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Effect of Drying Methods and Storage Periods on Wheat (*Triticum aestivum* L.) Quality Parameters

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Abstract

Objectives: To assess the effect of different drying methods on wheat grain quality, find out suitable storage and drying method. **Methods/Statistical Analysis**: The present research was carried out to determine the effect of drying methods (Sun dry, Air dry and Oven dry) and storage periods (90 and 180 days) on wheat quality parameters. The differences among the treatment's means were compared by the HSD test. **Findings:** The results indicated that hardness, germination capacity, protein and starch decreased greatly in all types of drying methods with the progress of storage period. The maximum hardness, germination capacity, protein and starch were recorded in the sun drying method followed by oven drying method under the storage period of 90 days. The minimum performance of these parameters was recorded in air drying method under the storage period of 180 days, this, may be due to presence of moistness and infestation of insect attacks. The highest values of all the tested parameters except moisture content were observed in sun drying method in the storage period of 90 days. The maximum moisture content was recorded in air drying method, while sun drying method ranked second for moisture content in the seed kept for 90 days. Minimum moisture content was noticed in oven drying method in the seed kept for 180 days. Air drying method proved worst as compared to sun drying and oven drying methods. The decreasing trend of tested traits was noticed with the increasing storage periods. The storage of period of 90 days gave the highest values in various observed traits as compared to 180 days. **Application/Improvements:** The Sun drying method should be used to store wheat at desired environment where grain could not be under stress and the place of stored grains must be changed after the storage of 90 days.

Keywords: Drying methods, Storage periods, Quality parameters, wheat

1. Introduction

The storage of wheat is practiced from the beginning of human civilization. Storage of wheat is the most important practice because the production of cereals is location specific and seasonal[1]; nonetheless, the utilization of cereals is constant throughout the year. Storage of cereals is essential in context to ensure smooth supply to distant areas for the whole year. Deterioration of produce may start in standing crop, which further elevates during

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unscientific storage. The primary factors affecting the grain storage are moisture, temperature, and humidity of storage environment. The safe moisture content for storage of wheat is 14-15% at 25 0C and 75% relative humidity. Other factors responsible for deterioration are poor containers/warehouses, feeding by rodents, insect pests, and microorganisms. Both primary and secondary factors bring chemical changes and weight loss as well as changes in quality[2].

The loss in seed viability will increase with prolonged storage period. In[3] found that increasing storage period from 6 to 30 months decreases the germination percentage and emergence from 85 to 10%, and also seedling lengths and dry weight were decreased during storage. In[4] studied the effect of storage period on wheat seed quality. The results revealed that prolonging storage period reduced germinability, seedling vigor and accelerated aging germination. Meanwhile, prolonging storage period increased mean germination time, electrical conductivity and dry weight losses of the seed. In[5] found that when the storage period increased the seed germination decreased.

Temperature and humidity of environment increase very rapidly during the rainy season of Pakistan, which starts about two months after harvesting of wheat. This period is favorable for insects and microbial attack on stored food commodities. During this period, biochemical changes occur in grains by the action of enzymes such as lipases, proteases, and amylases on lipids, proteins, and starches respectively, thus deteriorating the end use quality of wheat. A significant decrease in moisture content, amylase activity, pH and increase in titratable acidity was observed during storage of wheat at 45 0C. However, no significant biochemical changes occurred during storage at 10 0C[6]. Different containers behave differently in maintaining grain quality during storage, even under the same environmental conditions. Storage of wheat grains in tin containers at high temperature and moisture contents showed more increase in fat acidity than those stored in cotton and jute bags, thus lowering of the baking quality scores of wheats[7].

Among the various causes of losses, the improper drying before storage has also the major share. The act of drying is a well-established method for the preservation of various agricultural commodities. Open sun drying, drying in the bags and mud-plastered drying, are the commonly used methods of grains drying. The required days for the drying of different crops in the open sun ranges from 5 to 45 days depending upon the crop to be dried. The presence of favorable weather conditions has also great importance during the drying period because the unfavorable conditions produce damages in grain quality which becomes unavoidable[8].

After harvesting, drying is the main technological factor which determines the wheat quality characteristics, like protein, gluten, etc. The low or high-temperature drying can cause the protein denaturation and reduce the grain quality[9]. Protiec extraction is reduced by the temperature of higher than 60 0C. Wheat crop harvested with low moisture content produced the reduction in gluten extraction among drying temperature above than 75 0C; while wheat harvested with higher moisture reduced the proteic extraction[10]. Due to all these conditions, an experiment was conducted for combating these situations.

2. Materials and Methods

The present research was carried out at the Student Farm and Seed Testing Laboratory department of Agronomy, Sindh Agriculture University, Tandojam during 2016, to determine the effect of drying methods and storage periods on wheat quality parameters. The experimental details are given as under:

Experimental design: Complete Randomized Design (CRD) factorial
Replications: Three
Variety: Kiran-95
Treatments: Two factors (A and B)
Factor - A: (Drying methods) = 03
M1 = Sun dry
M2 = Air dry
M3 = Oven dry
Factor – B: (Storage periods) = 02
S1 = 90 (DAH)
S2 = 180 (DAH)
Following parameters were recorded

1. Hardness (%)
2. Moisture (%)
3. Germination capacity (%)
4. Protein (%)
5. Starch (%)

Methods of Determination:
Procedure: The sample of wheat was analyzed on Infrematic grain analyzer, for the following parameters.

1. Hardness (%)

2. Moisture (%)
3. Protein (%)
4. Starch (%)

300 gram of clean sample of wheat grain was run on Infrematic Grain Analyzer by feeding the sample in chamber and reading was appeared on digital screen of the Infrematic Grain Analyzer within one minute. The model number of the equipment was IM 9200-Infrematic Grain Analyzer by Perten Company.

Germination capacity (%): From each packing store samples of 100 seeds were taken and placed in petri dishes in germination cabinet programmed controlled maintain at 25 ^{0}C to determine the germination percentage. Each petri dish was moistened every day with distilled water to facilitate germination of seeds. The number of germinated seeds after 24 hours was recorded. The germination percentage calculated as follows:

Germination percentage=Number of seedling emerged/Number of seeds sown x 100.

Statistical Analysis: The statistical analysis was performed using the Statistix 8.1 analytical software. The data were subjected to factorial analysis of variance (ANOVA) to determine the significance of individual factors and their interactions. The differences among the treatment's means were compared by the HSD test, where necessary.

3. Results

Results of all the parameters collected and presented in Tables 1–6 and are interpreted in the following pages, whereas its analysis of variances are given as Appendix-I-V.

Table 1. Average ambient temperature and relative humidity at the experimental site SAU, Tandojam during storage period

Month	Temperature		Relative humidity %
	Maximum ^{0}C	Minimum ^{0}C	
April	40.67	21.23	42.30
May	45.55	26.39	49.58
June	44.83	28.13	52.00
July	41.45	28.10	61.19
August	38.97	26.35	67.71
September	40.46	25.00	59.60

Table 2. Hardness (%) of wheat variety Kiran-95 as affected by drying methods and storage periods

Storage periods	Sun drying	Air drying	Oven drying	Mean
90 DAH	11.36	9.93	10.36	10.55**a**
180 DAH	11.00	9.61	10.23	10.28**b**
Mean	11.18a	9.77c	10.29b	

Table 3. Moisture (%) of wheat variety Kiran-95 as affected by drying methods and storage periods

Storage periods	Sun drying	Air drying	Oven drying	Mean
90 DAH	11.16	12.00	9.93	11.03**a**
180 DAH	10.60	11.50	9.43	10.51**b**
Mean	10.88b	11.75a	9.68c	

Table 4. Germination capacity (%) of wheat variety Kiran-95 as affected by drying methods and storage periods

Storage periods	Sun drying	Air drying	Oven drying	Mean
90 DAH	84.00	79.00	82.00	81.66**a**
180 DAH	75.00	70.66	72.00	72.55**b**
Mean	79.50a	74.83c	77.00b	

Table 5. Protein (%) of wheat variety Kiran-95 as affected by drying methods and storage periods

Storage periods	Sun drying	Air drying	Oven drying	Mean
90 DAH	10.56	10.00	10.43	10.33**a**
180 DAH	10.46	9.93	10.33	10.24**b**
Mean	10.51a	9.96c	10.38b	

3.1 Ambient Temperature and Relative Humidity

The mean ambient temperature and mean relative temperature in store room for the storage period starting from April 1, 2016 to September 30, 2016 are presented

in Table 1. The highest temperature was recorded in the month of May, after that it gradually decreased. In case of relative humidity, the lowest humidity was observed in the first storage month of April, after that it was increased averagely, in each month.

Table 6. Starch (%) of wheat variety Kiran-95 as affected by drying methods and storage periods

Storage periods	Sun drying	Air drying	Oven drying	Mean
90 DAH	73.33	71.30	71.96	72.20**a**
180 DAH	69.53	66.46	66.80	67.59**b**
Mean	71.43a	68.88c	69.38b	

3.2 Hardness (%)

The data in relative to hardness (%) as affected by storage periods and drying methods is presented in Table 2 and its analysis of variance is given as Appendix-I. It was observed that hardness (%) of wheat variety Kiran-95 was influenced significantly (P<0.05) by storage periods and drying.

The results indicated that maximum hardness (10.55%) was recorded in seeds stored for 90 days. However, minimum hardness (10.28%) was noted in seeds kept for 180 days. In case of drying methods, maximum hardness (11.18%) was observed in sun drying method, followed by 10.29% hardness in oven drying method. However, minimum hardness of 9.77% was noted under sun drying method.

Interactive effect of storage periods x drying methods showed significant differences for this parameter. The maximum hardness (11.36%) was recorded in sun drying method kept for 90 days. However minimum hardness (9.61%) was noted in air drying method kept for 180 days.

Factor	HSD at 5%
Drying methods	0.31
Storage periods	0.21
Drying x Storage	0.56

3.3 Moisture (%)

The data in relative to moisture (%) as affected by storage periods and drying methods is presented in Table 3 and its analysis of variance is given as Appendix-II. It was observed that moisture (%) of wheat variety Kiran-95 was influenced significantly (P<0.05) by storage periods and drying.

The results indicated that maximum moisture (11.03%) was recorded in seeds stored for 90 days. However, minimum moisture (10.51%) was noted in seeds kept for 180 days. In case of drying methods, maximum moisture (11.75%) was observed in air drying method, followed by 10.88% moisture in sun drying method. However, minimum moisture of 9.68% was recorded in oven drying method.

Interactive effect of storage periods x drying methods showed significant differences for this parameter. The maximum moisture (12.00%) was recorded in air drying method kept for 90 days. However minimum moisture (9.43%) was noted in oven drying method kept for 180 days.

Factor	HSD at 5%
Drying methods	0.52
Storage periods	0.35
Drying x Storage	0.94

3.4 Germination Capacity (%)

The data in relative to germination capacity (%) as affected by storage periods and drying methods is presented in Table 4 and its analysis of variance is given as Appendix-III. It was observed that germination capacity (%) of wheat variety Kiran-95 was influenced significantly (P<0.05) by storage periods and drying.

The results indicated that maximum germination capacity (81.66%) was recorded in seeds stored for 90 days. However, minimum germination capacity (72.55%) was noted in seeds kept for 180 days. In case of drying methods, maximum germination capacity (79.50%) was observed in sun drying method, followed by 77.00% germination capacity in oven drying method. However, minimum germination capacity of 74.83% was recorded in air drying method.

Interactive effect of storage periods x drying methods showed significant differences for this parameter. The maximum germination capacity (84.00%) was recorded in sun drying method kept for 90 days. However minimum germination capacity (70.66%) was noted in air drying method kept for 180 days.

Factor	HSD at 5%
Drying methods	0.58
Storage periods	1.06
Drying x Storage	2.86

3.5 Protein (%)

The data in relative to protein (%) as affected by storage periods and drying methods is presented in Table 5 and its analysis of variance is given as Appendix-IV. It was observed that protein (%) of wheat variety Kiran-95 was influenced significantly (P<0.05) by storage periods and drying.

The results indicated that maximum protein (10.33%) was recorded in seeds stored to 90 days. However, minimum protein (10.24%) was noted in seeds kept for 180 days. In case of drying methods, maximum protein (10.51%) was observed in sun drying method, followed by 10.38% protein in oven drying method. However, minimum protein of 9.96% was noted in air drying method.

Interactive effect of storage periods x drying methods showed significant differences for this parameter. The maximum protein (10.56%) was recorded in sun drying method kept for 90 days. However minimum protein (9.93%) was noted in air drying method kept for 180 days.

Factor	HSD at 5%
Drying methods	0.10
Storage periods	0.06
Drying x Storage	0.18

3.6 Starch (%)

The data in relative to starch (%) as affected by storage periods and drying methods is presented in Table 6 and its analysis of variance is given as Appendix-V. It was observed that starch (%) of wheat variety Kiran-95 was influenced significantly (P<0.05) by storage periods and drying.

The results indicated that maximum starch (72.20%) was recorded in seeds stored for 90 days. However, minimum starch (67.59%) was noted in seeds kept for 180 days. In case of drying methods, maximum starch (71.43%) was observed in sun drying method, followed by 69.38% starch in oven drying method. However, minimum protein of 68.88% was recorded in air drying method.

Interactive effect of storage periods x drying methods showed significant differences for this parameter. The maximum starch (73.33%) was recorded in sun drying method kept for 90 days. However minimum starch (66.46%) was noted in air drying method kept for 180 days.

Factor	HSD at 5%
Drying methods	1.17
Storage periods	0.77
Drying x Storage	2.08

4. Discussion

Production of wheat is seasonal and its utilization is practically uniform consistently. The majority of the wheat production is held by the farmers for their own utilization and for seed. Because of this, the excessive quantity of grains has to be saved in context to utilization in its off-season. During the storage of wheat grains, a chunk part of the cereal is damaged by the different factors. Among the various causes of losses, the most essential one is improper drying before storage. The protection of agricultural commodities by drying well-established practice. Sun drying in the open is the conventional method of seed drying and also other cash crops. The required drying time in the open sun for these crops ranges from 5 to 45 days relying on the product to be dried. Undesirable climatic conditions are likely to occur during the drying time frame and debasement in quality of the final product, therefore, becomes unavoidable. So, in this regard research was carried out to estimate the effect of drying methods and storage periods on the grain quality parameters.

The temperature and moisture content of the stored grain varied with time because of changing weather conditions. The maximum temperature was recorded in the month of May, after that, it was gradually decreased. The average temperature remained 41.98 0C during the whole research period. The lowest temperature was noted in the month of August. In the case of relative humidity, the lowest humidity was observed in the first storage month of April, after that, it was increased averagely, each month. The maximum humidity was measured in the month of August. The average relative humidity remained around 55.40% throughout the storage period.

4.1 Hardness (%)

The hardness ranged from 9.61 to 11.36% throughout the storage periods in all drying methods. On an average, the maximum hardness showed by sun drying method (11.18%), while the minimum exhibited by air drying (9.77%). In case of storage periods it was observed that maximum hardness 10.55% was noted in seeds stored for 90 days. However, minimum hardness 10.28% was recorded in seeds stored for 180 days. The interactive results indicated that the maximum hardness was recorded in sun drying method (11.36%) under the 90 DAH followed by sun drying method (11%) under the

180 DAH, whereas the minimum was recorded in air drying method (9.61%) under the 180 DAH followed by air drying method (9.93%) in 90 DAH.

4.2 Moisture (%)

Moisture content is one of the major factors which alter the quality of wheat grain during the storage. Regular monitoring of store houses is important for identifying possible damages related to seed moisture which may cause grain weight and quality losses. The grains had moisture content 12.50% before storage. Moisture content gradually deceased in all three types of drying methods throughout the storage period. This is confirm with the results reported at the end of storage, there was a significant decrease in moisture contents in all the containers compared with the moisture content before storage. The highest moisture (12%) was measured in air drying method in 90 DAH followed by air drying method (11.50%) in 180 DAH, whereas, the lowest moisture (9.43%) was noted in oven drying method under 180 DAH followed by oven drying method, under the 90 DAH (9.93%). In case of storage periods it was observed that maximum moisture content 11.05% was noted in seeds stored for 90 days. However, minimum moisture content 10.51% was recorded in seeds stored for 180 days. The moisture content ranged from 9.43 to 12% throughout the storage periods in all drying methods. Our results are also conformity with Buriro[11,12] who reported the decrement of about 3% in moisture content during the storage.

4.3 Germination capacity (%)

The germination capacity ranged from 72 to 84% during storage periods in all the drying methods. The maximum germination capacity (84%) was recorded by sun drying method in storage period of 90 DAH followed by oven drying method (82%) the seeds kept for period of 90 DAH, while the lowest germination capacity was observed in air drying method (70.66%) followed by oven drying (72%) in the storage period of 180 days. In case of storage periods it was observed that maximum germination capacity 81.66% was noted in seeds stored for 90 days. However, minimum hardness 72.55% was recorded in seeds stored for 180 days. The main reason of falling germination capacity of the grains was due to insect infestation and retention of moisture content. The sun and oven drying methods gave the higher germination capacity than the air-drying method. This may be due to quick moisture losses. These results are confirmed by [13] who reported that 5-17% reduction in seed germination when grain was stored in concrete bins; the seed germination was higher against metal bins. In also reported the losses up-to 15% in the germination capacity throughout the storage period.

4.4 Protein (%)

The decrement in protein content was noticed throughout the storage period. The decrement in protein content might be due to the higher insect and fungal invasion on the wheat. The protein content ranged from 9.93 to 10.56% during storage periods in all the drying methods. The greatest amount of protein (10.56%) was recorded by sun drying method in 90 DAH followed by sun drying method (10.46%) under the 180 DAH, whereas, the lowest protein was observed in air drying method (9.93%) under 180 DAH followed by air drying method in 90 DAH (10%). In case of storage periods it was observed that maximum protein 10.33% was noted in seeds stored for 90 days. However, minimum protein 10.24% was recorded in seeds stored for 180 days. In our research, protein content was within the acceptable range as reported by [14,15] noticed a decline in protein content of maize amid 1-year stockpiling under surrounding conditions due to usage of proteins as a source of energy for fungi development metabolism. Our outcomes are in conformity with[13] who observed the decrement of about 0.9% in protein content of wheat grain during the storage periods of wheat.

4.5 Starch (%)

Starch content of kernel significantly diminished with respect to the storage period. The starch content ranged from 66.46 to 73.33% during storage periods in all the drying methods. In case of storage periods it was observed that maximum starch 72.20% was noted in seeds stored for 90 days. However, minimum starch 67.59% was recorded in seeds stored for 180 days. The damages of starch content can be a result of higher insect and fungal growth in the stocked kernels. The maximum starch (73.33%) was recorded by sun drying method in 90 DAH followed by oven drying method (71.96%) under the 90 DAH, whereas, the lowest starch was observed in air drying method (66.46%) in 180 DAH followed by oven drying (66.80%) in 180 DAH. These results are confirmed by [16] who observed changes in nutritional composition of the grain of different wheat varieties, when subjected to artificial infestation

with insects. The findings of Buriro[13] are also supporting my result. They reported the losses up to 7% in starch of wheat during throughout the storage period.

5. Summary, Conclusion and Recommendations

5.1 Summary

The present research was carried out to study the effects of drying methods (Sun drying, Air drying and Oven drying) on wheat variety Kiran-95 for 180 DAH of storage in the laboratory of Department Agronomy, Sindh Agriculture University, Tandojam during the year 2016. Hardness, moisture, germination capacity, protein and starch were recorded throughout the storage period and changes in the quality of stored grain were evaluated in terms of these variables.

The mean squares from analysis of variance revealed that drying methods and storage periods differed significantly for all the parameters under study, signifying the reliability of used materials for further breeding experiments in order to improve bread wheat quality.

The sun drying, air drying and oven drying methods were used as the drying methods in storage periods the hardness, moisture, germination capacity, protein and starch contents were decreased with the increase of storage period of wheat grain.

The maximum hardness, germination capacity, protein and starch were recorded in the sun drying method followed by oven drying method. The minimum performance of these parameters was recorded in air drying method. The maximum moisture content was recorded in air drying method while sun drying method ranked second for moisture content. Minimum moisture content was noticed in oven drying method.

5.2 Conclusion

It is concluded that the hardness, germination capacity, protein and starch decreased greatly in all types of drying methods with the progress of storage period. The sun drying method has the lowest decrease percentage in all the tested quality parameters of wheat, except moisture content.

Air drying method proved worst as compared to sun drying and oven drying methods, this may be due to presence of the higher moisture content.

The decreasing trend of tested traits was noticed with the increasing storage periods. The storage period of 90 days gave the highest values in various observed traits as compared to 180 days.

5.3 Recommendations

1. The storage life of other wheat varieties should also be determined.
2. Further research may be conducted to evaluate the effect of various parameters on the storage of wheat grain.
3. More research is suggested, so that the results of the present investigation may be confirmed.
4. Certain other drying methods may investigate for better results as compare to this study.
5. Sun drying method should be used to store wheat at desired environment where grain could not be under stress.
6. The minimum time period of storage should be used where possible, and the health of grain also would be maintained by the proper management like, the place of stored grains must be changed after the storage of 90 days.

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