum DMC with minimum KE was recorded.

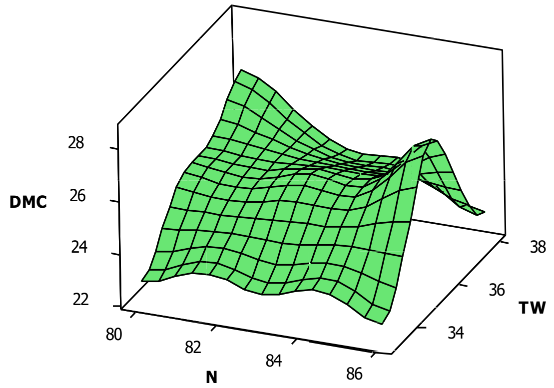

Fig. 16. The behavior of DMC, % Via "N" and TW for Penne (M3)

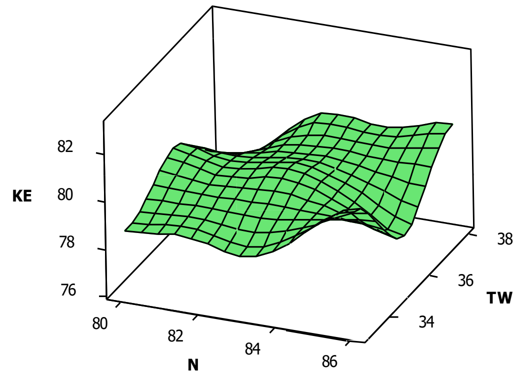

Fig. 17. The behavior of KE, N. mm^2 Via "N" and TW for Penne (M3)

For the Spirals dough "M4", Fig (18) indicates the behavior effect of a response surface for the effect of N, rpm, and TW, °C on the DMC, %. The maximum, minimum, and average of DMC were 28.6% (at 85 rpm and 35.5°C), 22.6% (at 82.5 rpm and 33°C), and 24.92% (at 82.5 rpm and 35.5°C), respectively. Otherwise, from Fig (19), the maximum, minimum, and average of KE were 83.0 N/mm^2 (at 82.5 rpm and 38°C), 76.0 N/mm^2 (at 80 rpm and 38 °C), and 79.17 N/mm^2 (at 82.5 rpm and 35.5°C), respectively. From the above results, at TW of 35.5°C and N of 85 rpm, the maximum of DMC is 28.6 % while, at the same TW, but with TW of 38 °C and N of 82.5rpm, the maximum of KE is 83 N/mm^2.

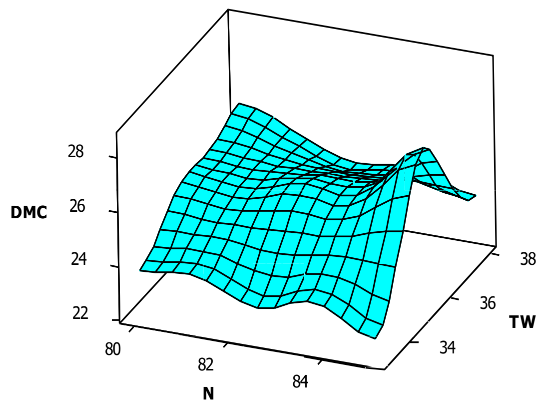

Fig. 18. The behavior of DMC, % Via "N" and TW for Spirals "M4"

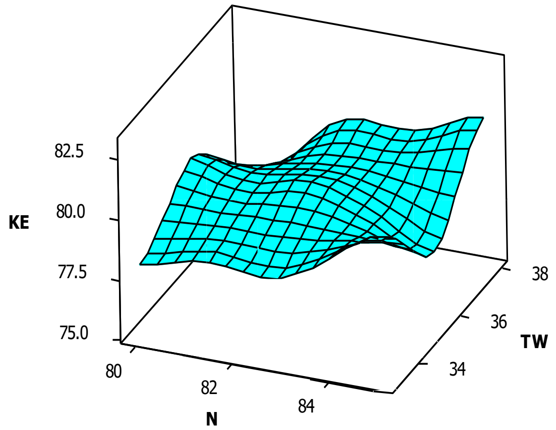

Fig. 19. The behavior of KE, N. mm^2 Via "N" and TW for Spirals "M4"

For the Sharia (M5), Fig (20) indicates the behavior effect of a response surface for the effect of N, rpm, and TW, °C on the DMC, %. The maximum, minimum, and average of DMC were 27.6 % (at 82.5 rpm and 35.5°C), 22.0 % (at 80 rpm and 33°C), and 24.25 % (at 82.5 rpm and 35.5°C), respectively. Otherwise, from Fig (21), the maximum, minimum, and average of KE were 83.0 N/mm^2 (at 82.5 rpm and 38.0 °C), 76.5 N/mm^2 (at 80 rpm and 38.0 °C), and 79.19 N/mm^2 (at 82.5rpm and 35.5 °C), respectively. From the above results, the TW of 35.50 °C is suitable, and the miner factor affects the performance of kneading dough.

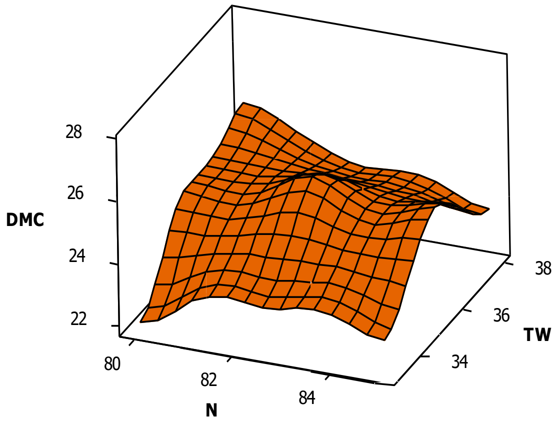

Fig. 20. The behavior of DMC, % Via "N" and TW for Sharia (M5)

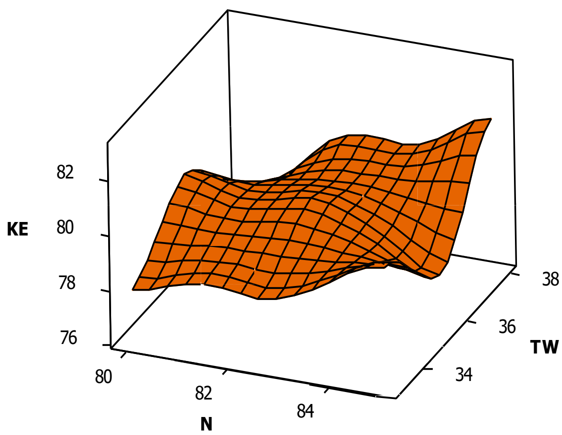

Fig. 21. The behavior of KE, N. mm^2 Via "N" and TW for Sharia (M5)

CONCLUSION

By comparing the results from using the regression analysis methods (ST1) and the using surface response system analysis (ST2), the best results were at 37.8 °C TW, and the mixer shaft was adjusted to run at 82.5 ± 1.0 rpm for ST1 and there was 38.0 °C and 80 N/mm^2 under ST2. The two analysis systems agreed that kneading dough performance is majorly influenced by the mixer shaft rotation numbers (N, rpm).

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تحليل السلوك اللحظي لعجينة المكرونة داخل الخلاط العجن

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الملخص

التنوع والجودة العالية في مجال تصنيع المكرونة يضمنان التطوير المستمر في الإنتاج. من أهم مراحل تصنيع المكرونة هي عملية العجن وهي المرحلة الأولى من الإنتاج والتي يتم من خلالها تحديد جودة التصنيع خلال المراحل الأخرى المتعاقبة. إن عملية الخلط الجيدة للمكونات تساعد في الحصول على عجينة المكرونة بقوام متجانس وخصائص مثالية. لذلك فإن هدف البحث هو تحليل السلوك اللحظي لعجينة المكرونة داخل خلاط العجين الأفقي باستخدام طرق التحليل وتصميم التجارب.وتم ذلك عند متغيرات دراسية لدرجة حرارة الماء المضاف (TW) وعدد لفات عمود الخلاط (N, rpm) لدراسة تأثيرهما على صفات العجين. أجريت التجارب بأحد مصانع المكرونة الموجودة بمحافظة الدقهلية. تم التعرف على أداء خلاط العجن من خلال تحديد خواص المحتوى الرطوبي والمرونة للعجين. وجدت أفضل النتائج مع تحليل الانحدار عند 37,8 درجة مئوية TW وعند ضبط عمود الخلاط ليعمل عند 82,5±1,0 دورة في الدقيقة. إلا أن أفضل النتائج التي تم التوصل إليها بواسطة نظام الاستجابة السطحية كانت عند 38,0 درجة مئوية و80 دورة في الدقيقة.