تأثير إضافة جنين القمح في الخصائص الريولوجيّة لنوعين من دقيق القمح مختلفي الاستخراج

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الملخص

يُعتبر جنين القمح منتجاً ثانويّاً في صناعة طحن القمح، يتميّز بقيمة غذائيّة مرتفعة، ومع ذلك، فإنّ استخدامه محدود نظراً لتأثيره السلبيّ في جودة العجين. يهدف هذا البحث إلى تحديد تأثير إضافة جنين القمح في الخصائص الريولوجيّة لنوعين من دقيق القمح مختلفين في نسب الاستخراج (80-70)%، حيث أُضيف جنين القمح بنسب (0-10-15-20)%، ودُرس تأثيره في خصائص خلط العجين (امتصاصيّة الماء، زمن تطوّر العجين، الثباتيّة أثناء العجن، ودرجة ضعف العجين) باستخدام جهاز الفارينوغراف، وخصائص العجين الإنسيابيّة (قوّة العجين- مقاومة العجين للتمدّد(المطاطيّة)) باستخدام جهاز الاكستنسوغراف، بهدف تحديد الدقيق المناسب لإضافة الجنين ونسبة الإضافة الملائمة ونوع المنتج النهائيّ.

تُظهر نتائج البحث أنّ إضافة جنين القمح في العجين أدّت إلى إحداث تأثير معنويّ في الخصائص الريولوجيّة لكلا نوعي الدقيق، وتشمل التأثيرات الريولوجيّة: زيادة في امتصاصيّة الماء بنسبة 1.1% لكل 5% زيادة في نسبة الإضافة، زيادة درجة ضعف العجين (97-94)% لدقيق استخراج (70-80)% على التوالي عند النسبة 20%، ازدياد زمن تطوّر العجين حتى (5.7-5.3) دقيقة لدقيق استخراج (70-80)% على التوالي، تقلّ ثباتيّة العجين ممّا يجعل العجين أقلّ قدرة على تحمّل المعالجات الميكانيكيّة الطويلة، وتُحدث نسبة الإضافة 20% تأثيراً معنويّاً سلبيّاً في مؤشّرات الفارينوغراف والاكستنسوغراف لذلك يُفضّل استبعادها، في حين تكون النسبة 10% ملائمة لدقيق استخراج 80%، أمّا دقيق استخراج 70% فكان أكثر تحملاً للإضافة 15-10%، ويُنصح بإضافة جنين القمح لمنتجات المخابز التي تستخدم دقيق عالي الاستخراج وزمن تخمير أقلّ.

الكلمات المفتاحيّة: جنين القمح، دقيق استخراج 70%، دقيق استخراج 80%، الخصائص الريولوجيّة

Effect of adding wheat germ on the rheological properties of two wheat flour types that differ in extraction rate

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Abstract

Wheat germ is known as a secondary product of wheat milling industry and considered as a product of high nutritional value. Nevertheless, the use of wheat germ is restricted due to its bad influence on dough properties. This research aims to determine the impact of adding wheat germ on the rheological characteristics of two types of flour differs in extraction rate a (70, 80)%. Wheat germ was added in 3 levels (10, 15, 20)%, and its influence in dough mixing properties (water absorption, dough development time, stability during kneading, degree of dough softening) was studied using farinegraph. Also, extensibility properties of dough (dough strength, dough resistance) were studied using Extensograph. In order to determine the appropriate wheat and suitable addition level of wheat germ and final product.

Results showed that adding wheat germ into dough caused notable influence on rheological properties of both types of wheat flour. This includes: increasing of water absorbance up to 1.1% for every 5% of addition level, increasing of dough softening 94% and 97% at extraction rate of 70% and 80% respectively (20% wheat germ). Also, dough development time was increased up to 5.3 and 5.7 min at extraction rate of 70% and 80% respectively, moreover, dough resistance was decreased which makes dough less able to bear long mechanical processing. The level of 20% of wheat germ was exclusion because it gives negative values in farinograph and Extensograph, while the level of 10% is more suitable for wheat of extraction rate of 70% and 10-15% is more suitable for wheat of extraction rate of 80%. Finally, it is advised to add wheat germ to baked products that uses high extraction ratio of wheat and low time of fermentation

Key words: Wheat germ, wheat flour extraction rate a 70% and 80%, rheological characteristics

Introduction:

Rheology science studies the deformation of the material and its response to stress applied to it. Most foodstuffs are classified under non-Newtonian viscoelastic regimes. Dough can be considered the most distinguished system because of its viscoelastic system that formed from gliadin and glutenin (the gluten complex is a sticky, rubbery protein responsible for forming the structure of dough) (Abang Zaidel *et al.*, 2010).

Rheological measurements are generally used in order to monitor mechanical properties in order to know the behavior of materials during processing, detect the effect of flour components and additives on the behavior of dough during baking industry, and predict the quality of the final product (Dobraszczyk and Salmanowicz, 2008).

The Farinograph is considered the most important experimental rheological device used to monitor the behavior of dough during mixing and kneading. The most important indicators that provides are: **a)** Water absorbance: water absorbance associates directly with the properties of major flour components: gluten and starch, therefore productivity of bakeries. Also it is one of the most important factors that evaluate the "flour strength", and calculate product prices. **b)** Dough development time: which is the time from the beginning of the kneading until the maximum consistency is achieved. It depends on the quality of the gluten, the size of the starch granules, and the percentage of the crumbled starch. **c)** Dough stability: It is one of the quality standards of gluten that describes the viscoelastic properties of the gluten compound formed. **d)** The degree of weakness of the dough: the greater it means, the increase in the weakness of the dough (Dubois *et al*., 2008).

Farinograph also makes it possible to monitor the effect of additives, thus allowing to improve flour processing in term of knowing the quality of flour produced from raw materials of variable quality (Ktenioudaki *et al.,* 2011).

The expandability is unique property of wheat dough, and the Brabender Extensograph instrument is the most common way to measure it by stretching a piece of dough at equal rates in two perpendicular directions in one vertical line (Kieffer *et al*., 2006).The most important indicators that provides are: **a)** Maximum stretching resistance (R_{max}), **b)** The stretching ability of dough (elasticity E). These two indicators are indirectly responsible for the expectation of volume increase of dough during the fermentation process and the capacity (energy). Note that the greater the space the greater of the ability of gas retention by the dough, also boost the capability to ferment, led to a large volume of bread, also the more The stronger the flour, the greater the energy required to stretch the dough (Anderssen *et al.,* 2004).

In recent years, there has been an increase in the consumption of bread made of highly extracted wheat flour, or whole wheat flour, or flour fortified with health-promoting ingredients, for low-extraction wheat flour depletes most of the valuable nutrients, such as dietary fiber, minerals and vitamins, which it loses during the milling stages (Mahmoud *et al.,* 2015).

Wheat germ is an essential source of nutrients due to its distinctive chemical composition, and is used either for direct consumption or to enhance the nutritional value of food products. Also it is composed about (2.5-3%) of wheat kernel and known as secondary product of wheat milling (Boukid *et al.,* 2018). Moreover, it is high in nutritional value because it is considered to be the main source of vitamin E in the wheat grain, and it is also rich in B vitamins, proteins and most essential amino acids. also, it is rich in Saturated fatty acids including oleic acid, linoleic acid, α-linolenic acid and biofunctional compounds including flavonoids, sterols and glutathione (Verni *et al.,* 2019).

The limited use of wheat germ (WG) in bakery industries is due to its instability during the preservation period of other baked products, as the high activity of lipase and lipoxidase causes the formation of free fatty acids and consequently the appearance of a rancid taste in baked goods (Marti *et al.,* 2014). In addition, the presence of wheat germ negatively

affects the technological quality of flour and more on the stability of the dough. The challenge is to isolate, store and use wheat germ to maintain this high nutritional quality and prevent fat oxidation (Giuseppe *et al.*, 2010).

Aim of search:

This research aims to study the rheological effect of adding wheat germ to two types of flour with different extraction rate, where the addition of wheat germ was in proportions (0-10-15-20)% in order to know the appropriate flour for adding and the best percentage of wheat germ so that its negative effect on the dough is not significant.

Materials and Methods:

Materials:

- **Wheat germ samples**: Wheat germ samples were taken from two different mills (A and B) that differ from each other in the length of the production line, the technology used in production, and the quality of wheat used. The most important difference between the two mills is that semolina flakes are used in the A mill and not in the B mill. In addition, wheat germ samples of two types of wheat were taken from the mill (A). One of them was used in the process of adding wheat germ to flour.
- **Wheat flour samples**: two flour samples were used in this research, one of which is 70% extraction flour and the other 80% extraction flour produced by the General Company for Mills in the city of Homs, Syria.

Analysis Methods:

- **Flour and wheat germ tests:**

The moisture of the studied wheat flour and germ samples was determined according to (AACC,44-15,2000), the ash according to

(AACC, 2000, No. 104/1), and the protein content using the Kieldahl method (AACC, 2000, No. 105/1). The percentage of wet and dry gluten and the gluten index according to (AACC, 2000, No. 155), and the percentage of Crude fiber according to (AOAC, 2000).

- **Rheological Tests:**

Farinograph method according to (ICC, No. 115,1999) to determine the indicators of dough mixing: the percentage of water absorbed - the dough development time - the stability of the dough - the degree of dough weakness.

Extensograph method according to (ICC, No. 114,1999) method to determine dough flow indicators.

- **Statistical Analysis:**

Three replicates were performed for all tests, then statistical evaluation of the results was carried out using Minitab version 19.0 at the level of reliability ($p \leq 0.05$).

Results and Discussion:

- **Characterization of the flour and wheat germ samples used**:

Table (1) shows the results of the tests of flour samples, where the high percentage of moisture and gluten in flour extracted 70% compared to flour extracted 80% was noticed. Although there is a clear difference in the percentage of wet and dry gluten, there is no significant difference in the gluten index, which means that there is no significant difference in the quality of gluten, and gluten is considered to be of strong quality in both two types of flour. Whereas water absorbency of 80% extraction flour was greater compared to 70% extraction flour, and this corresponds to (Hadnađev *et al.*, 2011).

Note that the low percentage of moisture, ash and protein for the 70% extraction flour and was due to the low percentage of extraction.

Table (1): Characterization of the wheat flour samples used

test	(80%) extraction flour	(70%) extract flour
Moisture content, (%)	13.70[a]	15.2[b]
Ash (dm), (%)	0.77[a]	0.58[b]
wet gluten, (%) *	21.70[a]	26.2[b]
Dry gluten, (%) *	7.60[a]	0.9[b]
Gluten Index	970[a]	98[a]
Absorbance, (%)	59.70[a]	58.4[b]

*** Based on 14% moisture.**

**** Numbers shares same letter in one line have no significant effect at (P≤0.05).**

dm: dry matter

Table (2) shows the results of tests of wheat germ samples. It was noted that there was no significant difference between the content of the two types of embryo produced by Mill A, while a slight difference is due to the difference in the type of wheat used, However, it is noted that the percentage of protein, fat and the low percentage of fiber were in the samples of the mill germ (B). Comparison with wheat germ samples from mill (A) is evidence of the purity of the germ. That was due to the differences in mill equipment (B) compared to mill (A).

As for fat: The experimental results confirm the theoretical principles that indicate a significant increase in the wheat germ content of fatty substances. As for the ash, a significant increase in the proportion of ash was found in the germ compared to flour, and this indicates the high content of the wheat germ of mineral elements.

Table (2): Results of wheat germ samples tests (%)

Sample Name Ratio	Moisture	protein (dm)	fat (dm)	Ash (dm)	Fiber (dm)
A-1	10.6[a]	23.4[a]	7.7[a]	4.6[a]	6.75[a]
A-2	11.2[a]	24.3[a]	7.0[a]	4.8[a]	6.65[a]
B-1	13.9[c]	27.5[b]	8.3[c]	3.9[b]	5.21[b]

*** Numbers shares same letter in the same column have no significant effect at (P≤0.05).**
dm: dry matter

- **Rheological tests:**

1-Farinograph indicators:

Figure (1) and Table (3) show the results of adding different percentages of wheat germ to the samples of **80%** extraction flour on the farinograph indicators. It was noted that there was no significant difference in the indicators when adding 10% of wheat germ, whereas the significant difference appears in the percentages 15 and 20%, hence the percentage of absorbed water increases with an increase in the percentage of addition, and the increase is at a rate of 1.1% for every 5% increase in the percentage of the wheat germ, because the fibers have a greater absorbency than flour.

The development time of the dough: results showed that this indicator increased significantly when adding 15% of wheat germ, and this when increasing the percentage of addition, the percentage of proteins forming the gluten network decreases, and the amount of water needed to form it increases because the wheat germ granules absorb part of the added water, and the fatty substances impede the formation of the gluten network. Therefore, gluten needs a longer time to form, and this is consistent with (Noori and Sabir, 2019).

Stability of the dough: it was noted that this indicator decreases significantly when adding 15-20%, this explained by the wheat germ is a source of reduced glutathione, that causes the continuity of the kneading process and leads the breakdown of the disulfide bonds formed in gluten network and binding of glutathione with it, which finally causes the weakness in stability of dough by increasing the percentage of addition (Noori, & Sabir, 2019).

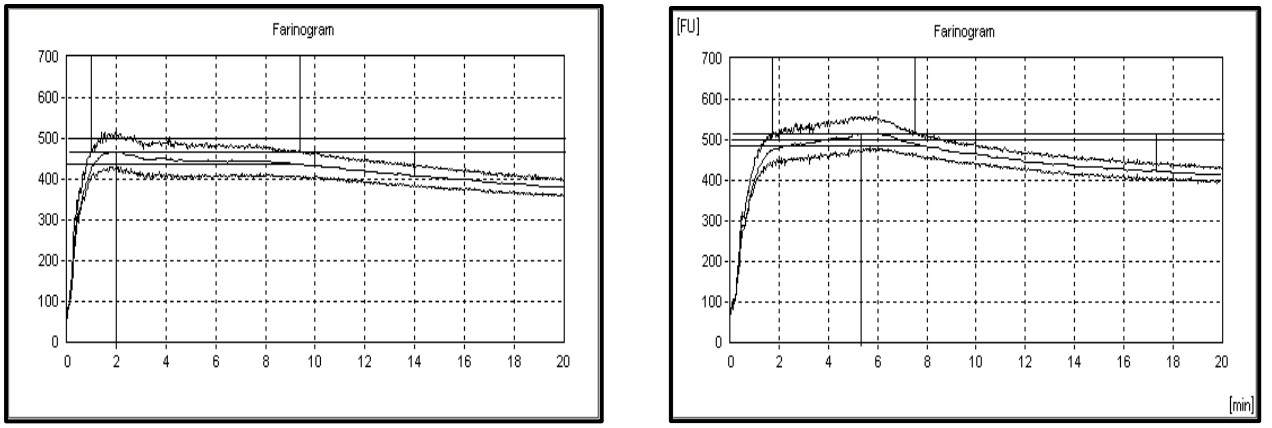
Degree of dough weakness: The dough weakness appears significantly when adding 15% of wheat germ and above.

Table (3): Farinograph results for a sample of 80% extraction flour and its mixtures from wheat germ

	Flour 80%	Flour +(10% germ)	Flour +(15% germ)	Flour + (20% germ)
Water absorbency*, (%)	**58.4[a]**	**58.4[a]**	**58.9[b]**	**59.6[c]**
Dough development time, (min)	**2 [a]**	**2 [a]**	**5.7 [b]**	**5.3 [b]**
immutability, (min)	**8.4 [a]**	**8.4 [a]**	**7.7 [b]**	**5.8 [c]**
The degree of weakness (FU)	**60 [a]**	**60 [a]**	**86 [b]**	**94 [c]**
Farinograph guide	**93 [a]**	**93 [a]**	**91 [b]**	**77 [c]**

***Water absorption values based on 14%.**

**** Numbers shares same letter in one line have no significant effect at (P≤0.05).**



(a) **(b)**

Figure 1: Farinogram of (A): 80% extraction flour + 0%wheat germ, (B): 80% extraction flour + 20% wheat germ

Figure (2) and Table (4) show the results of adding wheat germ to **70%** extraction flour, where it is noticeable **that water absorbency** increases with the first 10% addition, after that, the effect of adding wheat germ becomes insignificant, research found that the water absorbency increases when increasing the percentage of addition for whole wheat flour (Sun *et al*., 2015).

The development time of the dough: results showed that The dough development time increased in flour of 70% extraction rate up to 5.7 minutes at the addition rate of 20%, that was more than when compared to flour of 80% extraction rate which was 5.3 min at the same addition level.

the dough stability was significantly reduced until it reached 4.9 minutes at the 20% addition rate, which is less than the stability of the dough prepared from 80% extraction flour.

The degree of weakness of the dough: the dough showed a significant increase in the degree of weakness at the addition of 10%, and

the effect of the added wheat germ percentages of 15-20% was significantly close in weakness indicator.

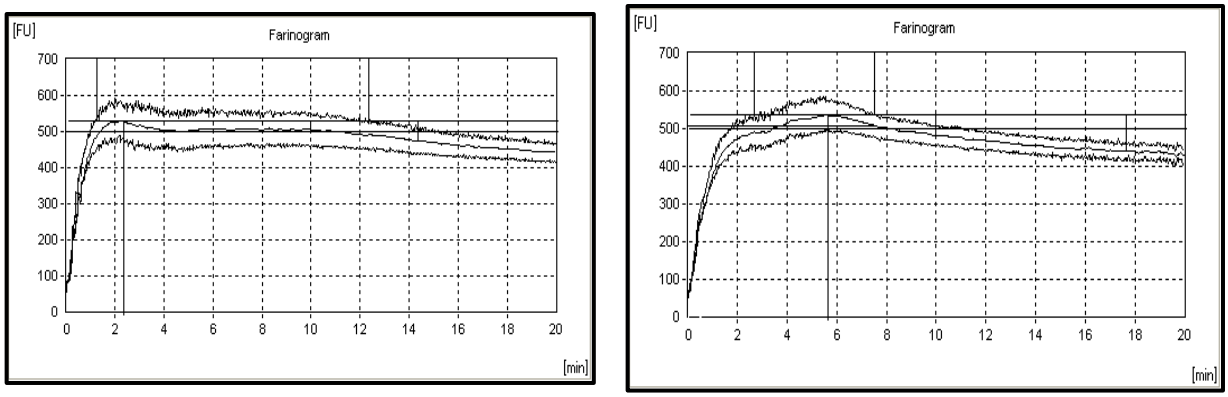
Farinograph index: it was found, when comparing tables (3) and (4), that the farinograph index decreases with the increase in the percentage of addition. In flour of 70% extraction rate, the moral effect appears at 10% and reaches a value of (76) at 20% of added wheat germ, which means that 20% causes a similar negative effect in both types of flour.

Table (4): Farinograph results for a sample of 70% extraction flour and its mixtures from wheat germ

	Flour 70%	Flour +(10% germ)	Flour +(15% germ)	Flour + (20% germ)
Water absorbency*, (%)	**59.7[a]**	**61.2[b]**	**61.5[b]**	**62[b]**
Dough development time, (min)	**2.4[a]**	**6.5[b]**	**5.8[b]**	**5.7[c]**
immutability, (min)	**11.1[a]**	**9.3[b]**	**7.1[b]**	**4.9[c]**
The degree of weakness (FU)	**54[a]**	**93[b]**	**98[b]**	**97[b]**
Farinograph guide	**114[a]**	**97[b]**	**90[b]**	**76[c]**

***Water absorption values based on 14%.**

**** Numbers shares same letter in one line have no significant effect at (P≤0.05).**



(a) **(b)**

Figure 2: : Farinogram of (A): 70% extraction flour + 0%wheat germ, (B): 70% extraction flour + 20% wheat germ

2-Extensograph indicators:

Figure (3) and Table (5) show the extensograph indicators of flour samples, **80%** extraction rate with the additions. The table shows that there is no significant difference in the **elasticity E**, adding 10% of wheat germ showed a very small improvement in the elasticity, then it returned to the limits of the control sample when adding 15% and decreased at 20% compared to the control.

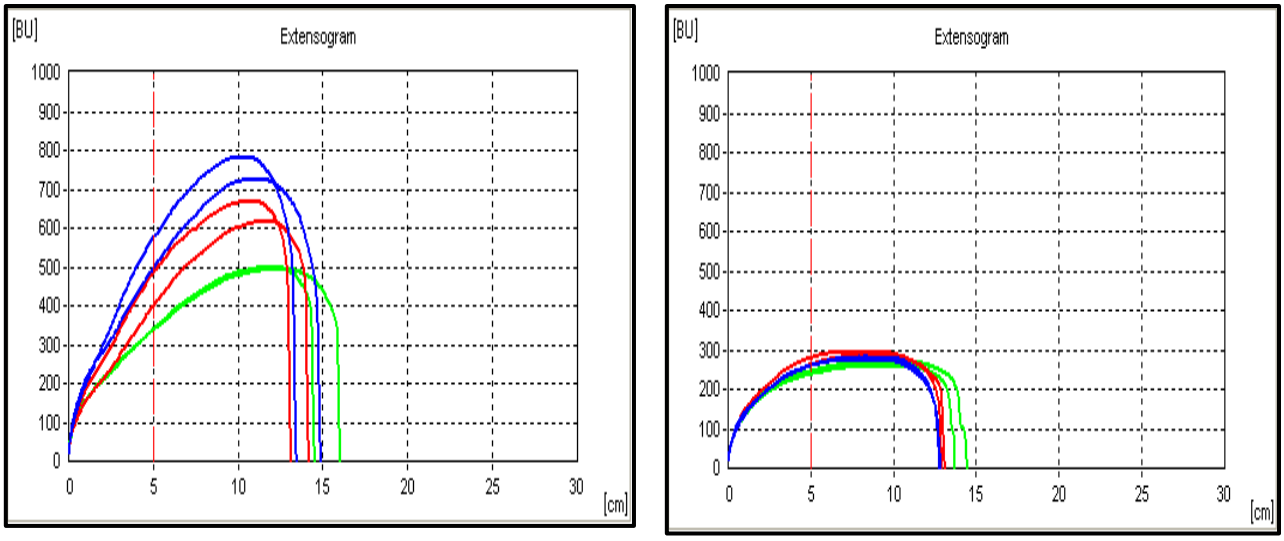
The resistance R5 showed a direct weakness when increasing the addition rate of wheat germ, and this is expected because the more the addition of wheat germ, the more the weakness of the gluten network. As for the **max resistance R_{max}**, there was a clear decrease and also a significant decrease in the **capacity (energy)**, especially at the addition rate of 20%. This shows the weak properties of gluten, as the decrease in the energy needed to expand the dough means that the flour has become weaker, and this leads to a decrease in the volume of baked products.

The shape of the extensogram curve gives an idea of the results that can be expected in the baking phase. Also it gives conceptions of the

appearance of the cross-section of bread loaf. Figure (3) shows the significant difference in the shape of the extensogram between the control sample and the sample when adding 20% wheat germ at 80% extraction rate of flour. The volume of product (B) can be expected to be significantly lower compared to the control (Gómez *et al.*, 2018).

Table (5): Extensograph results for a sample of flour, 80% extraction with additives from wheat germ.

sample	fermentation time, (min)	E , (min)	R_5, (Bu)	R_{max}, (Bu)	Energy, ($cm^{2)}$	R/E
Flour	45	153	343	497	102	2.2
	90	137	446	643	112	3.3
	135	142	540	755	138	3.8
Flour + 10% (wheat germ)	45	163	278	377	86	1.7
	90	145	334	445	87	2.3
	135	147	306	418	84	2.1
Flour + 15% (wheat germ)	45	142	289	341	70	2.0
	90	138	328	384	75	2.4
	135	146	326	383	78	2.2
Flour + 20% (wheat germ)	45	141	245	226	57	1.7
	90	130	273	291	57	2.1
	135	128	262	279	53	2.0



(a) **(b)**

Figure 3: Extension diagram of the flour sample: (A): 80% extraction + 0% wheat germ, (B): sample of 80% extraction flour + 20% wheat germ.

Figure (4) and Table (6) show the extensograph indicators of flour samples extracting **70%** with additions. Table (6) shows that **elasticity E** showed a non-significant decrease at 10% addition rate of wheat germ, and the effect was significant at 20%. Also, the **resistance R5** did not show weakness clearly except when adding 20% when brewing for 45 min, the percentage of addition of 10% did not show a clear weakness, and there was an improvement in the **resistance R5** and the weakness began to appear when brewing for 90 min, and for the **max resistance R_{max}**, the weakness appeared clearly from the first addition rate (10 %). Also, there was a decrease in the capacity to retain gas in the dough at 20% of wheat germ.

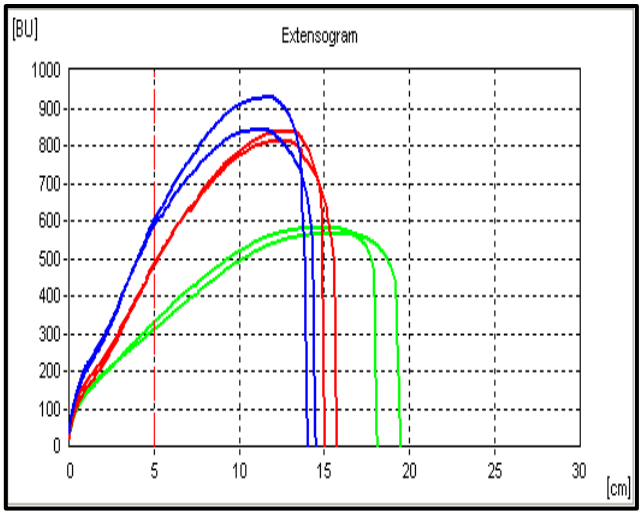
When studying the **fermentation times**, it was noted that the increase in the fermentation time did not lead to a significant increase in the values of capacity and elasticity at the rates of 10-15% of wheat germ addition levels, and the elasticity decreased at the rate of 20% at the

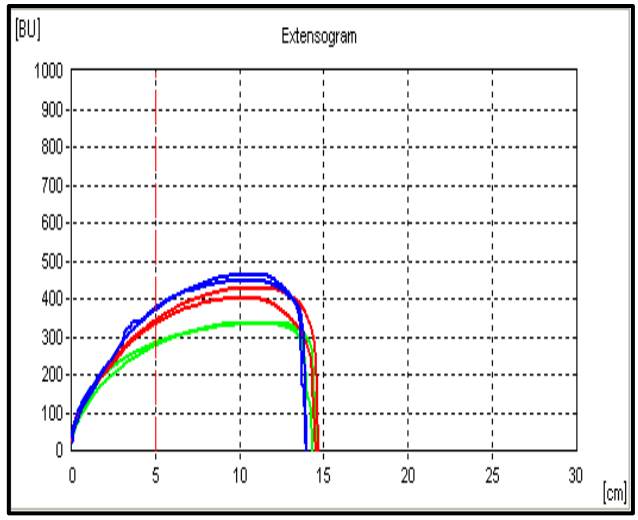
fermentation time of 135 min. It could be conclude that by shortening the fermentation time, it is possible to overcome the weakness of dough when adding wheat germ to the flour.

Extensograph curves with low resistance to expansion indicate the volume of sloppy bread (figure 4), and dough with a well-balanced **R/E ratio** is considered to be of good quality for bread production. A higher percentage indicates the stagnant properties of gluten, which leads to a lower volume of baked goods.

Table (6): Extensograph results for a sample of 70% extraction flour

sample	fermentation time, (min)	E , (min)	R_5, (Bu)	R_{max}, (Bu)	Energy, ($cm^{2)}$	R/E
Flour	45	188	325	576	141	1.7
	90	154	488	827	156	3.2
	135	143	600	886	160	4.2
Flour + 10% (wheat germ)	45	182	336	502	123	1.8
	90	151	418	601	119	2.8
	135	156	424	616	124	2.7
Flour + 15% (wheat germ)	45	160	326	429	96	2.0
	90	141	393	489	96	2.8
	135	145	447	593	115	3.1
Flour + 20% (wheat germ)	45	144	283	337	71	2.0
	90	146	342	415	85	2.3
	135	140	377	456	89	2.7





(a) **(b)**

Figure 3: Extension diagram of the flour sample: (A): 70% extraction + 0% wheat germ, (B): sample of 70% extraction flour + 20% wheat germ.

Conclusions:

1. The addition of wheat germ significantly affects the rheological properties of both types of flour (extraction rate 70 and 80%), and its effect on the gluten network is evident in the properties of farinograph and xtensograph at the ratio of 15 and 20%.

2. The addition percentage of 20% is excluded for both types of flour, but it can be added to 80% extracted flour in proportions of 10 and 15% with a fermentation time of 45 minutes, and therefore it can be added to Arabic bread or tannour bread in these proportions, since its fermentation time is less than that of samoon bread.

3. Wheat germ can be added to flour extracting rate 70% with a percentage of 10% and less, with the aim of making cake bread or

samoun bread because its tolerance is greater when the fermentation time is increased.

4. The rheological effects of adding wheat germ include: an increase in water absorption, an increase in the degree of weakness of the dough, an increase in the development time of the dough, a decrease in the stability of the dough, which makes the dough less able to withstand prolonged mechanical processing.

5. The extensograph provides data relevant to the assessment of dough behavior during fermentation processes and baking performance.

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