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EFFECT OF ENZYMATIC TEMPERING AND MILLING PROCESSES ON FLOUR YIELD AND CHARACTERISTICS OF AUSTRALIAN WHEAT GRADE

Abdalla M. Zain Eldin(1); M. Abd EL-Sattar Ahmed(2)*; Zienab R. Atia(2); Ahmed S. Abo-Donkol(3) and Mohamed S. Farag(2,4)

(1) Agricultural and Bio systems Engineering Department, Faculty of Agriculture, Alexandria University

(2) Crop Science Department, Faculty of Agriculture, Alexandria University.

(3) Chairman of Salah Abo-Donkol Companies.

(4) Post graduate student, Crop Science Department, Faculty of Agriculture, Alexandria University.

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ABSTRACT: The main objectives of this recent study were; to relate roller position, roller gap and tempering enzymes to flour yield and characteristics. Wet milling of wheat *(Triticum aestivum,* L.*)* represented by Australian commercial grade was included. Added enzymes were two levels; control, and hemicellulase + xylanase + fungal α-amylase. Results showed that, the highest significant values of wet gluten (%) were obtained with dull-to-sharp position and G_1 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (36.12%), while, the highest significant value of falling number (sec.) was obtained with dull-to-dull position and G_2 gap and no addition ($E_{0)}$ of enzymes (726.0 sec.). The highest significant values of extraction rate (%) was obtained with dull-to-dull and G_3 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (80.00%). The highest significant values of (FQN) were obtained with the combination of dull-to-sharp with G_2 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (369.0 mm). Meanwhile, the highest significant values of curve configuration ratio were presented with the combination of dull-to-dull with G_3 gap and no addition of enzyme (0.890). The highest significant values of loaf weight were obtained with dull-to-dull position, G_3 gap, and the addition of no enzyme (231.0 and 231.5 g, respectively). Also, the highest significant loaf volume (cm^3) was presented with dull-to-dull or dull-to-sharp, G_3 gap and adding (hemicellulase + xylanase + fungal α- amylase) enzymes (1475.0 or 1467.5 cm^3, respectively). The highest significant values of specific volume (cm^3/g) were presented with dull-to-dull position and adding (hemicellulase + xylanase + fungal α- amylase) enzymes and any of the studied gaps. The highest significant values of peak force were presented with the combination of dull-to-sharp position and five-days of storage time with addition or no addition of enzymes (759.9 and 765.3 g, respectively). Best-fit equations that related grain properties of Australian wheat grade, roller position, roller gap and tempering added enzyme to the out-come might be summarized as follow:

Extraction rate (%) R^2= 0.84

Y= - 427.216 + 6.567[Test weight (kg/h)] - 0.927[Particle size index (psi %)] -0.583[Tempering added enzyme] -1.894[First break position] -2.974[Roller gap (B1-B2-B3)]

Loaf volume (cm^3) R^2=0.78

Y= -13184.345+187.056[Test weight (kg/h)] -32.101[Particle size index (psi %)] +222.199[Tempering added enzyme] -190.579[First break position] +123.827[Roller gap (B1-B2-B3)]

Keywords: Enzymatic tempering, milling processes, flour yield.

INTRODUCTION

Milling is one of the oldest ways of food processing known to humankind. The techniques and tools used for milling have improved for centuries. Agricultural technology has changed drastically since its beginning and modern mills are highly elaborate machines *(*Revedin, 2010*).* So, milling is considered as an art. Unlike other

*Corresponding author: sattaralexun@yahoo.com

industries, where, the influence of various factors determining the dynamics of the process is well known, as the process is well described by equations and formulas that enable efficient sizing and operation of this equipment. The number of factors affecting milling quality and equally the quantity of finished products is extremely high. Often after the analysis of raw materials, the miller must adjust the entire plant according to his own intuition and ability, in order to obtain the best results in terms required by the expected quality of the finished product.

Wheat kernel structure broadly consists of three main constituents; endosperm, bran and germ. The endosperm, the major component, contains mainly starch granules embedded in a proteinaeous matrix and accounts for 81–84% of the grain. Germ amounts to 2–3% of the whole grain. The bran, outermost portion of grain forms 14–16% and contains the aleurone layer, which is the part of endosperm botanically is removed along with the bran during roller milling. Wheat is milled into the different finished products by roller milling method. Roller milling is a gradual control grinding process containing the break and reduction operation.

Conditioning is the addition of moisture to wheat, to modify its physical properties. The objective is to toughen the bran skin and mellow the endosperm. Conditioning time depends upon the structure of the kernel. Conditioning can be performed in two stages when higher water addition is required for optimum conditioning.

Roller mill machine consists of a pair of grinding cylindrical rolls, which rotates in the opposite directions. The roll surface can be smooth or fluted with grooves to produce cutting or shearing action. Roller milling process is traditionally used to fractionate wheat grain into bran, germ and different flour fractions. It is gradual grinding process, which involves break, open the grain and gradually scrapping the endosperm from the outer bran. The separated endosperm is further ground into flour. It is a gradual refining process, which includes grinding, sieving, purification and dusting operations.

The control of grinding parameters (roll gap and disposition) was noted more efficient in determining the particle size distribution of milling output. Equations had been used to reach the optimum particle size distribution through compilation of optimum roll-gap combination (Fistes *et al.,* 2017). Research and technical attempts in modifying milling techniques had resulted in developing novel milling methods that result in producing more consistent, high-quality flour that might be used for variance bakery products (Dziki, 2023).

The main objectives of the recent study were; to study the effect of tempering added enzymes, rolls position, and gap on milling out-come of Australian wheat grade. This approach was used to relate wheat grains physical properties (wheat grade) to optimum milling out- comes.

MATERIALS AND METHODS

The main objectives of this recent study were to relate wheat flour quality to rollers position, roller gap and added enzyme. Chemical analysis, rheological characters and pan-bread quality expressed wheat flour quality. Facilities of cereals quality lab of the crop science, department, Alexandria University and labs of quality control of the Arabian milling and food industries (Abo-Donkol) were used to carry-out this recent study. Studied treatments included two levels of roller position for first break represented by two levels; dull -to- dull and dull-to-sharp, three levels of roller gap and two levels of added enzyme ((E_0) no enzymes, (E_1) hemicellulase + xylanase + fungal α-amylase) (Table 1).

Table 1: Studied treatments

Code	Rollers position	Rollers gap	Added enzyme
T1	P_1	G_1	E_0
T2	P_1	G_2	E_0
T3	P_1	G_3	E_0
T4	P_1	G_1	E_1
T5	P_1	G_2	E_1
T6	P_1	G_3	E_1
T7	P_2	G_1	E_0
T8	P_2	G_2	E_0
T9	P_2	G_3	E_0
T10	P_2	G_1	E_1
T11	P_2	G_2	E_1
T12	P_2	G_3	E_1

P1: dull / dull, P2: dull / sharp, G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

Each treatment was applied to a sample of wheat weighted 50 tons. The milling process was controlled using an automatic program logic controller (PLC) system supplied by Buhler (Switzerland) mill at Arabian Milling and Food Industries Company, Alexandria, Egypt. The roller flour mill (Table 2) had five break rolls and eleven reduction rolls beside two additional reduction rollers (C10 and KLM) with 1100 flutes in circumference, and the capacity of the mill was 400 ton/day.

1. Physical analysis

Physical properties of the studied wheat grades (Table 3) were carried-out as follows;

1.1 Test weight; was determined according to AACC 2000 (method 55-10.01) after dockage was removed.

1.2 Specific volume; was determined according to AACC 2000 (method 55-50.01).

1.3 Impurities, shrunken and broken kernels, foreign material, insects test, total defects and cleaning test; were determined according to AACC 2000 (method 28-01-01).

1.4 Particle size index; hardness was determined according to AACCI 2000 (method 55-30, 01).

2. Chemical analysis

2.1 Moisture percentage; According to AACC-44-19.01, 1999.

2.2 Crude protein percentage; according to AACC.46-11.02,1999.

2.3 Ash percentage; according to AACC 08-01.01,1999.

3. Physio- chemical properties

3.1 Gluten content (%); According to AACC 38-12.02, 2000.

3.2 Falling Number (sec): AACC 56-81.03 Reapproval November 3, 1999.

4. Rheology characteristics

4.1 Farinograph; According to AACC 54-21.01.2000

4.2 Alveograph; According to AACC 54-30.02.2000

5. Extraction rate

The extraction rate of flour calculated automatically by milling scales as follows:

Extraction rate= (Weight of flour (kg) ⁄ weight of tempered wheat (kg)) ×100

Table (2). Gap (mm) between roller mills.

Treatment	Break stream					Reduction stream												
	B1	B2	B3	B4	B5	C1A	C2A	C1B	C2B	C3	C4	C5	C6	C7	C8	C9	C10	KLM
Dull –to -Dull	0.30	0.20	0.10	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50
	0.20	0.10	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50
	0.10	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50
Dull –to - Sharp	0.30	0.20	0.10	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50
	0.20	0.10	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50
	0.10	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0. 50

B: Break stage, C: Reduction Stag, C10 and KLM: additional reduction

Table 3: Physical characters and physio- chemical properties of the studied wheat grade.

Wheat grade	Australian wheat
Test weight (kg/h)	79.50±0.500
1000 kernel weight (g)	38.10±0.400
Single kernel	
Weight (mg)	38.00±0.100
Diameter (mm)	3.100±0.500
Length (mm)	6.100±0.500
Particle size index (psi)%	15.00±1.000 Hard
Dockage (%)	0.900±0.200
Damaged kernel (%)	0.500±0.200
Foreign material (%)	0.800±0.200
Shrunken & Broken (%)	0.800±0.500
Total defects (%)	3.000±1.000
Vitreous Kernels (%)	85.00±5.000
Moisture	11.00±0.300
Crud protein	17.60±0.300
Gluten content	37.70±0.600
Gluten index	73.00±7.000
Falling Number (sec)	510.0±20.00

±: stand for standard error.

6. Bread making

6.1 Pan-Bread

Pan-bread was prepared by mixing One kilogram of flour, 20gm active dry yeast, 80gm sugar and 5 gm sodium chloride. Were placed in the mixer and then mixed with water until optimum consistency was obtained. The dough was removed from the mixer and rounded, mounded and put in pan (6 * 8 * 21cm) lightly greased pan to prevent the sticking for resulted bread fermentation process was carried out for (60 min) through three consecutive stages at 45c°, 90 relative humidity. After proofing, the pans were placed in oven at 200 c° for 30 min.

6.2 Bread Loaf Specific Volume:

Each bread loaf was weighed in grams using analytical balance. Bread loaf volume was measured according to the rapeseed displacement method of measuring volume in cubic centimeters (cm^3) as described by the AACC approved method 10-05-01 (2011). Specific volume calculated as cm3/g by dividing the volume of the bread loaf by its weight.

6.3 Organoleptic evaluation of pan-bread

A panel of six judges evaluated the organoleptic characteristics of prepared breads. They assessed crust color, crumb color, flavor, texture, taste and overall acceptability, using a nine- point hedonic rating scale ranging from like extremely (9) to dislike extremely (1) for each characteristics as reported by Harinder *et al.*, *(*1999*)*. Key to bread score was liked extremely 9, liked moderately 7, neither like nor disliked 5, disliked moderately 3and disliked extremely 1. The overall acceptability score determined by summing the score for each characteristics and computing the average.

7. Crumb firmness

The crumb firmness or hardness was determined using texture analyzer perten instruments TVT type 6700 (Huddinge, Sweden). Texture profile analysis was carried- out in a single compression cycle using 25mm diameter stainless steel cylinder probe. Bread firmness and staling rate recorded by measure the hardness or force. Measurements (According to AACCI method 10-05, 01) of TVT (peak force) were taken in the first, second, third, fourth and fifth day.

Statistical analysis

Numerical data were transformed to fit normal distribution before analysis. Mstat-c program version (2.10) was used for data analysis. Data were statistically analyzed using the analysis of variance technique as a CRD design with four replicates. Means were compared using least significant difference test at 0.05 probability level ($L.S.D._{0.05}$) when F value was significant, according to Gomez and Gomez (1984). The results of the regression equation were statistically estimated by CoStat software (version 6.311).

RESULTS AND DISCUSSION

The main objectives of this recent study were; to relate wheat commercial grade, roller disposition, roller gap and added enzyme to flour yield and characteristics. Wet milling of wheat *(Triticum aestivum, L.)* represented by Australian commercial grade was included. Rollers position for first break represented by two levels, dull -to- dull and dull -to- sharp. Rollers gap was represented by three levels (G_1): B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, (G_2): B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, (G_3): B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm. Added enzyme represented by two levels (E_0) no enzymes, (E_1) hemicellulase + xylanase + fungal α-amylase.

1. Chemical analysis

Chemical analysis of Australian wheat grade included the determination of moisture (%), crude protein (%) and ash (%). Table (4), illustrated the analysis of variance of chemical analysis attributes as affected by roller position, roller gap and tempering added enzyme. Moisture (%), crude protein (%) and ash (%) were not affected by any of the studied factors or their interactions, except for, crude protein (%), had have significant affect by roller gap.

Table 4: Analysis of variance for chemical analysis of Australian wheat flour as affected by rollers position, rollers gap and tempering added enzyme.

S.O.V.	d.f.	M.S.		
		Moisture	Protein	Ash
Rollers position (P)	1	$0.025^{n.s.}$	$0.001^{n.s.}$	$0.004^{n.s.}$
Rollers gap (G)	2	$0.008^{n.s.}$	0.420^{**}	$0.002^{n.s.}$
P × G	2	$0.015^{n.s.}$	$0.116^{n.s.}$	$0.001^{n.s.}$
Added enzyme (E)	1	$0.025^{n.s.}$	$0.041^{n.s.}$	$0.001^{n.s.}$
P × E	1	$0.075^{n.s.}$	$0.068^{n.s.}$	$0.001^{n.s.}$
G × E	2	$0.001^{n.s.}$	$0.138^{n.s.}$	$0.001^{n.s.}$
P × G × E	2	$0.001^{n.s.}$	$0.031^{n.s.}$	$0.001^{n.s.}$
Error	36	0.030	0.067	0.001

*, **: indicates significance at 0.05 and 0.01 levels of probability, respectively.
n.s.: not significantly different.

Table (5), showed the main effects of roller position, roller gap and tempering added enzyme. Similar moisture percentages ranged between 14.01 and 14.06%. The highest value of protein (15.56%) was resulted with G_3 roller gap (B1, 0.1 mm; B2, 0.05 mm). Meanwhile, similar ash percentages ranged between 0.548 and 0.567 % were obtained.

Haros *et al.*, 2002. Studied the effect of carbohydrase treatment on four quality parameters during the tempering process and observed that enzymatic conditioning results in better moisture distribution inside the grain kernel. Moisture content, gluten index, color, and falling number decreased gradually with an increase in extraction rate versus, ash, crude fiber, and crude protein, wet and dry gluten. (Pang, *et al.*, 2021). The addition of combined enzymes cellulase, xylanase and pectinase to tempering water gave flour of higher protein content, no improvement in flour yield, no improvement in loaf volume, and an improvement in bread firmness (Yoo, *et al.*, 2009).

Table 5: Main effects of rollers position, rollers gap and tempering added enzyme for chemical analysis of Australian wheat flour.

Treatment	Moisture (%)	Protein (%)	Ash (%)
Roller position			
Dull -to-dull	14.01	15.37	0.567
Dull-to-sharp	14.05	15.37	0.550
$L.S.D._{0.05}$	n.s.	n.s.	n.s.
Roller gap			
G_1	14.01	15.30	0.548
G_2	14.02	15.26	0.561
G_3	14.06	15.56	0.567
$L.S.D._{0.05}$	n.s.	0.186	n.s.
Added enzyme			
E_0	14.05	15.40	0.562
E_1	14.01	15.34	0.555
$L.S.D._{0.05}$	n.s.	n.s.	n.s.

E_0: control, E_1: hemicellulase + xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

2. Physio-chemical properties

Wet gluten (%) and falling number (sec.) responses to the interaction among roller position × roller gap × tempering added enzyme were presented in Table (6). The highest significant values of wet gluten (%) were obtained with dull-to-sharp position and G_1 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (36.12%), while, the highest significant value of falling number (sec.) was obtained with dull-to-dull position and G_2 gap and no addition (E_0) of enzyme (726.0 sec.).

Table 6: Means of physio-chemical properties of Australian wheat as affected by the second order interaction among rollers position, rollers gap and tempering added enzyme.

Rollers position	Rollers gap	Wet gluten (%)		Falling number (sec)	
		E_0	E_1	E_0	E_1
Dull-to-dull	G_1	34.52	34.65	701.5	645.5
	G_2	34.60	34.75	726.0	641.0
	G_3	34.62	34.87	715.7	631.7
Dull-to-sharp	G_1	35.35	36.12	595.7	724.0
	G_2	35.32	35.97	589.5	696.7
	G_3	35.85	35.77	605.7	662.7
$L.S.D._{0.05}$		0.244		10.29	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

Reducing the particle size, significantly increased the damaged starch content, strengthen the gluten network, decreased loaf volume, and hardness of loaves (Pang *et al.*, 2021). In terms of whole- wheat flour quality, smaller particles (ranged from 115 to 258µm), exhibited higher water absorption and a greater contribution to damaged starch (Avarzed, and Kweon, 2023).

Commonly: the highest significant values of wet gluten (%) were obtained with dull-to-sharp position and G_1 gap and addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (36.12%). The highest significant values of falling number (sec.) were obtained with dull-to-dull position and G_2 gap and no addition of enzyme (726.0 sec.).

3. Extraction rate

Flour extraction rate is a measure of the percentage of the grain that is made into flour during the milling process. The extraction rate of flour calculated scales as follows:

Extraction rate = Weight of flour ⁄ weight of tempered wheat ×100.

Extraction rate (%) response to the interaction among roller position × roller gap × added enzyme was presented in Table (7). The highest significant values of extraction rate (%) was obtained with dull-to-dull and G_3 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (80.00%). Whereas, the least significant values of extraction rate (%) was obtained with dull-to-sharp and G_1 gap and no addition of enzyme (E_0) (70.80%).

Table 7: Means of flour extraction rate of Australian wheat as affected by the second order interaction among rollers position, rollers gap and tempering added enzyme.

Rollers position	Rollers gap	Extraction rate (%)	
		E_0	E_1
Dull-to-dull	G_1	75.07	73.42
	G_2	78.90	75.50
	G_3	79.47	80.00
Dull-to-sharp	G_1	70.80	76.47
	G_2	74.82	77.62
	G_3	78.40	78.37
$L.S.D._{0.05}$		0.739	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.

G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

Milling a mixture of small and large kernels in a roller mill reduces the flour yield because roll gap settings cannot be optimized for either the small or large kernels (Gaines *et al.*, 1997). Small-sized kernels are often considered to have lower potential flour yield, and these kernels have inferior milling properties. Therefore, the more uniform the kernel size, the more effective the mill pass will be (Gaines *et al.*, 1997). Ideally, the gap between the break rolls should be set for the average kernel size. Inamder and suresh, 2014, explained wheat grain components as three parts; endosperm, bran, and germ. About 81-84% of grain is represented by proteinaeous matrix filled with starch granules. 2-3% represents germ that includes embryo and scutellum. Outer-layers includes aleurone and other bran layers represents 14-16%. Rakszegi *et al.*, 2000, grains of harder endosperm produce higher flour extraction rate. Hoseny, 2010, reached that flour quantity and quality depends on type of grains (variety) of wheat, the nature of grinding equipment (rolls) and details of conditioning before milling. Enzymes addition to tempering water (arabinase, celluase, β-glucanase, hemicellulase, xylanase and a fungal α-amylase) independently of working temperature increased the percentage of fine particles and showed that, enzymatic preparation gave a further increase in fine fraction leading to higher milling yield (Gruppi, *et al.*, 2017). Jha, *et al.*, 2020, used cellulase, xylanase, and pectinase in wheat tempering process. An improvement in flour yield with enzymatic tempering had reached about four percent. Use of enzymes at the stage of flour production (milling), has the advantage of adjusting dough properties, nutritional value of flour, and quality indicators of flour. The functional properties of flour obtained on different steps of milling process depends up on the grain-part from which it has been extracted depending on the type of grinding rolls, particle size, starch damage, protein content, fat content, and ash content, the recommended level of tempering enzyme might be advised (Zhygunov *et al.*, 2019). Enzymatic conditioning was used to improve extraction rate and reduced fiber content of flour (Attia and obaid, 2023). Cellulase was added at rates of 24, 60, 0r 96 units/100gm of wheat. Overall, enzymatic conditioning levels, an increase in extraction rate was achieved relative to control (74.6 vs. 70.0% for the former and the latter, respectively).

4. Rheology characteristics

4.1 Farinograph parameters

The farinograph measurements, included, development time (DDT), water absorption(W), stability (S), degree of softening (10min after beginning) (Ds), degree of softening (ICC / 12 min after max.) (Ds (ICC)) and farinograph quality number (FQN). The second order interactions among roller position, roller gap and tempering added enzyme were presented in Table (8). The highest significant values of (Ds) were obtained with the combination of dull-to-dull position with G_3 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (83.00 FE), whereas, the least significant values of (Ds) were obtained with the combination of dull-to-sharp with G_1 gap and any of the addition or no addition of enzyme (3.000 FE), While, the highest significant values of (FQN) were obtained with the combination of dull-to-sharp with G_2 gap and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (369.0 mm).

Table 8: Means of Farinograph parameters of Australian wheat as affected by the second order interaction among rollers position, rollers gap and tempering added enzyme.

Rollers position	Rollers gap	Ds (FE)		FQN (mm)	
		E_0	E_1	E_0	E_1
Dull / Dull	G_1	19.00	19.00	120.0	114.0
	G_2	14.00	44.00	109.0	89.00
	G_3	45.00	83.00	76.00	84.00
Dull / Sharp	G_1	6.000	24.00	133.0	109.0
	G_2	3.000	3.000	140.0	269.0
	G_3	30.00	10.00	146.0	160.0
$L.S.D._{0.05}$		11.26		46.51	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

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 characters of dough weakening were reduced. Extensograph parameters were reduced with increase in extraction rate. (Pang *et al.*, 2021). Dough development time, used as an indicator of mixing requirements, the farinograph at which the dough reaches maximum consistency. In cereal technology, wheats that have long dough-development time considered strong (Bushuk *et al.*, 1969). The variation in dough rheology and bread making performance between wheat cultivars largely determined by differences in protein quantity and composition (MacRitchie, 1992). Dough development time and stability value are indicators of the flour strength, with higher values suggesting stronger doughs (Wang *et al.*, 2002). Some common predictor of dough strength include gluten index and empirical rheological tests such as farinograph and alveograph provide some information on dough extensibility as well as on overall strength (Carson and Edwards, 2009). α-amylase addition to tempering water, had a significant effect on dough development and gassing power parameters during proofing (Sanz Penella *et al.*, 2008).

4.2 Alveograph parameters

Results of alveograph measurements, included maximum over pressure (P), average abscissa at rupture (L), deformation energy of dough (W), curve configuration ratio (P/L) and elasticity index (Ie). Means of average abscissa at rupture and curve configuration ratio as affected by the second order interaction among roller position, roller gap and added enzyme were illustrated in Table (9). The highest significant values of average abscissa at rupture were presented with the combination of dull-to-sharp position with G_1 gap and the addition of enzyme (205.0mm), While, the least value of average abscissa at rupture was that expressed by the combination of dull-to-dull with G_3 and no addition of enzyme (95.00 mm). Meanwhile, the highest significant values of curve configuration ratio were presented with the combination of dull-to-dull with G_3 gap and no addition of enzyme (0.890).

Table 9: Means of Alveograph parameters of Australian wheat as affected by the second order interaction among rollers position, rollers gap and added enzyme.

Rollers position	Rollers gap	L (mm)		P/L (mm/mm)	
		E_0	E_1	E_0	E_1
Dull-to-dull	G_1	153.0	152.0	0.560	0.570
	G_2	131.0	117.0	0.590	0.710
	G_3	95.00	159.0	0.890	0.480
Dull-to-sharp	G_1	173.0	205.0	0.520	0.430
	G_2	170.0	140.0	0.530	0.800
	G_3	191.0	149.0	0.430	0.690
$L.S.D._{0.05}$		52.47		0.206	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

Increasing extraction rate of produced flour up to 92% with adding fine particle size bran had no significant effect on the rheological properties of the produced flour compared to 80% extraction rate (Alhendi *et al.*, 2021). Particle size influences flour starch, protein, and rheological properties of dough (Tian *et al.*, 2022). The latter process might help effective transport of enzyme to the aleurone-endosperm interface. Moderately positive results in term of straight-flour yield with similar protein and flour color were obtained from enzyme tempering (Lamsal *et al.*, 2009). size of flour particle had significant effect on elasticity of dough (Ma *et al.*, 2020).

5. Physical properties of pan-bread

Physical properties of pan-bread included the determination of loaf weight (g), loaf volume (cm^3), and specific volume (cm^3/g). Means of loaf weight (g), loaf volume (cm^3) and specific volume (cm^3/g) as affected by the interaction among rollers position × rollers gap × tempering added enzyme were presented in Table 10. The highest significant values of loaf weight were obtained with dull-to-dull position, G_3 gap, and the addition of no enzyme (231.0 and 231.5 g, respectively). The highest significant loaf volume (cm^3) was presented with dull-to-dull or dull-to-sharp, G_3 gap and adding (hemicellulase + xylanase + fungal α- amylase) enzymes (1475.0 or 1467.5 cm^3, respectively). The highest significant values of specific volume (cm^3/g) were presented with dull-to-dull position and adding (hemicellulase + xylanase + fungal α- amylase) enzymes and any of the studied gaps.

Table 10: Means of physical properties for pan-bread of Australian wheat grade as affected by the second order interaction among rollers position, rollers gap and tempering added enzyme.

Rollers position	Rollers gap	Loaf weight (g)		Loaf volume (cm^3)		Specific volume (cm^3/g)	
		E_0	E_1	E_0	E_1	E_0	E_1
Dull-to-dull	G_1	232.2	223.2	1310.0	1415.0	5.643	6.340
	G_2	229.0	227.7	1370.0	1415.0	5.983	6.213
	G_3	231.5	231.0	1375.0	1475.0	5.937	6.388
Dull-to-sharp	G_1	226.2	258.2	1002.5	1442.5	4.430	5.585
	G_2	222.5	257.5	997.5	1435.0	4.480	5.570
	G_3	223.7	256.0	1005.0	1467.5	4.490	5.735
$L.S.D._{0.05}$		2.980		21.24		0.120	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

The effect of different milling processes on the quality of pan bread, the straight dough process was performed in pan bread Curie *et al.*, (2002). The volume and height of whole wheat bread from smaller particle size were superior, confirming the influence on bread quality (Avarzed, and Kweon, 2023). Small particles size had better gluten forming capabilities. Loaf volume and height made from small particle sizes were superior to large particle size (Avarzed and Kweon, 2023).

6. Freshness of pan-bread

The ability of bread to be stored with no stalling was measured as one of the most important factors for indicating the keeping quality of the resulted product. Pan-bread was stored for one, three and five days at room temperature. Means of bread freshness as affected by the second order interaction among rollers gap, storage time and added enzyme were illustrated in Table (11). The highest significant values of peak force were presented with the combination of G_1 gap and five-days of storage time with addition of enzymes (780.9 g,). While, the least value of peak force was accompanied with the combination of G_2 gap and one-day storage and the addition of E_1 (hemicellulase + xylanase + fungal α- amylase) enzyme (247.6g).

Size of flour particle had significant effect on firmness (Ma *et al.*, 2020). Research and technical attempts in modifying milling techniques had resulted in developing novel milling methods that result in producing more consistent, high-quality flour that might be used for variance bakery products (Dziki, 2023). The addition of combined enzymes cellulase, xylanase and pectinase to tempering water gave flour of higher protein content, improvement in bread firmness (Yoo *et al.*, 2009). Hill and schooneveld-Bergmaus, 2004, stated that, the addition of cellulase and cellobiohydrolyase to fungal and bacterial endoxylauase enzymes improved the tempering process. Cellulases open and break down cellulase, which inter twined with the arabinoxylan polymer, resulted in helping the endoxylanase activity. Such synergistic effect had a positive influence on bread volume and crumb softness.

Table 11: Means of freshness of pan bread of Australian wheat as affected by the second order interaction among storage time, rollers gap and tempering added enzyme.

Storage	Rollers gap	Peak force	
		E_0	**E_1**
1day	G_1	323.4	253.6
	G_2	223.2	247.6
	G_3	233.9	295.6
3days	G_1	359.1	627.2
	G_2	470.1	503.0
	G_3	407.5	489.7
5days	G_1	726.4	780.9
	G_2	740.7	733.4
	G_3	663.7	694.4
$L.S.D._{0.05}$		92.19	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

7. Sensory evaluation of pan-bread

Sensory evaluation of pan-bread included crust color, crumb color, flavor, texture, taste and overall acceptability. Response of texture and overall acceptability to rollers gap × added enzyme interaction was presented in Table 12. The highest significant texture and overall acceptability value was obtained with G_3 gap and addition of (E_1) enzyme (8.500 and 8.666, respectively).

Table 12: Means of sensory evaluation of pan-bread made from Australian wheat flour as affected by the interaction between rollers gap and tempering added enzyme.

Roller gap	Texture		Overall acceptability	
	E_0	**E_1**	**E_0**	**E_1**
G_1	7.417	7.500	7.033	7.500
G_2	6.583	8.167	6.617	8.300
G_3	6.167	8.500	6.733	8.666
$L.S.D._{0.05}$	0.317		0.200	

E_0: control, E_1: Hemicellulase + Xylanase + fungal α- amylase.
G_1: B1, 0.3 mm; B2, 0.2 mm; B3,0.1 mm, G_2: B1,0.2 mm; B2, 0.1 mm; B3, 0.05 mm, G_3: B1,0.1 mm; B2, 0.05 mm; B3, 0.05 mm.

Treating wheat kernels during tempering by enzymes, such as; cellulase, xylanase, and β-glucanase, had a positive effect on improving final products quality. Bread quality characters represented by volume, crumb and firming are major affected quality characters. Although of that, enzymes addition to tempering water has been less studied. Best-fit equations that related grain properties of Australian wheat grade, roller position, roller gap and tempering added enzyme to the out-come might be summarized as follow:

Extraction rate (%) R^2= 0.84

Y= - 427.216 + 6.567[Test weight (kg/h)] - 0.927[Particle size index (psi %)] - 0.583[Tempering added enzyme] -1.894[First break position] -2.974[Roller gap (B1-B2-B3)]

Loaf volume (cm^3) R^2=0.78

Y= -13184.345+187.056[Test weight (kg/h)] -32.101[Particle size index (psi %)] +222.199[Tempering added enzyme] -190.579[First break position] +123.827[Roller gap (B1-B2-B3)]

The major objectives of enzymes use are improving milling and baking performance (Haros *et al.*, 2002, and Yoo *et al.*, 2009). Hill and schooneveld-Bergmaus, 2004, stated that, the addition of cellulase and cellobiohydrolyase to fungal and bacterial endoxylauase enzymes improved the tempering process. Cellulases open and break down cellulase, which inter twined with the arabinoxylan polymer, resulted in helping the endoxylanase activity. Such synergistic effect had a positive influence on bread volume and crumb softness. Enzyme addition to tempering water might be accomplished by scarifying kernels before enzyme application. Addition of xylanase enzyme to tempering water gave a positive impact on dough rheology characters and bread sensory evaluation attributes (Ahmad *et al.*, 2013).

REFERENCES

Ahmad, Z.; · Butt, M.S.; Ahmed, A. and Khalid, N. (2013). Xylanolytic Modification in Wheat Flour and its Effect on Dough Rheological Characteristics and Bread Quality Attributes. J. Korean Soc Appl Biol Chem. 56: 723−729 DOI 10.1007/s13765-013-3132-7.

Alhendi, A.S.; Ahmed, Z.A.; Hussein, M.S. and Abed, S.A. (2021). Large-scale industry mill: effect of extraction rate of flour on the dough rheological properties. Food Research, 5 (4): 80–85.

American Association of Cereal Chemists AACC. (1999). Approved Method of American Association of Cereal Chemists. Published by American Association of Cereal Chemists, Inc. St., Paul, Minnesota, USA.

American Association of Cereal Chemists AACC. (2000). Approved Method of American Association of Cereal Chemists. Published by American Association of Cereal Chemists, Inc. St., Paul, Minnesota, USA.

Attia, E.T. and Obaid, A.A. (2023). The effect of enzymatic tempering of wheat on the extraction rate and the quality of the resulting flour. J. bionatura; 8(3)41. http://dx.doi.org/10.21931/rb/css/2023.08.03.41.

Avarzed, E. and Kweon, M. (2023). Combined Effects of Particle Size and Dough Improvers on Improving the Quality of Purple-Colored Whole Wheat Bread. Foods, 12: 2591. https://doi.org/10.3390/ foods12132591.

Bushuk, W.; Briggs, K. G. and Shebeski, L. H. (1969). Protein quantity and quality as factors in the evaluation of bread wheats Canadian Journal of Plant Science (49)2P:113-122.

Carson, R. G. and Edwards, M. N. (2009). Criteria of wheat and flour quality. Wheat: chemistry and technology. AACC international Inc. Fourth edition p: 97-108. ISBN: 978-1-891127-55-7.

Curie, D.; Dugum, J. and Bauman, I. (2002). The influence of fungal amylase supplementation on amyl lytic activity and baking quality of flour. International Journal of Food Science and Technology, 37: 673–680.

Dziki, D. (2023). The latest innovations in wheat flour milling. Agricultural Engineering, 27(1): 147-162.

Fistes, A.; Rakic, D.; Đuro Vukmirovic, D. and Bojanic, N. (2017). The possibilities of wheat roller milling optimization using the response surface methodology. Journal on Processing and Energy in Agriculture. Journal on Processing and Energy in Agriculture. Biblid: 1821-4487 (2017) 21(2): 118-123.

Gaines, C. S.; Finney, P. L. and Andrews, L. C. (1997). Influence of kernel size and shriveling on soft wheat milling and baking quality. Cereal Chem. 74; 700-704.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons, New York, 680 p.

Gruppi, A.; Garrido, G. D.; Dordoni, R.; De Faveri, D.M. and Spigno, G. (2017). Enzymatic Wheat Conditioning. Chemical Engineerin VOL. 57, ISSN 2283-9216.

Harinder, K.; Kaur, B. and Sharma, S. (1999). Studies on the baking properties of wheat: pigeon pea flour blends. Plant Foods for Human Nutrition, 54: 217-226.

Haros, M.; Rosell, C.M. and Benedito, C. (2002). Improvement of four quality through carbohydrase treatment during wheat tempering. J. Agric. Food Chem. 50: 4126-4130.

Hille, J. D. R. and Schooneveld-Bergmans, M. E. F. (2004). Hemicelluloses' and their synergism in breadmaking. Cereal Food World. 49(5): 283-286.

Hoseney, R.C. (2010). Principles of Cereal Science and Technology. 3rd ed. AACC, pp. 110–118.

Inamdar, A.A. and Suresh, D.S. (2014). Application of color sorter in wheat milling. International Food Research Journal, 21(6): 2083-2089.

Jh, A.; Baruah, K.N. and Tripathy, P.P. (2020). Influence of enzymatic tempering on milling characteristics, four quality, crystallinity and microstructure of wheat Journal of Food Measurement and Characterization; 14:1986–1997.

Lamsal, B.P. and Faubion, J.M. (2009). Effect of an enzyme preparation on wheat flour and dough color, mixing, and test baking. LWT-Food Sci. Technol. 42: 1461.

Ma, S.; Wang, C.; Li, L. and Wang, X. (2020). Effects of particle size on the quality attributes of wheat flour made by the milling process. Cereal Chemistry, 97: 172–182.

MacRitchie, F. (1992). Physico-chemical properties of wheat proteins in relation to functionality. Advances in Food and Nutrition Research 36: 1–87.

Pang, J.; Guan, E.; Yang, Y.; Li, M. and Bian, K. (2021). Effects of wheat flour particle size on flour physicochemical properties and steamed bread quality. Food Science & Nutrition, 9, 4691–4700.

Rakszegi, M.; Juhász, A.; Láng, L. and BedőZoltán. (2000). Rheological properties of wheat varieties with different endosperm structures. J. Novenytermeles. 49(6): 599-606.

Revedin A. 2010. Thirty thousand-year-old evidence of plant food processing. Proc. Nat Acad. Sci. USA 107. (18): 815 – 819. (doi:10.1073/pnas. 1006993107).

Sanz Penella. J.M.; Collar, C. and Haros, M. (2008). Effect of wheat bran and enzyme addition on dough functional performance and phytic acid level in bread. Journal of Cereal Science. 48(3): November 715-721. https://doi.org/10.1016/j.jcs.2008.03.006.

Tian, X.; Sun, B.; Wang, F.; Ma, S.; Gu, Y. and Qian., X. (2022). Particle size distribution control during wheat milling: nutritional quality and functional basis of flour products—a comprehensive review. International Journal of Food Science and Technology, 57: 7556–7572.

Wang, J.; Rosell, C. M. and Benedito, B. C. (2002). Effect of the addition of different fibers on wheat dough performance and bread quality. Food Chemistry, 79: 221–226.

Yoo, J.; Lamsal, B. P.; Haque, E. and Faubion, J. M. (2009). Effect of enzymatic tempering of wheat kernels on milling and baking performance. Cereal Chemistry, 86: 122–126. (https://doi.org/10.1094/ CCHEM-86-2-0122).

Zhygunov, D.; Marchenkov, D. and Lebedenko, T. (2019). Adjusting flour quality by enzymes: current state, problem analysis, future development prospects. Food Science and technology. 13 (2): 24-33. Doi: http:// dx.doi.org/10.15673/fst.v13i2.1380.

تأثير التكييف الانزيمى وعملية الطحن على محصول الدقيق ومواصفاته لرتبة القمح التجارية الاسترالى

عبد الله مسعد زين الدين(١)، محمد عبد الستار احمد(٢)، زينب رافت عطيه(٢)، احمد صلاح ابو دنقل(٣)، محمد سعد فرج(٤)

(١) كلية الزراعة (الشاطبى) قسم الهندسة الزراعية و النظم الحيوية - جامعة الاسكندرية

(٢) كلية الزراعة (الشاطبى) قسم علوم المحاصيل - جامعة الاسكندرية

(٣) رئيس مجلس ادارة شركات صلاح أبودنقل

(٤) طالب دراسات عليا - كلية الزراعة (الشاطبى) قسم علوم المحاصيل - جامعة الاسكندرية

الملخص العربى

تعد الأهداف الرئيسية لهذه الدراسة هو ربط درجة القمح التجارية و أوضاع الدرافيل (الدشة الأولى) المسافة بين الدرافيل و الترطيب بإنزيمات بإنتاج الدقيق وخصائصه. تضمن الطحن الرطب للقمح الدرجات التجارية الاسترالي. تم تمثيل وضع الدرافيل بمستويين و المسافة بين الدرافيل ثلاث مستويات. و الإنزيمات المضافة لماء الترطيب ذات مستويين؛ عدم اضافة و اضافة مخلوط، هيميسيلوليز + زيلاناز + ألفا أميليزالفطرى . سجلت أعلى قيمة معنوية للجلوتين الرطب (٣٦,١٢%) عند وضع الدرافيل ظهر على سن و مسافة بين الدرافيل G_1 وإضافة إنزيم (هيميسيلولاز + زيلاناز + فطر ألفا أميليز). بينما سجلت أعلى قيمة معنوية لرقم السقوط (٧٢٦,٠ ثانية) مع الوضع ظهر على ظهر و مسافة بين الدرافيل G_2 وعدم إضافة إنزيم. هذا وسجلت أعلى قيمة معنوية لمعدل الاستخلاص (٨٠,٠٠%) من وضع الدرافيل ظهر على ظهر والمسافة بين الدرافيل G_3 وإضافة إنزيم (هيميسيلولاز + زيلاناز + ألفا أميليز الفطرى) فى حين تم الحصول على أقل القيم معنوية لمعدل الاستخلاص (٧٠,٨٠٪) مع وضع الدرافيل ظهر على سن والمسافة بين الدرافيل G_1 وعدم إضافة إنزيم. هذا وقد سجلت أعلى قيمة معنوية لدرجة الاضعاف (Ds) (٨٣,٠٠ وحدة فارينوجراف) من معاملة التفاعل بين وضع الدرافيل ظهر على ظهر و المسافة بين الدرافيل G_3 وإضافة إنزيم (هيميسيلولاز + زيلاناز + فطر ألفا أميليز) بينما سجلت أقل قيمة معنوية لدرجة الاضعاف (Ds) (٣,٠٠٠ وحدة فارينوجراف) من معاملة التفاعل بين ظهر على سن و المسافة بين الدرافيل G_1 و إضافة أو عدم إضافة للإنزيم. وقد سجلت أعلى قيمة معنوية لرقم جودة الفارينوجراف (٣٦٩,٠ مم) من التفاعل بين ظهر على سن و المسافة بين الدرافيل وإضافة إنزيم (هيميسيلولاز + زيلاناز + فطر ألفا أميليز). سجلت أعلى القيم معنوية لنسبة بين المرونة و المطاطية (٠,٨٩٠) من التفاعل بين ظهر على ظهر و المسافة بين الدرافيل G_3 وعدم إضافة الإنزيم. ونتجت أعلى قيمة معنوية لحجم الرغيف مع وضع ظهر على ظهر أو ظهر على سن و المسافة بين الدرافيل G_3 وإضافة إنزيمات (هيميسيلولاز + زيلاناز + ألفا أميليز الفطرى) (١٤٧٥,٠ أو ١٤٦٧,٥ سم٣ على التوالي). وسجلت أعلى قيمة معنوية للحجم النوعي مع وضع ظهر على ظهر وإضافة إنزيمات (الهيميسيلولاز + الزيلاناز + ألفا أميليز الفطرى) و أي من المسافة بين الدرافيل . وقد سجلت أعلى قيمة معنوية لقوة الضغط (٧٨٠,٩ جم) من التفاعل بين المسافة بين الدرافيل G_1 و التخزين لمدة خمسة أيام من التخزين مع إضافة الإنزيمات. بينما سجلت أقل قيمة لقوة الضغط (٢٤٧,٦ جم) من التفاعل بين المسافة بين الدرافيل G_2 والتخزين ليوم واحد وإضافة إنزيم (هيميسيلولاز + زيلاناز + ألفا أميليز الفطرى). وقد أعطت إضافة الإنزيم أعلى لون للقشرة ولون اللبابة والرائحة والقوام والقبول العام مع إضافة إنزيم (٨,٠٥٦ ، ٨,٥٠٠ ، ٨,٢٧٨ ، ٨,٢٢٢ و٨,١٥٦ على التوالي). وقد نتجت أعلى قيمة معنوية للقوام والقبول العام مع المسافة بين الدرافيل G_3 وإضافة إنزيم (٨,٥٠٠ و ٨,٦٦٦ على التوالي).

يمكن تلخيص أفضل المعادلات التي تربط خصائص الحبوب من درجة القمح الأسترالي بوضع الدرافيل والمسافة بين الدرافيل والإنزيم المضاف على النحو التالي:

Extraction rate (%) R^2= 0.84

Y=   - 427.216 + 6.567[Test weight (kg/h)] - 0.927[Particle size index (psi %)] -0.583[Tempering added enzyme] -1.894[First break position] -2.974[Roller gap (B1-B2-B3)]

Loaf volume (cm^3) R^2=0.78

Y= -13184.345+187.056[Test weight (kg/h)] -32.101[Particle size index (psi %)] +222.199[Tempering added enzyme] -190.579[First break position] +123.827[Roller gap (B1-B2-B3)]