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The Effect of Storage Methods and Periods on Four Local Varieties of Wheat in Basra Governorate

Shahad M. Iskander*, Waleed A. Jabail and Ali D. Shaaban

Department of Biology - College of Education / Qurna - Basrah University – Iraq
*Corresponding author's e-mail:qedupg.shahad.mohammed@uobasrah.edu.iq

Wheat is a staple crop essential to the diet and economy of Basra Governorate. Ensuring its quality and viability post-harvest is crucial for food security and economic stability in the region. The study was conducted during the period from November 1st ,2021, to August 1st, 2022, at the College of Education, Qurna - University of Basra. The aim is to determine the best storage method and duration for preserving wheat seeds. Four varieties of wheat seeds (Ibaa 99, Al-Baraka, Al-Rashid, Abu Ghraib) were stored using two storage methods (piles, bags) and three time periods (3 months, 6 months, 9 months). Laboratory germination tests and chemical analysis of the seeds were also performed after each storage period. The results showed that the method of storage in bags and the time period of three months was the best in preserving the seeds, and it also resulted in the highest germination percentage and fastest germination speed. Al-Baraka cultivar showed the highest average germination rate (96.38%), while Abu Ghraib cultivar gave the lowest germination rate (92.77%). In the triple interactions (varieties x storage methods x storage periods), the four cultivars x two storage methods (bags and piles) x the storage period for three months, and the same cultivars x two storage methods x the storage period for six months gave the highest germination rate, which ranged between (100 and 95). %. While, Abu Ghraib cultivar × piles method × nine-month storage period, and Al-Rasheed cultivar × piles method × nine-month storage period gave an average germination rate of (78.33 and 76.66) %, respectively. As for Al-Baraka variety, it showed the highest average germination speed (5.91), while the Al-Rasheed variety showed the lowest germination speed (5.25). In the triple interactions, the four cultivars x the two-storage methods x the storage period for three months, and the same cultivars x the two-storage methods x six months gave the highest germination speed, which ranged between (7.96 and 4.60). While, Abu Ghraib cultivar × piles method × storage period of nine months, and Al-Rasheed cultivar × piles method × storage period of nine months gave the lowest average germination (3.73 and 4.06), respectively. The results of the chemical analysis of the stored seeds showed a decline in the quality of the seeds with the length of the storage period, as the percentages of protein, starch, and fat decreased. As the cultivar Ibaa 99 gave the highest average protein percentage (11.20) %, while the Abu Ghraib cultivar gave the lowest average protein percentage (9.84%). The Al-Baraka variety gave the highest average fat percentage (1.76) %, while the Ibaa 99 variety gave the lowest average fat percentage (1.08%). As for the starch percentage, the Abu Ghraib cultivar showed the highest average (64.46) %, while the Al Baraka variety gave the lowest average starch percentage (63.03%).

Keywords: Storage methods, Storage periods, Varieties, Wheat, Fat Content, Seed Quality, Preservation, Protein Content, Starch Content.

INTRODUCTION

Wheat is a fundamental crop in Basra Governorate, playing a vital role in both local diets and the economy. Ensuring the quality and viability of wheat after harvest is essential for food security and economic stability. However, the effectiveness of various storage methods in preserving the quality of local wheat varieties over extended periods is not well understood. High temperatures and humidity in Basra pose significant challenges to wheat storage, often leading to spoilage and decreased germination rates. Traditional storage methods, such as open storage and silos, may not adequately protect against these conditions. Modern storage solutions, like sealed plastic containers, offer potential advantages but require thorough evaluation in the context of local conditions. Seed deterioration during storage is a gradual process triggered by damage to cellular components like membranes, enzymes, proteins, and nucleic acids. Over time, these

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cumulative degenerative changes lead to a complete breakdown of membranes and organelles, ultimately causing seed death and loss of germination ability (Roberts, 2012; El-Kholy, 2021; Karthikeyan *et al*., 2009). The wheat crop, *Triticum aestivum* L., is one of the most important crops that humans need in abundant quantities, as it is considered the main source of food for more than 35% of the world's population (Abboud, 2018). Wheat grains contain vitamins, minerals, and essential for protein synthesis, in addition to metabolites and beneficial dietary fiber (Eser, 2017). In order to obtain a high production of this crop, many local cultivars were developed that differ in genetic makeup, which gives each of them special characteristics in terms of productivity, quality, and tolerance to harsh conditions and fungal diseases, as well as insect pests (Al-Husseini, 2021). Among the local varieties in the agricultural sector in Iraq are (Abu Ghraib, Al-Fatah, Al-Baraka, Babel 113, Latifa, Al-Rasheed, Ibaa 99, Ibaa 95, Research 22), which vary in the amount of production (Al-Aboudi, 2019). Wheat is a winter crop in Iraq, despite being a staple food source. Therefore, people have resorted to storing wheat grains (Ismail, 2014). Storage methods are one of the reasons for the aggravation of grain losses, and thus make them vulnerable to disease or insect pests. The storage factor is one of the most important influences on the quality and quality of seeds, and thus may increase the risk of infection with storage pests and increase the rate of losses in the quantity, quality and germination rate of stored seeds in the event that the correct methods necessary for preserving seeds in storage silos are not followed, in addition to the traditional methods that are possible to be in different ways (Mohammed *et al*., 2010). The storage period is one of the environmental factors affecting the vitality of grains, and therefore it is possible to change the rate of germination and its speed when the grains are exposed to this environmental factor, and as a result it is reflected in the latent viability of grains during the growth period. Seeds that germinate quickly produce strong and fast-growing seedlings, which are better equipped to handle environmental stresses (Sonuwal *et al*., 2021).

MATERIALS AND METHODS

***Collection of wheat grains*:** The wheat seeds used in this study (Al-Baraka, Al-Rashid, Ibaa 99, and Abu Ghraib) were obtained from Al-Hartha Research Station of the Field Crops Department / College of Agriculture / University of Basra. Where 2 kg were taken and kept in paper bags, and the name of each item was recorded on it. After examining the seeds to ensure they were free of insect infestation, they were placed in a refrigerator for 72 hours to purify them from any potential infections. For the purpose of conducting the subsequent experiments, the grains were stored using two storage methods, and the seeds were examined after the end of each storage period.

***Methods of storing grains of studied wheat varieties*:** The varieties obtained according to Paragraph 2-1 were approved for the purpose of storage in the following ways, to match the local storage of approved grains for seeds for the purpose of cultivation:

***Storage in the form of open piles*:** Where the above-mentioned wheat varieties were stored in a pile method in open plastic containers at a rate of three replicates for each variety in the laboratory and at home in dark places.

***Storage using burlap bags*:** The above varieties of wheat were stored in local grain storage bags circulating in the markets called "burlap" at a rate of three replicates for each variety, and the bags were stored in the laboratory and at home as identical to the above storage conditions. Transactions were examined every three months, at a rate of three readings after 3 months, 6 months, and 9 months, with the following tests being conducted.

***Laboratory germination test*:** Four cultivars were selected for the study (Al-Baraka, Abu Ghraib, Al-Rashid, Ibaa 99), and after the end of each of the storage periods above, they were planted in pots containing peat moss after being randomly distributed using complete random distribution at a rate of 20 seeds per pot, with three replications for each method store for each of the items. The number of growing seeds was monitored and calculated on a daily basis for a period of eight days from the start of the test until 14 days. The morphological characteristics of the seedlings after germination were also tested. The experiment was carried out inside a growth chamber at a temperature of 25 °C in the Graduate Studies Laboratory.

***Germination rate calculator*:** Germination speed = number of germinated seeds in the first count / number of days from sowing to the first count + the difference between the number of seeds germinated between the first and final count / number of days between the first and final count (Maguire, 1962).

***Determination of chemical content in grains of stored wheat varieties*:** An analysis of the chemical content of grains of wheat varieties stored before storage and after each storage period was carried out in the laboratory of the Feed Quality Control Division of the Animal Wealth Department - Ministry of Agriculture, Basrah Branch, Qurna district.

RESULTS AND DISCUSSION

Laboratory germination test.:

***Germination percentage*:** The results of the statistical analysis showed that there was a significant effect of cultivars, storage methods and periods, and their double and triple interactions between varieties, storage methods and storage periods on the percentage of germination. And from the results of Table 1, we note that the Al-Baraka variety gave the highest average germination rate (96.38%), while the Abu Ghraib variety gave the lowest germination percentage (92. 77%). Increasing the length of the storage period also reduced

Table 1. Effect of cultivars, methods, storage periods and their interactions on the percentage of germination (%).

Average method x storage period	Categories				Storage periods (month)	Storage method
	Abu Ghraib	Rashid	Al Baraka	Ibaa		
100	100	100	100	100	3	piles
99.16	100	100	100	96.66	6	
84.15	76.66	78.33	93.33	88.30	9	
100	100	100	100	100	3	cysts
97.91	98.33	100	98.33	95.00	6	
86.24	81.66	90.00	86.66	86.66	9	
4.217		8.433			LSD (P<0.05)	
Average storage method						
94.43	92.22	92.77	97.77	94.98	piles	Storage method x items
94.71	93.33	96.66	94.99	93.88	cysts	
		4.869			LSD (P<0.05)	
Average storage times						
100	100	100	100	100	3	Storage periods x items
98.53	99.16	100	99.16	95.83	6	
85.19	79.16	84.16	89.99	87.48	9	
2.982		5.963			LSD (P<0.05)	
	92.77	94.72	96.38	94.43	Average items	
		3.443			LSD (P<0.05)	

the germination percentage, as the three-month period gave the highest percentage of germination (100%), while the nine-month period gave the lowest percentage (85%). The method of stocking with piles and the pond variety gave the highest average germination percentage (97.77%) without significant difference from the other two-way interactions. While, the pile method × Abu Ghraib variety gave the lowest average germination percentage (92. 22%). The interaction between storage periods and varieties showed that all four varieties had the highest germination percentage (100%) after three months of storage. While, Abu Ghraib x nine months gave the lowest germination rate (79.16%), and this may be due to the low content of seeds in terms of protein (8.19%) and starch (62.80%). As for the triple interaction (varieties × storage method × storage period), the four cultivars × two storage methods × storage period of three months, and the same cultivars × two storage methods × storage period of six months gave the highest germination rate, which ranged between (100 and 95%). While, Abu Ghraib cultivar × piles method × storage period of nine months, and Al-Rasheed cultivar × piles method × storage period of nine months gave an average germination rate of (78.33 and 76.66) %, respectively.

***Germination speed*:** The results showed that there was a significant effect of cultivars, storage methods and periods in their bilateral and triple interactions between varieties, storage methods and storage periods on germination speed. As it is clear in Table 2 that the Al-Baraka variety gave the highest average germination speed (5.91), while the Al-Rasheed variety gave the lowest average germination speed (5.25). Storage periods also had an effect on reducing the germination speed when increasing the length of the period, as the three-month period gave the highest germination speed (7.09), while the nine-month period gave the lowest rate (4.50). With regard to the storage method, the storage method by piles and the Al-Baraka variety gave the highest average Germination speed (6.05), and there were no significant differences compared to other binary interactions. While, the method of storage in piles with Al-Rasheed cultivar gave the lowest germination speed (5.25). As for the interaction between storage periods x cultivars, it was noted that the cultivar Abu Ghraib x three-month storage period gave the highest germination speed (6.71, 7.18, 6.71, and 7.76), respectively. While, Abu Ghraib cultivar x nine months gave the lowest germination speed (4.13). As for the triple interaction (varieties × storage methods × storage periods), the four cultivars × two storage methods × storage period of three months, as well as the same cultivars × two storage methods × six months gave the highest germination rate, which ranged between (7.96 and 4.60). While, Abu Ghraib cultivar × piles method × storage period of nine months, and Al-Rasheed cultivar × piles method × storage period of nine months gave the lowest average of germination speed (3.73 and 4.06), respectively.

From the results of the above Tables (1 and 2), it is clear that the storage method in bags was the best method for preserving the quality of grain, unlike the method of storage in piles, which gave the lowest value for the percentages of the studied traits. This is consistent with what was mentioned by (Ali, 2007), who stated that an open storage causes significant losses in grain weight compared to closed storage. Also, the storage period of three months was the best period in

Table 2. Effect of cultivars, storage methods and periods and their interactions on germination speed.

Average method x storage period	Categories				Storage periods (month)	Storage method
	Abu Ghraib	Rashid	Al -Baraka	Ibaa		
7.03	7.56	6.80	7.36	6.40	3	piles
5.22	4.93	4.90	5.63	5.43	6	
4.37	3.73	4.06	5.16	4.53	9	
7.15	7.96	6.63	7.00	7.03	3	cysts
4.93	4.60	4.76	5.33	5.06	6	
4.64	4.53	4.40	5.00	4.66	9	
0.6192		1.2384			LSD (P<0.05)	
average storage method						
5.53	5.40	5.25	6.05	5.45	piles	Storage
5.57	5.69	5.26	5.77	5.58	cysts	method x items
0.3575		0.7150			LSD (P<0.05)	
average storage times						
7.09	7.76	6.71	7.18	6.71	3	Storage
5.07	4.76	4.83	5.48	5.24	6	periods x items
4.50	4.13	4.23	5.08	4.59	9	
0.4378		0.8757			LSD (P<0.05)	
	5.55	5.25	5.91	5.51	Average items	
		0.5056			LSD (P<0.05)	

Table 3. the effect of cultivars, methods, storage periods and their interactions on protein percentage (%).

Average method x storage period	Categories				storage periods (month)	Storage method
	Abu Ghraib	Rashid	AI-Baraka	Ibaa		
13.65	13.20	14.40	12.50	14.50	3	piles
9.75	8.40	10.80	9.70	10.10	6	
9.32	8.28	9.96	9.17	9.87	9	
13.05	11.90	15.10	12.00	13.20	3	cysts
9.66	9.20	10.30	9.27	9.90	6	
9.22	8.10	9.95	9.20	9.64	9	
0.1518		0.3037			LSD (P<0.05)	
average storage method						
10.90	9.96	11.72	10.45	11.49	piles	Storage method x
10.64	9.73	11.78	10.15	10.91	cysts	items
0.0877		0.1753			LSD (P<0.05)	
average storage times						
13.35	12.55	14.75	12.25	13.85	3	Storage periods x
9.70	8.80	10.55	9.48	10.00	6	items
9.26	8.19	9.95	9.18	9.75	9	
0.1074		0.2147			LSD (P<0.05)	
	9.84	10.25	10.30	11.20	Average items	
		0.1240			LSD (P<0.05)	

preserving the quality and vitality of the grain, as the germination rate during this period reached (100%). This may be due to the high protein content of the four varieties of grain during this period, which ranged between (12.25, 14.75) %.
The length of the storage period was also accompanied by a decrease in the speed of the structural processes, as a result of a decrease in the activity of enzymes responsible for activating the process of germination, growth and development of seedlings, as a result of the aging process that leads to damage and oxidation of the bio-membranes and a slow rearrangement of them upon imbibition (Al-Fahd, 2016). The appearance of the difference in the traits studied above (germination percentage - speed of germination) may be due to the differences in the genotypes of the four varieties and the different chemical compositions, as the percentages of the above traits decreased with the increase in the length of the storage period, as a result of the decrease in the contents of the grains of the four varieties in terms of protein, starch and

fat. This is evident in the results of the chemical analysis, as in Tables (3, 4 and 5), which was reflected negatively on these characteristics, as the lengthening of the storage period is negatively associated with the percentage of germination and its characteristics and thus is negatively reflected on the growth and quality of seedlings (Sibande *et al*., 2015).

Chemical analysis

***Protein percentage*:** The results of the statistical analysis showed that there was a significant effect of varieties, storage methods and storage periods in their double and triple interactions between varieties, storage methods and storage periods on the protein percentage of the stored grains. It was noted from the results of Table 3, that the IPA 99 variety had the highest average protein percentage (11.20%), while the Abu Ghraib variety had the lowest average protein percentage (9.84%). This may be explained by the fact that the difference in cultivars in this trait is due to the variation in cultivars in genetic makeup, and these results agreed with what was mentioned by (Al-Abdullah, 2015; Siddiq *et al*., 2017), who indicated that wheat cultivars differ among themselves in the protein trait due to Genetic variation and the extent of the influence of each variety on the environmental factors of the

Table 4. Effect of cultivars, methods, storage periods and their interactions on fat percentage (%).

Mean methods x storage periods	Categories				storage periods (month)	Storage method
	Abu Ghraib	Rashid	Al-Baraka	Ibaa		
2.42	2.10	2.20	3.10	2.30	3	piles
1.45	1.80	1.70	0.80	1.50	6	
0.20	0.10	0.40	0.20	0.10	9	
4.37	10.30	1.90	3.60	1.70	3	cysts
1.42	1.70	0.60	2.70	0.70	6	
0.27	0.10	0.60	0.20	0.20	9	
0.1954		0.3908			LSD (P<0.05)	
average storage method						
1.35	1.33	1.43	1.36	1.30	piles	Storage method
2.02	4.03	1.03	2.16	0.86	cysts	x items
0.1128		0.2256			LSD (P<0.05)	
average storage times						
3.40	6.20	2.05	3.35	2.00	3	Storage periods
1.43	1.75	1.15	1.75	1.10	6	x items
0.23	0.10	0.50	0.20	0.15	9	
0.1382		0.2763			LSD (P<0.05)	
	1.18	1.23	1.76	1.08	Average items	
		0.1595			LSD (P<0.05)	

Table 5. Effect of cultivars, storage methods and periods and their interactions on starch percentage (%).

Average method x storage period	Categories				Storage periods (month)	Storage method
	Abu GHraib	Rashid	AI-Baraka	Ibaa		
66.52	67.50	65.20	68.30	65.10	3	piles
62.80	62.50	63.70	62.00	63.00	6	
60.80	61.70	61.10	58.70	61.70	9	
67.97	66.90	68.10	67.90	69.00	3	cysts
63.30	65.10	64.10	61.00	63.00	6	
61.85	63.10	63.50	60.30	60.50	9	
0.4327		0.8655			LSD (P<0.05)	
average storage method						
63.37	63.90	63.33	63.00	63.26	piles	Storage method
64.37	65.03	65.23	63.06	64.16	cysts	x items
0.2498		0.4997			LSD (P<0.05)	
average storage times						
67.25	67.20	66.65	68.10	67.05	3	Storage periods
63.05	63.80	63.90	61.50	63.00	6	x items
61.32	62.40	62.30	59.50	61.10	9	
0.3060		0.6120			LSD (P<0.05)	
	64.46	64.28	63.03	63.71	Average items	
		0.3533			LSD (P<0.05)	

study site. It was found that the long storage periods had an effect on reducing the protein percentage, as the three-month period gave the highest average germination rate (13.35%), while the nine-month period gave the lowest average protein percentage (26.9%). As for the storage method, the bag storage method for Al-Rasheed cultivar gave the highest average protein percentage (11.78%), without significantly differing from other binary crosses. While the bag method with the Abu Ghraib cultivar gave the lowest average protein percentage (9.73%), and this may be attributed to the same previous reasons. As for the overlap between storage periods x cultivars, the four cultivars with a storage period of three months gave the highest average protein percentage (13.85%) Whereas, the Abu Ghraib cultivar × nine-month storage period gave the lowest average protein percentage (8.19%). As for the triple overlap between (varieties x storage method x storage period), the four cultivars x two storage methods x storage period for three months, and the same cultivars x two storage methods x storage period for six months gave the highest average protein percentage, which ranged between (11.90 and 14.50) %. Whereas, the Abu Ghraib cultivar in the heap storage method × the storage period for nine months, and the same cultivar in the bag method × the storage period for nine months gave the lowest average protein percentage (8.28, 8.10) %, respectively.

***Fat percentage*:** The results of the statistical analysis also showed that there was a significant effect of the varieties, methods and storage periods in their binary and triple interactions between the varieties, methods and periods of storage in the percentage of fats in grains, as in Table 4. Where it was observed that the Al-Baraka variety gave the highest average fat percentage (1.76) %, while the Ibaa 99 variety gave the lowest average fat percentage (1.08%). This may be due to the genetic difference and the chemical composition of the grains of the cultivars. The results also showed that the length of the storage periods had a significant effect on reducing the fat percentage, as the three-month storage period gave the highest average fat percentage (3.40%), while the nine-month period gave the lowest average fat percentage (0.23%). The bag method with the Abu Ghraib cultivar gave the highest average percentage of fat (4.3%), and it differed significantly from the other two-way interactions. While, the cultivar Ibaa 99 in the pile method gave the lowest average percentage of fat (0.86%). This can be attributed to the low percentage of protein in the grains of the Abu Ghraib cultivar, Table 3, where the percentage of fat was inversely proportional to that of protein. As for the interaction between storage periods x varieties, the four varieties with a storage period of three months gave the highest percentage of fat, which ranged between (2.00 and 6.20) %. Whereas, the Abu Ghraib cultivar × nine-month storage period gave the lowest average fat percentage (0.10%). As for the triple interaction between (varieties x storage method x storage period), (the four varieties x two storage methods x storage period for three months), and (the same cultivars x two storage methods x storage period for six months) gave the highest average percentage of fat, which ranged between (0.80 and 10.30) %. As for (the Abu Ghraib cultivar x bag method x storage period for nine months), (the same cultivar x pile method x nine months period) gave the lowest average fat percentage (0.10%). The deterioration in the fat percentage of grains can be attributed to the long storage period, as the fat decomposes easily and this is a major reason for the loss of grain quality, and the sensitivity to fat spoilage varies according to the genetic makeup of the wheat cultivars (Alconada and Moure 2022).

***Starch percentage*:** The results of the statistical analysis also showed that there was a significant effect of the varieties, methods and storage periods in their binary and triple interactions between the varieties, methods and storage periods in the starch percentage of the grains. As shown in Table (5), the Abu Ghraib cultivar gave the highest average starch percentage (64.46) %, while Al Baraka cultivar gave the lowest average starch percentage (63.03%), due to the genetic and structural differences between the cultivars. Storage periods also had a significant effect on reducing the percentage of starch in grains when the storage period increased, as the storage period for three months gave the highest average percentage of starch (67.25%), while the storage period for nine months gave the lowest percentage (61.32%). This may be attributed to the fact that the long storage period reduces the qualitative characteristics of the grain. this finding is consistent with (Azadi and Younesi, 2013), who stated that the prolonged storage period negatively affects the qualitative characteristics of the grain, as most of the qualitative characteristics of the grain decreased after being stored for eight months compared to with their qualities before storage. The method of storage in bags with Al-Rasheed cultivar gave the highest average percentage of starch (65.23) %, without significantly differing from the other two-way interactions. While, Al-Baraka variety gave the lowest average starch percentage (63.00%). As for the interaction between storage periods x varieties, it was found that the four varieties during the three-month storage period gave the highest average starch percentage (68.10) %, while the same variety during the nine-month storage period gave the lowest average starch percentage (59.50%). This may be due to the decomposition of starch by the action of enzymatic and microbial activity and respiration in wheat grains, and this is fully consistent with the results of (Junnan *et al.*, 2018). As for the triple interactions between (varieties x storage method x storage period), (the varieties x two storage methods x storage period for three months), and (the same varieties x two storage methods x storage period for six months) gave the highest average percentage of starch, which ranged between (65.10-69.00) %. Whereas, Al-Baraka variety × pile method × nine months gave the lowest mean of starch percentage (58.70%).

***Conclusions*:** Through the results of the current experiment, we conclude that the storage method by using bags gave the best results in maintaining the quality of the stored grains, and that the storage period for three months preserved most of the specific characteristics of the grains, and gave the highest value for the proportions of protein, fat and starch. Therefore, depending on the results of the experiment and its consistency with the results of some previous studies, we can recommend the following: The need to educate cereal farmers about storing grain using bags and for a storage period not exceeding 6 months, because it has a positive effect in preserving grain from spoilage.

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Contribute to the idea, field implementation, writing, data collection and analysis of data. All authors contribute to fieldwork, linguistic and statistical review

All authors read and approved the final manuscript.

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