Effect of storage conditions on sensory, physicochemical and rheological properties of some types of bread flour produced from local and imported wheat.

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تأثير ظروف التخزين على الخصائص الحسية والفيزيوكيميائية والريولوجية لبعض أنواع دقيق الخبز المنتج من حبوب القمح المحلية والمستوردة

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الملخص:

تناولت هذه الدراسة تأثير ظروف التخزين على بعض الصفات الحسية والخواص الكيميائية والريولوجية لبعض أنواع الدقيق المنتج من أصناف القمح الربيعية المحلية والمستوردة. شملت الدراسة دقيق القمح المنتج من الصنف المحلي (الكفرة)، الروسي، الأوكراني والألماني (تعتبر هذه الدراسة جزء مكمل لدراسة سابقة تحت عنوان " تقييم صفات الجودة لأصناف من القمح المحلي والمستورد المستخدمة في المطاحن الوطنية لإنتاج دقيق الخبز ومدى مطابقتها للمواصفات القياسية الليبية"). تم تخزين عينات الدقيق لمدة 6 أشهر (من شهر مارس إلى نهاية أغسطس 2015) في أكياس من البولي ايثيلين تحت درجة حرارة الغرفة 20 °م مع مراعاة التهوية الدورية. أوضحت نتائج المتابعة والتي كانت على فترات 0، 45، 135، 180 يوم أن الدقيق الناتج من الأصناف قيد الدراسة غير مُطابق للمواصفة القياسية الليبية الخاصة بدقيق القمح في بعض الخصائص مثل الإصابات الحشرية لنوعي الدقيق المحلي والروسي، وكذلك تكون الرائحة غير المرغوبة في جميع الانواع خلال شهري يوليو وأغسطس. الدقيق الناتج من الأصناف قيد الدراسة كان مُطابقاً للمواصفة القياسية الليبية الخاصة بدقيق القمح من حيث محتواه من الرطوبة، البروتين، الرماد، الجلوتين الرطب، وأيضاً الامتصاصية وزمن تطور العجينة، هذا وأظهرت العينات عدم تطابقها مع المواصفة في اختبار ثباتية العجينة، ماعدا دقيق الصنف الألماني وذلك بعد التخزين على درجة حرارة الغرفة ولمدة 6 أشهر. يعتبر عامل ارتفاع درجة الحرارة التدريجي خلال فترة التخزين وراء تدهور الصفات الكيميائية والريولوجية للعينات المدروسة.

الكلمات المفتاحية: *الخواص الريولوجية، الخواص الفيزيوكيميائية، الصفات الحسية، أصناف الاقماح المستوردة، صنف القمح المحلي.*

Abstract:

This study investigated the impact of storage conditions on some sensory characteristics and chemical and rheological properties of some types of flour produced from domestic and imported spring wheat varieties. The study included wheat flour produced from the local variety (Kufra), Russian, Ukrainian and German (this study is considered an integral part of a previous study entitled "Assessment of the quality qualities of varieties of local and imported wheat used in national mills for the production of bread flour and the extent of their compliance with Libyan standard specifications"). Flour samples were stored for 6 months (from March to the end of August 2015) in polyethylene bags under a room temperature of 20 ºC subject to periodic ventilation. The results of follow-up, which were at intervals of 0, 45, 135, 180 days, showed that the flour produced from the varieties under study does not conform to the Libyan standard for wheat flour in some characteristics, such as insect infestations of the domestic and Russian flour types, as well as the undesirable smell in all types during the months of July and August. The flour produced from the varieties under study was identical to the Libyan standard for wheat flour in terms of its moisture content, protein, ash, wet gluten, as well as absorbency and dough development time, and the samples showed non-conformity with the specification in the dough stability test, except for German flour, after storage at room temperature for 6 months. The factor of gradual overheating during the storage period is considered to be behind the deterioration of the chemical and rheological qualities of the studied samples.

Keywords: *Local wheat cultivar, imported wheat cultivars, sensory characteristics, chemical properties, rheological properties*

Introduction:

Food grains and their products have a special and distinctive importance in human nutrition in general and especially for the Libyan consumer, as they are considered one of the main daily meals. Libya is one of the countries with a relatively high consumption of wheat flour products, where the per capita consumption is estimated at about 350 g per day (Eshtew. 2016), mainly represented by bread and baking products. The average per capita consumption of Libya per year is about 150 kg according to data recorded during the period between 1996 and 2005, an amount considered high compared to some countries of the world such as Algeria, Morocco, Egypt, Iraq, Yemen and Turkey, where the average per capita consumption per year was about 143, 124, 103, 108, 120 and 135 kg, respectively (Al-Zaqqat et al. 2006, Eshtew. 2016).

To cover consumer needs of wheat, Libya relies on imports from abroad in the form of grains that have been ground into flour in local mills. The resulting flour is sometimes stored in unsuitable conditions of temperature and ventilation, which may lead to undesirable changes in the physical and chemical properties as well as insect infestations. One of the most common types of corruption that occurs in wheat flour during storage is rancidity and the development of an undesirable flavour This change in the properties of flour, whch results in a deterioration in its quantity and quality, is known as post-harvest losses and this occurs in the period from harvest to (Kader et al., 2004; Eshtew, 2016). In developing countries, the greatest amount of post-harvest losses usually occurs during harvesting, trading and storage. Such losses are most often caused by improper packing,

poor transportation, inadequate storage facilities (Baqui, 2005; Hruškova et al. 2002; Ofor and Ibeawuchi, 2010). Wheat belongs to the grass family Gramineae and the genus Triticum and has known three types of wheat of commercial and economic importance: common wheat T. aestivum (bread wheat), T. compactum wheat (biscuit wheat and pies) and durum wheat T. durum (pasta wheat and couscous) (Kaliyan et al. 2005. Maio, 2022). In the past 50 years, wheat production has increased dramatically to reach approximately 615 million tons per year worldwide, wheat is produced in about 120 countries around the world and wheat crop represents about 19% of the total world cereal output in various varieties. China, India, USA, Russia, France, Canada and Australia are the most producing countries (Maio, 2022). Locally produced wheat accounts for 5% of the annual consumption, with Libya importing about 95% of its food needs, or approximately 1.571 million tons of wheat per year (Ahmed, 2015). Wheat is used in most countries of the world in the production of flour needed for the manufacture of bread, baking and others, as it is the main food for most human societies. Wheat is considered to have good nutritional value as it contains most of the elements needed by the body, and wheat flour is added to some food products to raise the nutritional value and improve the quality of rheological properties through gluten and starch and increase their cohesion ((Almusali and Ba Sombol, 2009). The study found that the nutritional and technological value of wheat flour decreases with increasing the storage period, especially if it is in inappropriate conditions of temperature and humidity, such as increased solubility of gluten protein and the transformation of some amino acids such as Cysteine, methonin, lysine, tryptophan into non-ready derivatives (Almusali and Ba Sombol, 2009). Research also suggests that freshly ground whole grain flour is better in vitamin E content than flour stored for a long time (Hruškova and Machová , 2002). The main objective of this study was to evaluate the effect of storage conditions at a room temperature of 20 ºC for six months (March to the end of August 2015) on the organoleptic qualities and physicochemical and rheological properties of flour of domestic spring wheat varieties (Kufra), and some imported varieties represented in Russian, Ukrainian and German and used mainly for the production of bread flour and compare it with scientific standards as well as Libyan standards.

Materials and methods

Preparation and storage of samples

Samples of spring wheat flour were collected from the National Company for mills and feed (Ain Zara), which included local wheat flour (Kufra) and imported from Russia, Ukraine and Germany. Flour samples were stored in bags made of polyethylene with a capacity of 1 kg (5 kg of each sample) for 6 months at room temperature 20ºC.

Natural evaluation of flour

Virtual examination

Sensory tests were conducted, including color, odor and apparent insect infestation, on wheat flour produced from local and imported spring wheat varieties, according to specifications and standards (N.C.S.L, 2006)

Chemical Analysis:

Determination of humidity

The moisture content of the samples under study was estimated using a drying oven device, according to the method approved by the American Society for Grain Chemistry No. 44-15. (AACC, 2003).

Estimation of wet gluten

The percentage of wet gluten was determined automatically using a device of Gluten Index using the method approved by the International Society for Grain Science and Technology No. 155 (ICC Standard No. 155:1994).

Determination of fat and ash

The percentage of fat was estimated using the Soxhlet method (7.054) according to what was stated in AOAC [14]. As for the total ash, it was estimated using an incineration furnace, according to the method approved and stipulated by the American Society for Grain Chemistry No. 08-01 (AACC, 2005).

Alpha-amylase activity

This test was performed using a Falling number device (Falling number) following the method approved by the American Society for Grain Chemistry No. 22-10 (AACC, 1976), The results were recorded based on a humidity of 14%.

Rheological properties of wheat flour:

Ratio estimate absorption Water, development time and stability of the dough.

This test was performed using a device Farinograph manufactured by the German company Brabender according to the method approved by the American Society for Grain Chemistry No. 54-20 (AACC, 1976) Based on the moisture content of 14%, noting that the basin used to mix the dough had a capacity of 300 grams.

Statistical analysis

The statistical analysis was carried out according to a completely randomized factorial design (CRD) using the General liner model, and the averages were compared using Tukey's test to determine the significant differences. between the means at a 5% confidence level ($P \geq 0.05$). Graphs drawn using software Microsoft Excel 2021.

Results and discussion

Sensory qualities and insect injuries

The physical examination revealed the conformity of the sensory properties (color, smell) of the samples under study to the Libyan Standard (National Center for specifications and standards, during the 6-Month Storage period. As for the results of insect injury tests, they did not conform to the specification during the months of July and August, as the frequency of insect injury increased due to the high ambient temperature, and this is considered normal in the summer months when storing in uncontrolled conditions in terms of temperature and relative humidity. The abnormal smell also appeared during the hot summer months (July and August) and is mainly due to the breakdown of fats by lipase enzymes and possibly also due to the oxidation of unsaturated fatty acids resulting from hydrolysis by oxygen (Kechkin et al., 2020). Some studies have reported that when storing grain products at the humidity specified in the standards, hydrolysis processes continue and increase in intensity as the temperature and relative humidity of the air in the store increase. As a result, lipid hydrolysis products of free fatty acids, amino acids from the partial hydrolysis of water-soluble proteins, acid phosphates from the hydrolysis of phytins and others accumulate (Kaliyan et al., 2005).

Table 1: Organoleptic qualities and insect infestations of the wheat flour samples under study.

Item	Natural Evaluation		insect infestation
	Colour	Odor	
Kufra	Natural	Normal during March, April and May, with changes during June and August	The presence of insect infestation during the months of June and August
Russian	Natural	Normal during March, April and May, with changes during June and August	The presence of an insect infestation at the end of July and August
Ukrainian	Natural	Normal during March, April and May, with changes during June and August	Nothing
German	Natural	Normal during March, April and May, with changes during June and August	Nothing

Physiochemical properties

The storage results of various spring wheat flour samples during the 6-Month Storage period showed a gradual decrease in moisture content at the level of the sample itself as shown in Figure 1, but at the level of the average samples in general during the entire storage period, an insignificant decrease was recorded among all varieties, where the flour of the Ukrainian variety recorded the highest moisture content (12.17%) while the local variety recorded the lowest moisture content (11.82%). The decrease in humidity may be attributed to storage conditions of high and low temperature and relative humidity. Another study indicated that the moisture content of flour increased during storage for 3 months (Eshtew, 2016; Kamboj et al., 2018). In a study, researchers found that during the 15-month storage period of American wheat flour at a temperature ranging from 0 ºC to 25 ºC and a relative humidity of 28% and 73%, the properties of flour changed during the ripening process (Ofor et al., 2010; Eshtew, 2016).

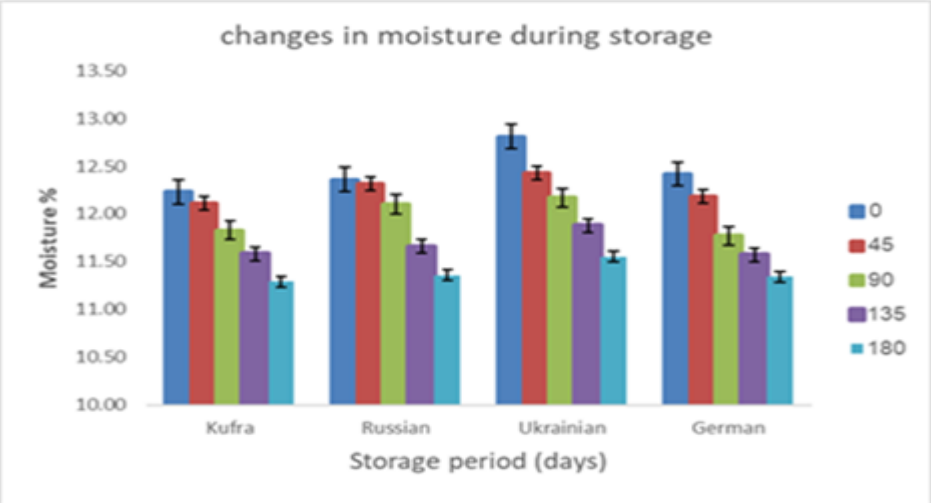

Figure 1: the effect of storage periods on the moisture content of domestic and imported wheat flour.

Results of the change in the moisture content of domestic and imported wheat flour during the storage periods were noticeable, although not significant during the storage period, which is consistent with the study conducted by Hruskova and machova (2002). The results of the current study also coincided with the study conducted in Libya by Jadaan et al., (2003), in which they confirmed a decrease in the percentage of humidity in samples of local, Tunisian, Belgian and German flour from 11.54 to 9.65% during four months of storage in the stores of the price balancing fund branch Brak Alshaty city (Eshtew, 2016). Results indicated that the percentage of fat in flour samples produced from domestic and imported wheat varieties was characterized by relative stability during the first months of storage at the level of the same varieties, as for the overall average during the six months of storage, shown in Figure (2), the Russian variety recorded the highest fat percentage of 1.67%, which differed significantly *(P≤0.05)* with the rest of the other types of flour, which did not register a significant difference between them. The slight increase in the percentage of fat during the last period of storage during the months of June and August may be due to the release of some fatty acids due to heat or as a result of insect infestation, which explains the appearance of some odors due to the rancidity of those fats. Another study indicated that changes occurred in the sixth, seventh and eighth months of the storage period at a relative humidity of more than 65% and temperatures above 20 ºC. In the same study it was noted that when the relative humidity was below 60%, and the temperature was 10 ºC, the rate of the acidity number of wheat grains practically did not change during the storage period of 6 months (Kechkin et al., 2020; Eshtew, 2016). The percentage of ash for domestic and imported flour samples did not register noticeable changes during the storage period, but maintained the same level recorded from the beginning of the storage period, as it is known that the determinant of the percentage of ash in the flour sample is mainly due to the initial extraction ratio and the extent to which the mill contains mineral elements, which are mainly based in the outer shell layers.

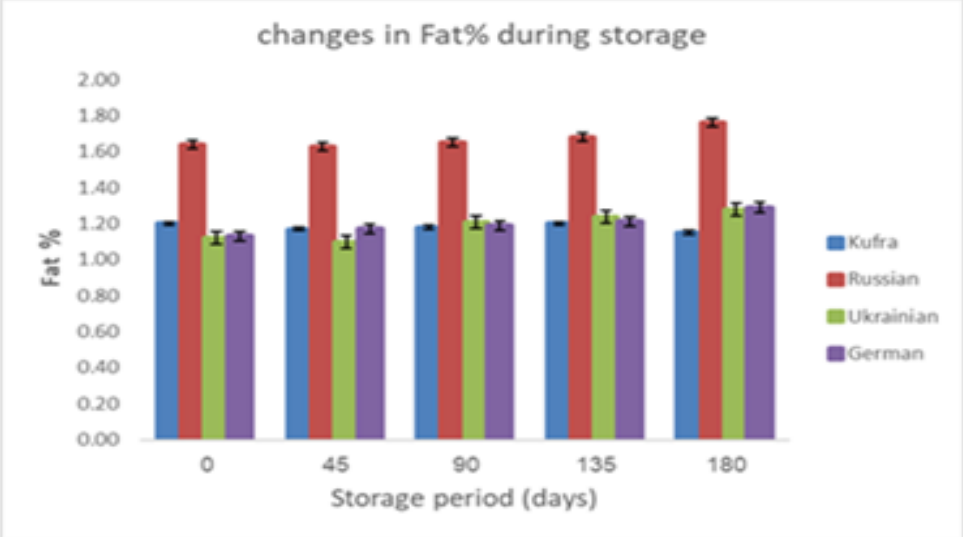

Figure 2: the effect of storage periods on the fat content of domestic and imported wheat flour.

The average percentage of ash during the six months recorded the highest value of flour of the Russian, Kufra, German and finally Ukrainian varieties, respectively, the differences between the varieties were significant ($P \leq 0.05$) as shown in Figure (3).

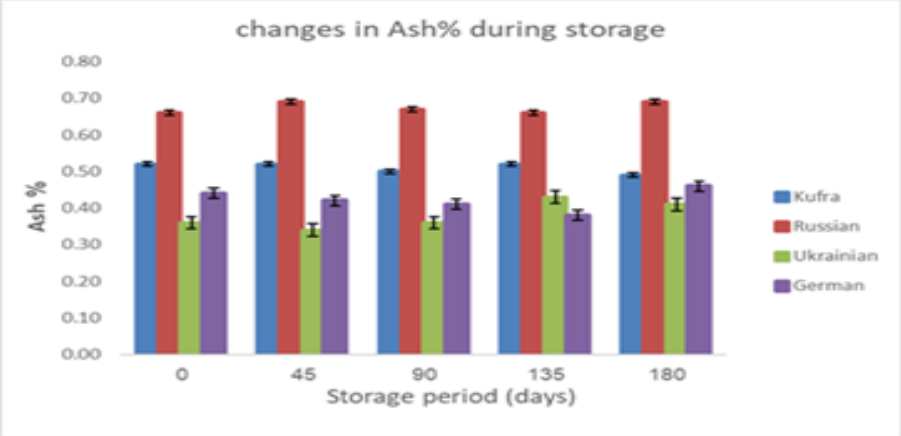

Figure 3: the effect of storage periods on the ash content of domestic and imported wheat flour.

Results of storing samples of domestic and imported spring wheat flour during the first months of storage indicated a gradual decrease in the average protein percentage at the level of the varieties per se, for example, Russian wheat and Kufra recorded the highest protein percentage with the beginning of the storage period (Time 0) 13.02% and 12.44%, respectively, and they witnessed a gradual decrease during the entire storage period as noted in Figure 4. The Russian variety was declining at an almost constant pace and at a rate of 0.30-0.50% every 45 days, as is the case for the rest of the varieties. This significant decrease ($P \leq 0.05$) in the protein percentage is directly due to the activity of proteolytic enzymes and is associated with the moisture content of stored wheat flour, which in turn leads to the release of amino acids, causing a decrease in the quality of flour protein and, consequently, the quality of the loaf of bread. A previous study found that the optimal flour moisture ratio to prolong the shelf life of wheat flour without any noticeable changes is between 9 and 10% (Nasir et al., 2003; Eshtew, 2016).

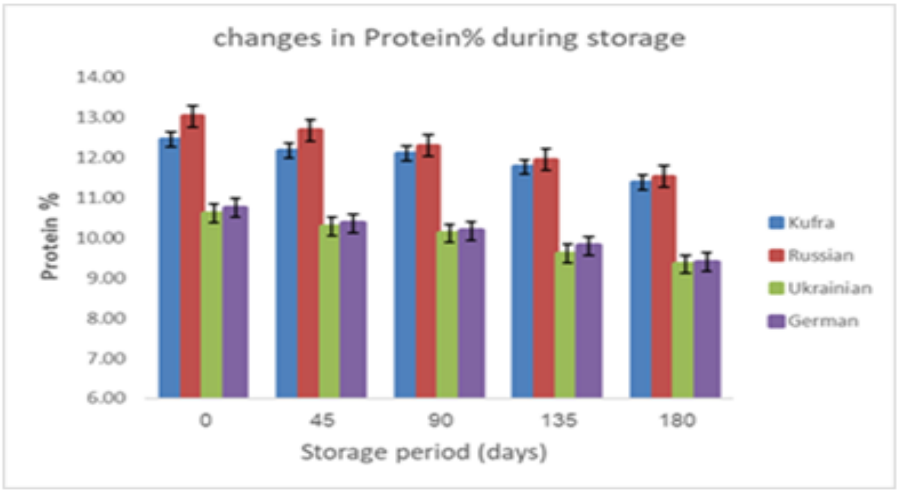

Figure 4: the effect of the storage period on the protein content in domestic and imported wheat flour.

The test results shown in Figure (5) indicated a gradual decrease in the percentage of wet gluten for wheat flour samples produced from domestic and imported wheat varieties during the storage period under room temperature for 6 months, through the results we note that the percentage of wet gluten in the German flour variety, which is considered the highest value among the studied varieties, recorded a gradual decrease during the six-month period, the initial percentage at Time 0 was 27.82% and then increased to 27.30, 26.70 and then decreased to 26.39, and 26.06% within 45, 90, 135 and 180 days respectively. The average percentage of gluten recorded during the entire storage period was variable and significantly different ($P \leq 0.05$), where the German variety recorded the highest percentage of wet gluten 26.82%, while the local variety recorded the lowest percentage of wet gluten among the studied varieties 22.22%. In another study, a decrease in the gluten index and, consequently, the amount of wet gluten was found with an increase in the storage period of wheat flour in uncontrolled conditions (Akhlaq et al., 2019). Results of this study agreed with a previous study conducted on the storage of samples from wheat flour for a period of three months, where the results indicated a gradual decrease in the percentage of wet gluten from 33.50 to 31.20%, at a temperature and relative humidity that ranged from 25.2 to 33.51ºC and from 33 to 38%, respectively (Hruškova et al., 2002, Eshtew, 2016).

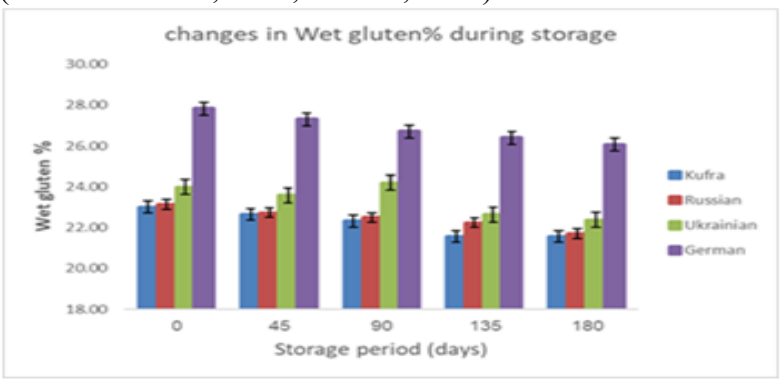

Figure 5: effect of storage periods on the percentage of wet gluten in domestic and imported wheat flour.

Alpha-amylase activity

The average Falling number for spring wheat flour samples produced from domestic and imported wheat varieties under study stored for 6 months recorded a gradual increase, for example, the Russian variety recorded the highest value of the Falling number during the storage period in general compared to other flour varieties (407 seconds) during Time 0 and then gradually increased to record 415, 423, 429, 438 seconds during 45, 90, 135, 180 days in a row as shown in Figure (6). The average projection number of flour samples at the level of the storage period in general recorded species ($P \leq 0.05$). The result of the Falling number reflects the activity of the enzyme alpha-amylase in flour samples, through the results it can be concluded that all varieties are considered incompatible with the Libyan and international standards for bread flour, which demands that the Falling number is between 250 – 350 seconds. The domestic and Ukrainian flour variety considers its activity better than the Russian and German varieties. The results of another study indicated an increase in the value of the Falling number as an indicator of a

decrease in the activity of alpha-amylase during storage under different conditions of humidity and temperature (Hruškova et al., 2002; Eshtew, 2016; Akhlaq and Alil, 2019).

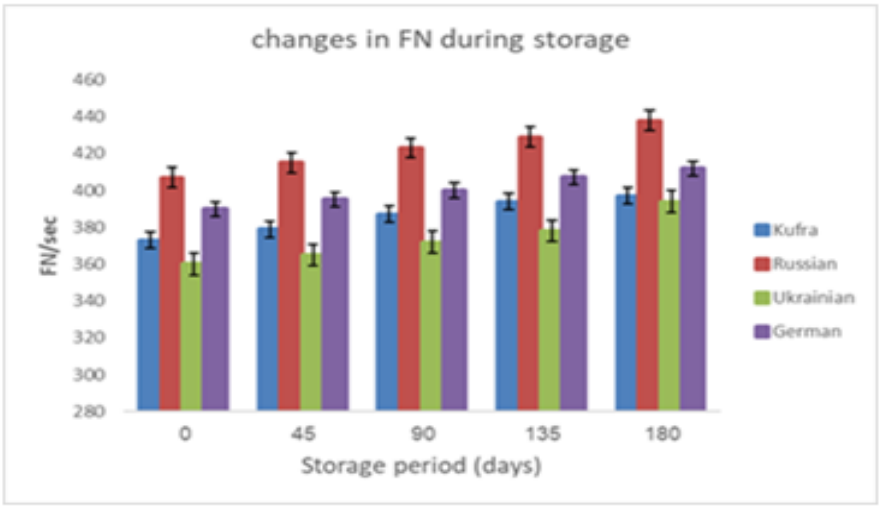

Figure 6: the effect of storage periods on the Falling number in domestic and imported wheat flour.

Rheological properties

The water absorption ratio of flour samples produced from domestic and imported spring wheat varieties varied during the storage period.it is noticeable from the results that the absorption ratio gradually decreased with increasing storage period. for example, the absorption ratio of the Russian variety, which recorded the highest absorption rate during Time 0, was 78.4% and the gradual decrease was recorded to 73.4, 68.7, 62.8, 52.52% during 45, 90, 135, 180 days, respectively. The results of storage for a period of 6 months showed that the Russian flour variety maintained the highest absorption ratio during the storage period and did not record any significant differences with the domestic variety, while both varieties recorded significant differences with both German and Ukrainian flour ($P \leq 0.05$). The percentage of water absorption for the flour of the studied wheat varieties was in accordance with N.C.S.L (2006).

The results of the dough development time Test obtained from the Farenogram curve for flour of domestic and imported wheat varieties indicated the presence of significant differences *($P \leq 0.05$)* during the storage period. The German class recorded the highest time of 4.45 minutes during the storage period 0, which was significantly different only with the Ukrainian class, while it was not significant with both the domestic and Russian class, as shown in Table (2). The average dough development time for flour varieties within 6 months showed a gradual decrease over the storage period, in general, the German variety recorded the highest dough development time, followed by the Russian and Ukrainian varieties, while the local variety recorded the lowest dough development time. The decrease in the content of domestic and Russian flour of wet gluten was reflected in the reduction of the development time, while in the case of the German variety with a high percentage of wet gluten, the development time of the dough was high.

Table 2: The effect of different storage periods on the rheological properties of the flour samples under study.

Flour type	Period (day)	Absorbance (%)	Dough development time (minute)	Stability time (minute)
Kufra	0	70.31^{b}	2.93^{c}	1.61^{d}
Russian		78.40^{a}	3.05^{b}	2.32^{c}
Ukrainian		57.64^{d}	1.49^{d}	3.19^{b}
German		57.64^{d}	4.45^{a}	7.69^{a}
Kufra	45	65.24^{b}	3.17^{b}	1.53^{d}
Russian		73.43^{a}	3.36^{b}	2.25^{c}
Ukrainian		53.40^{c}	1.62^{c}	3.12^{b}
German		54.54^{c}	4.48^{a}	7.15^{a}
Kufra	90	61.22^{b}	3.25^{c}	1.46^{d}
Russian		68.71^{a}	3.41^{b}	2.20^{c}
Ukrainian		48.66^{c}	1.70^{d}	3.10^{b}
German		49.55^{c}	4.54^{a}	7.0^{a}
Kufra	135	59.69^{a}	3.43^{b}	1.40^{d}
Russian		62.78^{a}	3.48^{b}	2.15^{c}
Ukrainian		42.15^{b}	1.80^{c}	2.96^{b}
German		44.76^{b}	4.62^{a}	6.97^{a}
Kufra	180	56.01^{a}	3.54^{b}	1.36^{d}
Russian		52.52^{a}	3.59^{b}	2.09^{c}
Ukrainian		38.44^{b}	2.10^{c}	2.82^{b}
German		38.26^{b}	4.67^{a}	6.32^{a}

Averages with similar letters in the same column for each time of storage have no significant differences between them at level (5%).

The results of the stability time test for the dough of different wheat flour varieties shown in Table (2) indicated that there were significant differences *(P≤0.05)* between the values of the averages of the studied varieties during the storage period, as the German variety recorded the highest stability time of 7.69 minutes during storage Time 0, which was significant with the rest of the Times recorded by the domestic, Russian and Ukrainian varieties. The average stability time readings for the doughs of different types of flour during the storage period in general showed significant differences between them *(P≤0.05)*. The German variety recorded the highest stability time compared to the rest of the studied varieties, while the infidel flour variety recorded the lowest stability time. The stability time is controlled by many factors, the most important of which are the genetic factors of the wheat variety and the percentage of protein, as well as the percentage of gluten, it was also found that there is a positive relationship between the stability of the dough and the amount of protein (Ayoub et al., 1993; Eshtew, 2016). The results of another study showed that the behavior of the dough of wheat flour prepared from wheat grains, which was stored for 6 months at a temperature of 20ºC, was characterized by a hard dough behavior and high maximum elasticity (Kamboj et al., 2018).

Conclusion and recommendations:

The results of this study showed that the sensory qualities and exposure to insect infestations of both local (Kufra) and Russian wheat did not match the Libyan standard during the period from June to August, in addition to the development of undesirable flavor during the same months for all types of flour studied. The results of chemical tests indicated a slight decrease in the percentage of moisture, protein, wet gluten, and an increase in the value of the Falling number per second for all types of flour and its non-compliance with the Libyan standard, non-conformity in the stability of the dough in minutes for all samples of mills under study, except flour produced from German flour due to their decrease from the minimum recommended in the standard.

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