

STUDIES ON THE PRESERVATION OF FOODGRAINS UNDER NATURAL AIRTIGHT STORAGE

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ABSTRACT

Studies were undertaken to determine the losses and eco-climatic conditions of foodgrains viz temperature, oxygen concentration, moisture content, germination, damaged grain, insect fauna, free fat acidity and alcoholic acidity in some of the underground storage structures.

Two types of underground structures (1) made up of brick masonry and plastered with Cement ("Pucca Khattis") and (2) structures without any brick masonry or cement plaster ("Kaccha Khattis") were selected for these studies. It is concluded from the results that there was an increase in temperature from top to bottom layers of both types of structures. The grain in "Kaccha Khattis" remained cooler as compared to the grain in "Pucca Khattis". The oxygen content in both types of structures was much lower than normal. More spoilage was observed in top layers. The stored grain pests were present only in the top layers. Continuous decrease in FFA and alcoholic acidity was observed from top to bottom layers in both structures.

INTRODUCTION

Preservation of foodgrains under natural airtight underground storage has long been practised in India and other countries. Absence of insect attack has been reported to be a good feature of underground storage structures. In fact, this easy way of solving the insect problems has caught the imagination of many workers in different parts of the world and many investigations have been carried out to understand the cause of insect death in airtight condition.

There are various types of underground storage structures in India

viz Khatti (U.P. & Punjab), Khani (Orissa), Patra (Andhra), Kondi and Banda (M.P) etc. Studies were undertaken to determine the losses and eco-climatic conditions of foodgrains in some of the underground storage structures.

MATERIALS AND METHODS

Description of Khattis (underground storage structures): where the sub-soil water is low, underground cellars known as "Khattis" are used for storage of foodgrains. A "Khatti" is an underground pit with a narrow circular opening at the top, about 2.5 feet in diameter, through which a man can pass. It is usually 15 ft to 16.5 ft deep and can usually take 24 to 32 tons.

Generally wheat, barley, peas, gram and maize are stored. This method of storage is extremely cheap. A "Khatti" once made, is serviceable for years. In some parts where this method is prevalent, "Khattis" as old as 100 years have been observed.

Before putting in the grain, a layer of straw is placed at the bottom and against the walls. When it is full, its mouth is closed with straw and plastered with mud in flush with the surface of the ground, a man goes down into the "Khatti" with a basket, which is pulled up by means of two thick ropes at opposite ends on the rim of the basket.

The most serious defect in this storage is that the grain absorbs moisture from the walls and turns black and becomes sometimes unfit for human consumption.

During the present investigations four Khattis made up of brick masonry with cement (Pucca Khattis) at Shamli and ten "Kaccha Khattis" (underground pits without any brick masonry or cement plaster) at Hapur were selected for the studies. The "Khattis" were filled with grain during April and May and the observations were made during November and December just before removal of grain for sale by the traders. The general information about these "Khattis", is given in Table 1. The "Khattis" were opened and oxygen concentration and temperature in the bulk at different depths were recorded. Samples of grain were withdrawn from the same places using a "Thermosampler". The grain samples were

analysed for moisture content, germination, damaged grain, insect fauna, free fat acidity and alcoholic acidity. All the observations were made at the top of the "Khattis" and at depth of 0.46, 1.0, 2.0 and 2.5 meters.

Recording of temperature:

Temperature measurements were made by using a "Telemex" temperature recording unit. The probe was inserted in the grain at desired depths and was left undisturbed for 3 minutes at the same place and the temperature was recorded on the scale.

Determination of moisture:

The samples of grain from desired depths were taken out and the moisture percentage was recorded using a moisture meter (Ceratester).

Determination of oxygen:

Oxygen concentrations were estimated using a Beckman oxygen analyzer model D2. The air intake tube of the oxygen analyzer was inserted in the grain bulk at desired depths with the help of an iron rod. Air was sucked and oxygen percentage was recorded on the scale.

Determination of germination:

The grain samples were mixed thoroughly and 100 grains were taken in a Petri dish for testing. They were washed with 0.1 per cent mercuric chloride solution followed by distilled water. The grains were kept on moist filter paper at 90 percent humidity and 30°C temperature for 7 days. After 7 days the sprouted grains were counted and the germination percentage was recorded. There were three replications for each sample.

Determination of percentage damaged grain:

One hundred grains from thoroughly mixed samples were taken in an enamelled plate and the damaged grains (damaged by moulds, heating and insects) were picked out, counted and expressed as damage percentage. There were three replications for each sample.

Estimation of alcoholic acidity:

The alcoholic acidity was estimated according to ISI method using 5 gms sample 11.

Estimation of free fat acidity:

FFA was estimated according to AACC method 12.

RESULTS AND DISCUSSIONS

In these studies four "Pucca Khattis", two filled with wheat and another two with gram and ten "Kaccha Khattis", eight filled with wheat and one each with maize and peas were examined after a storage period from 7-9 months (Table 1).

TABLE 1

General information about the "Khattis" which were studied

S. No.	Place	Type of Khatti	Capacity (quintals)	Commodity stored	Variety	Duration of storage (months)	Remarks
1	Shamli	Pucca	180	Wheat	K. 68	8	Average of two Khattis
2	"	"	180	Gram	--	8	- do -
3	Hapur	Kaccha	160	Wheat	Dara	7	Average of four Khattis
4	"	"	160	Maize	--	9	
5	"	"	160	Wheat	S. 227	9	Average of four Khattis
6	"	"	160	Peas	--	9	

The "Kaccha Khattis" are located in a well drained area where some gain in weight in grain after a normal storage period is observed by the traders. The results obtained are summarised in Tables 2 and 3.

Temperature:

There is a slight increase in temperature from top to bottom layers

in both type of "Khattis" (Pucca and Kaccha). The temperature in "Pucca Khattis" ranged from 35.5 to 42.5°C, while in "Kaccha Khattis" it ranged from 24.5 to 36.0°C. However, the temperature difference in the bottom layers was not significant in any "Khatti". The data indicate that the grain in "Kaccha Khattis" remained cooler as compared to the grain stored in "Pucca Khattis". The lower temperature in the top layers may be due to the lower atmospheric temperatures.

Moisture:

In the "Pucca Khattis" the moisture content of grain in the top layers was less than in the middle and bottom layers, while in "Kaccha Khattis" it was reverse.

In the "Kaccha Khattis" Nos. 4, 5 and 6 the grain in the top layers had very high moisture contents as compared to the remaining lots. The grain near the side walls of "Khattis" also showed higher moisture contents. This is perhaps due to the fact that they are in the open and rain water might have percolated into the "Khattis" and the top layers of grain absorbed the water. The lower moisture content in the grain of top layers in "Pucca Khattis" may be because of driage and the construction is such that no rain water can enter in these "Khattis".

Oxygen:

The oxygen content in the "Khattis" of both types, was much lower than normal. The oxygen percentage in "Pucca Khattis" ranged from 3.5 to 10.0 per cent, while in "Kaccha Khattis" it ranged from 0.0 to 18.5 per cent. In the deeper layers slightly more oxygen was present in "Pucca Khattis" as compared to "Kaccha Khattis" as in "Khatti" No. 5 (Kaccha Khatti) there was only 2.0 per cent oxygen at a depth of 1.0 meter, while even in the deepest layers i.e. at a depth of 2.5 meters, there was 3.5 to 4.0 per cent oxygen in "Pucca Khattis" (Khatti Nos. 1 and 2).

The lowering of oxygen in both types of "Khattis" is due to respiratory activities of grain. More reduction in oxygen content in "Kaccha Khattis" was perhaps due to higher respirative activities as

TABLE 2

Various observations in the "Pucca Khattis".

Khatti No.	Depth of observation (meters)	Temperature (°C)	Moisture content (%)	Oxygen (%)	Damaged grain (%)	Germination (%)	FFA mgs./100 gms	Alcoholic acidity (%)	No. of insects in 100 gms-sample	Remarks
1	Top	35.5	10.1	10.0	24	9	32	0.072	10 larvae	(T.granarium)
	0.4	40.0	10.8	5.5	8	62	19	0.072	---	
	1.0	40.0	10.9	4.5	2	91	18	0.072	---	
	2.0	41.0	10.9	4.5	1	96	16	0.070	---	Average of
	2.5	41.0	11.0	3.5	2	94	15	0.068	---	two Khattis
2	Top	36.5	7.9	5.0	3	85	25	0.127	3 adults	(Alphitobius)
	0.4	40.0	9.4	5.0	1	86	23	0.098	"	"
	1.0	42.5	9.4	5.0	0	92	22	0.108	"	"
	2.0	42.5	10.0	4.5	1	94	23	0.117	"	"
	2.5	42.5	10.1	4.0	0	96	23	0.078	"	"

TABLE 3

Various observation in the "Kaccha Khattis".

Khatti No.	Depth of observation (meters)	Temperature (°C)	Moisture content (%)	Oxygen (%)	Damaged grain (%)	Germination (%)	FFA mgs./100 gms	Alcoholic acidity (%)	No. of insects in 100 gms-sample adults larvae	Remarks
3	Top	29.5	13.2	9.0	35	0	46	0.116	11	(Alphitobius)
	0.4	32.5	11.8	5.0	15	10	25	0.107	---	
	1.0	35.0	11.1	3.5	8	78	20	0.083	---	Average of four Khattis
	2.0	36.0	9.7	3.0	7	87	19	0.068	---	
	2.5	36.0	9.7	2.0	3	94	16	0.066	---	
4	Top	24.5	26.5	18.5	35	0	135	0.210	---	
	0.4	25.5	16.5	13.0	20	0	118	0.196	---	
	1.0	32.0	15.5	4.0	8	10	104	0.186	---	
	2.0	32.5	13.5	0.0	4	10	88	0.173	---	
	2.5	32.5	13.5	0.0	0	16	80	0.150	---	
5	Top	25.0	19.5	15.5	31	0	70	0.144	6	4 (Alphitobius)
	0.4	29.0	19.0	4.5	17	6	63	0.085	---	
	1.0	31.0	13.5	2.0	12	68	36	0.057	---	Average of four Khattis
	2.0	33.5	11.0	1.0	4	71	28	0.055	---	
	2.5	34.0	11.0	0.5	3	92	16	0.049	---	
6	Top	25.0	15.0	7.0	100	0	59	0.178	---	
	0.4	26.5	7.5	5.5	4	8	48	0.127	---	
	1.0	28.0	7.1	2.5	4	20	42	0.116	---	
	2.0	30.0	6.1	1.0	2	68	34	0.125	---	
	2.5	32.0	5.6	0.0	0	96	23	0.082	---	

a result of more moisture content in the grain in these "Khattis" than in "Pucca Khattis".

Damaged grain and insect infestation:

In general there was more spoilage in the grain in the top layers as compared to deeper layers in both types of "Khattis.". In "Khatti" No. 2 (Table 2) the damaged grain was only 3 per cent even in the top layers. The damage was comparatively more in "Kaccha Khattis." than in "Pucca Khattis.". More damage in "Kaccha Khattis " may be due to high moisture content in the top layers.

The stored grain insect pests were present only in the top layers of both types of "Khattis ". No insect was present in the deeper layers due to insufficient supply of oxygen. The insect pests found on the top were adults and larvae of Alphitobius, adults of Tribolium castaneum, larvae of Trogoderma granarium and adults of Rhizopertha dominica.

Germination:

Lower germination percentage was recorded in the grain in the top layers as compared to deeper layers due to more insect infestation and mould damage in both types of "Khattis ". The difference observed in germination from top layers to bottom layers was from 11 to 85 per cent and 16 to 96 per cent in "Pucca" and "Kaccha Khattis " respectively. The loss in germination in maize in "Khatti" No. 4 (Table 3) was very high. The loss in germination in grain stored in "Pucca Khatties" was comparatively less than in "Kaccha Khattis ".

F. F. A.:

Maximum free fat acidity was observed in the grain of top layers in both type of "Khattis". There was continuous decrease in FFA from top to bottom layers. The FFA range in "Pucca Khattis " was from 15 to 32 mgs/100 gms, while it was from 16 to 135 mgs/100 gms. in "Kaccha Khattis ". The difference in FFA from top to bottom layers was from 2 to 17 and 30 to 55 gms./100 gms in "Pucca Khattis" and "Kaccha Khattis " respectively. High fat acidity values have been shown to be

associated with high content of damaged kernels and low viability 13, 14. Ordinarily, fat acidity values increases and viability decreases significantly long before external physical evidence of wheat deterioration appears.

Alcoholic acidity:

There was a decrease in alcoholic acidity, estimated in the samples collected from top to bottom layers in both types of "Khattis". The alcoholic acidity ranged from 0.068 to 0.127 per cent and 0.049 to 0.210 per cent in "Pucca" and "Kaccha Khattis" respectively. The difference in alcoholic acidity in the grain from top to bottom layers was from 0.004 to 0.049 per cent in "Pucca Khattis" and from 0.050 to 0.096 per cent in "Kaccha Khattis".

These studies indicate that the grain stores better in "Pucca Khattis" than in "Kaccha Khattis". Except in top layers, the damage in the grain and loss in viability also is less. The slight insect infestation also can be controlled with proper fumigation. The "Kaccha Khattis" allowed seepage of moisture into the top layers of grain which resulted in more damage and loss in viability. The increase in free fat acidity and alcoholic acidity was also more, indicating the damage in the grain in the top layers. The insect infestation in these "Khattis" can be controlled by proper fumigation but provision to make it water proof at the top is necessary.