STORAGE OF FABA BEANS IN UNDERGROUND PITS

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Abstract

An experiment was conducted to evaluate the efficiency of storing faba beans in underground pits . The results obtained revealed an increase in CO_2 concentration in the different heights of the pit. This was attributed to respiration of faba bean embryos and the accompanied microorganisms. This method of storage had arrested initial infestation with bruchid beetles (3%) and prevented further develpment of insects. The respiration process caused an increase in the concentration of CO_2 on the expense of O_2 concentration.

Storage of faba bean seeds in the underground pit for a period of 8.5 months did not affect the germinative capacity . There was an obvious increase in the moisture content of stored faba bean seeds.

The testa of the seed remained white instead of turning brown as in the case of beans stored in the light and exposed to air and sun .

The hectolitre weight of the seeds, cooking time and percentage of stewing were not affected . The water absorption of stewed bean seeds and the total solids increased markedly, while viscosity and amylose percent decreased.

There was an increase in reduced sugars, a decrease in non- reduced sugars and no change was observed in total sugars. The effect on total protein and totla lipids was negligible.

INTRODUCTION

The experiment was conducted in Barheem village (Menoufia Governorate) which is the only village where faba beans (*Vicia faba* L.) is stored on a commerical basis in underground pits. The purpose of such experiment was to evaluate the feasibility of underground storage as a protective method for faba beans. Several points were studied. These were : the effect of storage on insect infestation , germination of seeds, moisture content of grains , grain technology and grain chemical composition.

MATERIALS AND METHODS

The pit was nearly conical, of about three meters in bottom diameter and two meters high with a flat bottom. Through one hole of one meter diameter and two meters depth at the top, grain can be either introduced or removed. The pit was excavated in the soil, with the floor and sides well pressed and smoothed. As the pit was filled, the bottom and walls were lined with faba bean straw or fenugreek (*Trigonella foenum graecum*) straw. Gas sampling connections (copper tubes) were fixed at three levels near the bottom, in the middle , and near the top of the seed. The copper tubes were ended with a rubber connection with a clip to make it tight. After complete filling, the hole at the top was covered and sealed with mud. The ends of the sampling connections were also covered with mud near the surface.

To study the changes of CO_2 concentration in the intergranular spaces, sampling was undertaken using a gas tight syringe (100ml capacity). The syringe was adapted for sampling from the copper tubes that were inserted at the three heights of the pit. Accurate samples of air of known volume under atomspheric pressure were taken one from each copper tube, and CO_2 was analysed for each tube individually.

Carbon dioxide concentration was determined using the titrimetric method . A conical flask was designed to be convenient for this method of analysis . A quantity of 25ml of barium hydroxide (0.025 N) was placed in the conical , 2-3 drops of phenolphthalene indicator plus 1 ml of butanol.

The sample was injected under the surface of the solution. After injection, another 10ml of the air was injected through the capillary tube to expell all CO_2 under the solution. The rate of CO_2 sample injection was made very slow to ensure complete reaction (5ml minute) . The solution was shaken for about 15 minutes and then titrated against Oxalic acid (0.01 N). A blank was conducted using space air.

The effect on insect infestation was determined before and after storage by testing faba bean random samples against tinfestation with pulse beetles.

The effect on the germinative capacity of seeds was studied by taking randomly 4 replicates of 100 seeds each before and after storage (Abrol and Mackay, 1980).

Each replicate was planted on surface layer of sand, moistened to 50% of its water holding capacity, in an aluminium dish of 150 mm. diameter. After planting, the seeds were covered by 13 mm. of sand of the same moisture content and the dish covered with a flat aluminium plate. After incubation for a further four days at 18°C ., seedlings were evaluated according to International Rules.

Samples of soil, from the pit walls and floor , samples of faba bean straw and fenugreek straw and samples of faba bean seeds, were taken before and after storage to determine their moisture contents. The determination of moisture contents was achieved by using the air -draft oven method specified in the A.O.A.C. (1970).

The hectolitre weight was determined according to the method described by the Cereal Laboratory Methods (1962).

Cooking quality test was perfomed by placing a sample of ten seeds of known weight (A) in a carbohydrate tube. Fifty cubic centimeters of distilled water were then added . Afterwards, the tubes were placed in an autoclave under 1.5 K/C^2 pressure for the periods 1.25, 1.50 and 1.75 hr. Finally , the tubes were taken out of the autoclave at the time when the stewing percentage reached 100% . The stewing liquor is separated by filtration and evaporated to calculate total soilds (B). The stewed seeds were then weighed (C). Absorption rate is calculated from the following equation :

$$\text{Absorption rate} = \frac{C - (A-B)}{(A - B)} \times 100$$

Viscosity of cooking liquor was studied by the method reported by Meyers and Smith (1952) . A sample of cooking liquor of stewed bean seeds (10 cc) was accurately introduced through Ostwald viscometer. The relative viscosity (μ_2) was calculated from the following equation $\mu_2 = t_s/t_o$

when μ_2 = relative viscosity, ts = time of flow of cooking

Liquor, and t_o = time of flow of water.

Amylose content was determined in stewed bean seeds using the method adpoted by Juliano (1971) .

Water soluble protein fraction was prepared according to the method adopted by El-Dash and Jonson (1967).

Extraction of soluble sugars and determination of reduced, non -reduced and total sugars were performed according to the technique adopted by Shaffer and Hartman (1921).

Crude protein was determined by the microkjeldahl method outlined in the Cereal Laboratory Methods (A.A.C.C., 1962).

The total lipid content of the samples was determined according to the methods of A.O.C.S. (1955).

RESULTS AND DISCUSSION

Table 1 shows the mean % concentrations of CO_2 build up in the underground pit during the storage of bean seeds up to 8.5 months. This increment of CO_2 concentrations might be due to the respiration of the bean seeds' embryos and the accompanied microorganisms. A slight increase in CO_2 concentrations occurred in the different heights of the pit throughout the storage period. This is an expected result when storing dry seeds (10.4 % m.c.) , where the respiration is relatively low. Hyde and Oxley (1960) mentioned that with grain of less than 14 % m.c. , the rate of respiration was slow, the carbon dioxide concentration being only about 2% after 18 months of storage. As long as oxygen remained, the apparent respiratory quotient was consistently between 0.6 and 0.7 whatever the moisture content of the seed.

Table 1. Percentages of CO_2 concentration in the underground pit during storage of faba beans up to 8.5 months.

Storage time level	15 days	35 days	51 days	67 days	82 days	137 days	189 days	235 days
Upper	0.8	1.6	2.2	3.1	4.0	4.9	5.3	6.1
Middle	1.4	1.5	2.0	3.4	4.3	4.9	5.3	6.5
Lower	0.6	1.7	2.1	3.5	4.8	4.8	5.4	6.5
Mean	0.9	1.6	2.2	3.3	4.4	4.9	5.3	6.4

The initial infestation of faba beans with bruchid beetles was 3% . This percentage was not changed even after 8.5 months of storage in the underground pit. This could be attributed to the fact that storage of dry seed in underground pit had resulted in a low increase in the concentration of CO_2 which did not exceed 6.5 %, meanwhile depletion of oxygen remained the principal factor for limiting insect development.

The storage of faba bean seeds in the underground pit for a period of 8.5 months did not affect significantly the germinative capacity of beans . The percentage of germination was 97 % and 95% before and after storage, respectively.

The increase in soil moisture content either in floor or in walls of the pit was the highest (Table 2) , which could be due to infiltration of water. The increase in moisture content of faba bean and fenugreek straw was intermediate, and this increase in moisture was absorbed from the moisture content of the enclosed soil. The increase in faba bean moisture was relatively low and could be attributed to the equilibrium of its moisture with the relative humidity of air atmosphere in the pit which became higher after storage.

Table 2. Percentages of Moisture content of pit walls , pit floor, fenugreek straw , faba bean straw and faba bean seeds before and after storage in the underground pit.

	Moisture contents of				
	Pit walls	Pit floor	Fenugreek straw	Faba bean straw	Faba bean seeds
Before Storage	24.5	22.4	6.8	6.3	10.4
After storage	28.0	23.0	14.6	21.0	11.8

Data shown in Table 3 indicate that storage of bean seeds in underground pits for 8.5 monts has no effect on the hectolitre , cooking time and percentage of stewing but the water obsorption of stewed bean seeds increased markedly . Data in table 3 also show that the total solids behaved in complete accordance with water absorption. This is due to the bounding chemical constituents of solids in the cooked beans .

Also, the viscosity decreased under the condition of underground pit storage. Concerning amylose percentage, a noticeable decrease in the amylose content of starch was observed. This decrease in the optical density (O.D.) of starch refers only to the change in special relation-ships of such molecules that lead to a variation of the affinity of such molecules to absorb iodine. A slight decrease in the protein fraction was noticed (Table 3). This decrease was due to an alteration in the colloidal nature of the protein matrix when associated with starch molecules through coacervates in the acidic pH of CO_2.

Table 3. Percentages of Chemical constituents of faba bean stored in underground pit for 8 months and 15 days.

	Hoctolitic weight (g)	Cooking time (min)	Stewing %	Water absorption %	Total solids	Viscoity	Amylose	Protein fraction
Before Storage	172.2	90	100	155	8.42	0.1320	35.2	4.80
After storage	174.6	90	100	178	14.55	0.0722	23.4	4.71

Data presented in Table 4 show a slight increase in the total protein of bean seeds after 8.5 months of underground pit storage. This had showed that storage has no effect on the total protein of bean seeds. The percentage of lipid content of bean seeds varied only from 1.6% to 1.8%. This is in agreement with Nikitinski (1955) ,

Table 4. Percentages of Chemical constituents of faba bean stored in underground pit for 8 months and 15 days.

	Total protein	Lipids	Reduced sugars	Non-reduced sugar
Before Storage	24.5	22.4	6.8	6.3
After storage	28.0	23.0	14.6	21.0

Oxley and Hyde (1955) and Shvetsova and Sosedev (1958) who found that the hermetic storage of grains having a moisture content below 16% unaltered the chemical properties of the stored grain. They also showed that there was virtually no change in protein content or total nitrogen of seeds.

After 8.5 months of storage in underground pit, the reduced sugars increased (Table 4). This increase may be interpreted by the degradation of carbohydrates into reduced sugars during the respiratory process. The non-reduced sugars of bean seeds decreased after 8.5 months of underground pit storage (Table 4). These results are in agreement with the findings of Nikitinski (1955) , Oxley and Hyde (1955) and Shvetsova and Sosedov (1958) who indicated that the main changes in seed contents were the increase in reduced sugars and the decrease in non-reduced sugars. Also, Shoji and Takasuke (1980) found that the CO_2- filled package demonstrated a significant increase in the reduced sugar content of seeds.

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خزن الفول في المكامير

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أجريت تجربة لدراسة تأثير تخزين الفول البلدي في مكامير تحت الأرض علي صفات الفول التكنولوجية ومكوناته وكذلك الحفاظ عليه من الاصابة بالحشرات، وأوضحت النتائج ما يلي :

١ – زاد تركيز ثاني اكسيد الكربون فى عنيات الهواء المأخوذة علي ارتفاعات مختلفة من المكمورة ويرجع ذلك الي تنفس حبات الفول وكذلك الكائنات الحية الدقيقة المحمولة عليها.

٢ – أدت طريقة التخزين هذه الى موت الحشرات الموجودة (٣٪ اصابة) وعدم حدوث اصابات جديدة والحفاظ علي االفول. وهذا يرجع الي زيادة تركيز غاز ثاني أكسيد الكربون ونقص تركيز الاكسيجين.

٣ – لم يؤثر تخزين الفول في مكامير لفترة بلغت ٨ أشهر ونصف علي حيوية التقاوي.

٤ – زادت المحتويات المائية للفول المخزن بهذه الطريقة زيادة معنوية.

٥– احتفظت الحبوب المخزنة في المكمورة بعيدا عن الضوء بلونها الفاتح وهذه صفة تجارية مرغوبة.

٦ – لم تؤثر طريقة التخزين في المكامير علي وزن الهكتوليتر ووقت الطهي ونسبه الحبوب الناضجة، وزادت نسبه الماء الممتص في عملية الطهى وكذلك نسبه المواد الصلبة الكلية ، بينما نقصت اللزوجة ونسبة الأميلوز.

٧ – زادت نسبه السكريات المختزله ونقصت نسبه السكريات الغير مختزلة مع عدم حدوث تغيير في النسبة الكلية للسكريات.

٨ – لم يحدث تأثير يذكر علي البروتينات والليبيدات الكلية.