294

STORAGE OF HIGH MOISTURE WHEAT AFTER TREATMENT WITH FLASH HEAT

by

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TABLE OF CONTENTS

page

INTRODUCTION 1

REVIEW OF LITERATURE 3

MATERIALS AND METHODS 11

RESULTS AND DISCUSSION

A- Total Count of Microorganisms 16

1- Small samples studies

2- Large samples studies

B- Farinogram, Baking and Germination Studies 31

SUMMARY 38

ACKNOWLEDGMENTS 39

BIBLIOGRAPHY 40

INTRODUCTION

Safe storage of cereals is an important biological problem. The average loss produced by heating of cereals during storage is large costing millions of dollars annually. Several factors are found to affect storage and respiratory activity of cereal grains (1,2,3). Moisture content, temperature, and oxygen are the most important factors influencing respiratory activity of the grain (2).

Heating of cereals during storage depends mainly upon moisture content and microflora present on the grain. As pointed out by most investigators, growth of microorganisms in moist cereal is perhaps the most important factor related to the safe storage. Microorganisms found on the stored grain produce heat during storage just as other living organisms do when they respire. Because microorganisms can not grow in dry grains, storage of such cereals is safe compared to high moisture grains. Higher moisture grain provides microorganisms with favorable conditions to grow, and with the heat generated deterioration to the grain during storage can occur. Mold is the most abundant microorganism on stored grains, especially, in high moisture grains. The number of mold depends on the quality and soundness of grains.

Many methods have been introduced to prevent or minimize deterioration of high moisture stored grains. One of the methods recommended for storage of high moisture grains is the use of chemical compounds, such as propionic and acetic acid, to inhibit mold growth. Storage of grains at low temperature or reduction of moisture are also common methods to

retard the microorganisms growth.

The purpose of this investigation was an attempt to sterlize damp grain by treatment with flash heat. It was also an objective to study the effect of heat treatment on mold , bacteria, yeast and quality of wheat for bread making.

REVIEW OF LITERATURE

Early investigations of heating of cereals during storage believed that heating was caused by respiration of viable grains and second by the growth of fungi. More recently, it has been established that growth of fungi causes excessive heat in moist grains (2,3).

Large losses, due to heating of wheat and corn are caused by fungi (3). It has been estimated that losses of grains world wide amounts to 1% of the annual cereal production. Some years it may be higher at some localities and usually losses run higher in such grains as sorghum and corn depending on locality of growth.

Fungus spores can germinate at low critical moisture level of 14%, especially at warm temperatures. Some species of fungi such as, the Aspergillus glaucus group, can be grown at lower moisture than the other species. Under these conditions, more moisture will accumulate and other species of fungi develop (3).

Deterioration in quality of grains can also be caused by the fungal enzymes. These enzymes attach the carbohydraes, fats and proteins of grains causing high acidity and deterioration of portein and starch (3).

Both external and internal molds are responsible for the deterioration of stored moist wheat (4). It has been found that the external molds are more abundant than the internal molds in the stored wheat but this also depends upon some factors such as, the amount of mold present, conditions of storage and the age of grains.

Christensen and Gordon (5) stated that molds able to grow on the

sound grain at relatively low moisture level causing temperature to rise in stored grains. Respiration and temperature increase in wheat according to the growth of mold until a temperature of 52-55°C is reached. At higher moisture levels, bacterial growth will increase causing wheat to heat further until the thermal death range of bacteria (68-70°C) is reached (6).

Mold population and temperature increase in stored wheat with increasing moisture contents (3,5,7,8,9,10,11,13,14). Even when wheat is stored at 13-14% moisture, certain molds invaded wheat causing deterioration and an increase in the fat acidity by elaboration of lipase enzyme. Two treatments were used to study relationship of mold to grain spoilage (7). Grain surface-disinfection and mold-inoculated samples of wheat were stored at room temperature for 5,10, and 15 days with 15%, 18%, and 21% moisture contents, respectively. High levels of mold infestation caused an increase in the fat acidity and mold count. Samples with 15% moisture had less mold than samples with 21% moisture.

Deterioration caused by mold to the stored wheat has been also studied by Papavizas and Christensen (8). Wheat was stored at different moisture levels and temperatures for several months. They found that when wheat was stored at 5° - 10°C with 15 - 15.5% moisture content, it remained sound for one year while mold growth caused damage to the wheat stored with 16 - 17% moisture at 5°C. Considerable damage resulted when the 17% moisture wheat was stored at 10°C for the same period of time. At 18% moisture, wheat was stored for 19 months and damage was caused by mold at both 5°C and 10°C.

Hummel, et al. (9) pointed out that when wheat was stored at moisture contents exceeding 14.5 to 15%, growth of molds normally present on and within grain caused increases in the respiration and fat acidity and decrease in nonreducing sugars. They also compared the respiratory rate of mold-free wheat and moldy wheat stored at 35°C with moisture levels from 15 to 31% and found it was low and constant with time in the mold-free wheat, while it markedly increased after a few days in the moldy wheat.

"Chemical changes in stored grain occur at varying rates which depend upon the moisture content, the oxygen supply, the temperature, and the degree of soundness of the grain" (10). The action of the enzymes of grains or fungi which are present within the seed coat is responsible for these changes. Geddes (10) found that respiratory activity increased when grain was stored at higher levels of moisture and temperature. *Deterioration of grain increased and various chemical changes took place during storage.*

Kind of microorganisms, especially molds, found on and within grain have been studied by many investigators (1,3,4,5,6,12,13,14). Johnson (3) pointed out that Penicillium,Aspergillus,Fusarium,Rhizopus and Cladosporium are the common fungi found on the stored grains.

James, et al. (12) found the following genera of molds on wheat:

Aspergillus
Cephalosporium
Alternaria
Cephalothecium
Fusarium

Helminthosporium
Mucor
Penicillium
Rhizopus

Molds were examined in both high and low-grade lots. Alternaria was found in the first lots, while Aspergillus and Penicillium were found in the second lots (4,6). "The high-grade lots were mostly of the top commercial grade. The low-grade lots contained from 10 to 30% damaged seed." (4). Three of the most common molds in stored grains were found to grow and cause heating in moist sound wheat (5). These molds are, Aspergillus candidus, A.flavus and A.glaucus.

Christensen (13) stated that when wheat with 13.5 - 14.5% moisture content stored for 16 months, Aspergillus restrictus, a member of A. glaucus group, invaded this wheat especially from the germ of seed causing brown color characteristic of "sick" wheat. Wheat with a critical moisture level of approximately 13.5% or more may not be stored safely for long time (13). This is true, Christensen added, because A.restrictus mold was isolated in high percentages from commercial bins. Other members of A.glaucus group such as, A.repens, and A.ruber, found also growing on the stored wheat.

Tuite and Christensen (14) inoculated different samples of mold-free wheat with four of Aspergillus species which are commonly found on the commercial stored grains. Samples were stored with 12.2 to 16% moisture contents at 25°C for 1 - 15 months. At a 13 - 13.6% moisture content, A.restrictus and A.asnstelodami (glaucus) invalded the grain gradually, while A.repens and A.ruber developed more slowly. They also

mentioned that A.repens invaded a larger percentage of grain than did other species at a moisture level of 14.3 - 14.6% after two months of storage, while grain was invaded by all fungi within four months. All samples with 15.5 - 16% moisture content were invaded by mold after only one month.

High number of bacteria has been found on the stored grains (12, 15). Several investigators studied number and genera of bacteria on surface of wheat and other cereals grains (12,16,17). Mack (19) found 60,000 bacteria per 1 gram of wheat. Rautenstein (17) found 570,000 - 70,000,000 bacteria per 1 gram of wheat, while James, et al. (12) determined the number of bacteria to be between 280,000 and 164,000,000 per 1 gram of wheat.

Many genera of bacteria were found on grains and their products (1,18). These genera are:

Pseudomonas
Acetobacter
Micrococcus
Pediococcus
Lactobacillus
Streptococcus
Flavobacterium
Achromobacterium
Escherishia
Serretia
Bacillus
Clostridium
Bacterium

The most abundant bacteria found on the normal wheat and other cereal grains is Bacterium herbicola aureum (17,19,20,21,22). This bacteria represents 86% to 100% of bacteria found in wheat, oat, barley or rye kernels, followed by Bacterium fluorescens and Bacterium putidum.

Many attempts, procedures and methods have been introduced for storage of high moisture wheat and other cereals (5,23,24,25,26,27,28,29,30). More than 100 compounds were tested as fungicides to inhibite mold growth, but only 8 of those compounds were effective as fungicides on wheat with 20% moisture (23). The 8 effective compounds were as follow: a-hydroxyquinoline sulfate, thiourea, P-aminobenzoic acid, sulfanilamide, benzene sulfanamides, a-aminothiozole, chloramine B, and calcium propionate. At moisture contents below 24%, thiourea was found to has a little toxic effect on seed, while germination of seeds was reduced more than 30% by a-hydroxyquinoline sulfate (23). Christensen and Gorden (5) tested several fungicides to store high moisture wheat. They found that none of those fungicides reduced mold from wheat, and they stated that while thiourea apparently inhibited some molds completely, growth and sporulation of Aspergillus candidus developed in their test. A given compound may be effective against certain organisms and under certain conditions (5). Stevenson (24) also treated damp grains with propionic acid and a mixture of acetic and propionic acids. By the strong vinager-like vapors and the low PH of acetic and propionic acids, microorganisms of the grain were inhibited. Moist grain can be stored without deterioration if treated with acids. He also stated that while propionic acid has more effect as a fungicide, acetic acid is better than propionic as a bactericide.

Stevenson (24) added "this method will never entirely replace artificial drying, cribbing, or ensiling, but it offers an alternative to those methods for a grower who does not want to invest in a silo or grain dryer". Seed embryos have been known to be killed by the action of acids.

Stone (25) studied organic acids, such as propionic, to store damp grains. The concept of this procedure is to spray a small quantity of organic acid on a high moisture grain at the harvest time to lower the PH of grain below 4.0. This low PH inhibites the development of micro-organisms. Such grains can be stored without further drying.

In Japan, underwater storage gave satisfactory results when cereals were stored for a long period. There was no substantial loss of quality (26).

Another method was introduced to prevent mold and insect damage of high moisture grains, especially those cereal grains of high specific surface such as wheat, corn and milo (27). Air, between 30^{o} and $70^{o}F$ and about 70% relative humidity was circulated to the stored grain. Temperature of the grain mass remained below $50^{o}F$ by cooling and de-humidified the air to maintain below 70% relative humidity. In general, this method has not met with common success.

A new procedure has been developed in 1963 to preserve grains with dry, cool air (28). The units of this method are called "granifrigors". By this method, grains with 17% moisture content stored after cooling in the "granifrigors" units. Wheat with 18.5% moisture content was stored at $10^{o}C$ for 40 days, and when temperature of storage was lowered to $5^{o}C$, wheat stored up to 80 days without any change. These units have not met with wide acceptance.

Gamma-Irradiation treatment has also been used for storage of high moisture wheat (29). The number of mold and bacteria was found to decrease when wheat of 16 - 20% moisture was treated with 10^5 kilorads of irradiation. But development of microorganisms has been retarded even in 20% moisture wheat when 140 kilorads of irradiation was used. Jakubczyk, et al. (30) found that darkening of flour, especially at a higher moisture level was caused when 47 kilorads of gamma-irradiation have been used. On the other hand, there was no adverse effect on quality of flour milled from wheat samples which have been subjected to 20 kilorads of gamma-irradiation (31). Dough stability, the amylogram peak hight and loaf volume decreased as the irradiation dose increased. "Gluten fraction was responsible for the lower loaf volume potential of flour milled from irradiated 1000 kilorads wheat (31).

MATERIALS & METHODS

Hard red winter wheat with a moisture content of 11.9%, a protein content of 12.8%, and an ash content of 1.54% was used in these studies. Wheat was divided into two parts, one with the original moisture content and the other was tempered to 18% moisture by addition of water. Each part was subdivided into seven 5-pounds samples and treated as follows:

1 - Control

2 - Flash heated at $600^{\circ}C \pm 10$, once.

3 - Flash heated at $700^{\circ}C \pm 10$, once.

4 - Flash heated at $800^{\circ}C \pm 10$, once.

5 - Flash heated at $600^{\circ}C \pm 10$, twice.

6 - Flash heated at $700^{\circ}C \pm 10$, twice.

7 - Flash heated at $800^{\circ}C \pm 10$, twice.

An instrument was designed and built to treat wheat samples with flash heat at different temperatures. This instrument consisted of a 60"x5" steel tube. Six baffle plates were located alternately inside the tube to regulate flow of grains. Two gas burners were installed inside the tube at 40" and 45" from its top. These burners were connected to gas-air mixing valves from outside. Compressed air and gas were used as a source of fuel. A 9" long hopper with slide and ventilation gate was attached to the top of the tube, while a metallic 10" X 8" X 6" receiving box was attached at the bottom of the tube to receive the grain after treatment. To measure the temperature of flash heat, a pyrometer was inserted just above the burners. The instrument

was held vertically by a triangle iron stand. Treated wheat samples were passed quickly through flash heat into the receiving box. The average time for kernel to pass through the intense heat (600^{o}-800^{o}C) was 0.1 second. Since this apparatus has a gate to regulate flow of the grain, the rate of passage of grain was regulated at 6 lbs./minute. This instrument is illustrated in Plate 1.

Temperature of grains after treatment was measured by inserting a thermometer in the grain.

Total count of microorganisms was performed on the samples before and after treatment, while physical and baking tests were performed on the flour made from wheat samples which were milled on a Buhler experimental mill. Samples of original moisture content were milled after treatment, while those with 18% moisture were milled after storage. Plate count method was used to determine number of mold, bacteria and yeast colonies. Potato dextrose agar (PDA) was used as a medium for mold, while nutrient agar (N.A.) used for bacteria and yeast. Three different dilutions and two plates for each dilution were made for each sample. Incubation temperature was 30^{o}C for a 5 days period.

Total count of mold was performed for the original moisture samples (treated and control) just after treatment, while total counts of mold, bacteria and yeast were performed for the 18% moisture samples (treated and control) twice, once just after treatment and the other after 10 days of storage at room temperature (about 75^{o}F) with air supplied during the storage period. Compressed oxygen was passed to the samples through sterilized glasswool during storage, periodically.

Illustration of Flash Heater used for Sterlizing

Grains - Plate 1 -

To the left of tube can be seen thermostate leading to pyrometer for recording temperature of flash heat. Just below the thermostate are two gas burners attached to gas mixing valves. At the top of the tube is the hopper and regulating valve, while the receiving box is attached to the bottom of the tube. This box was located to receive the treated grain.

The tube is equiped with baffle plates to reduce the flow rate of the grain.

Entire assembly is supported by a tripod.

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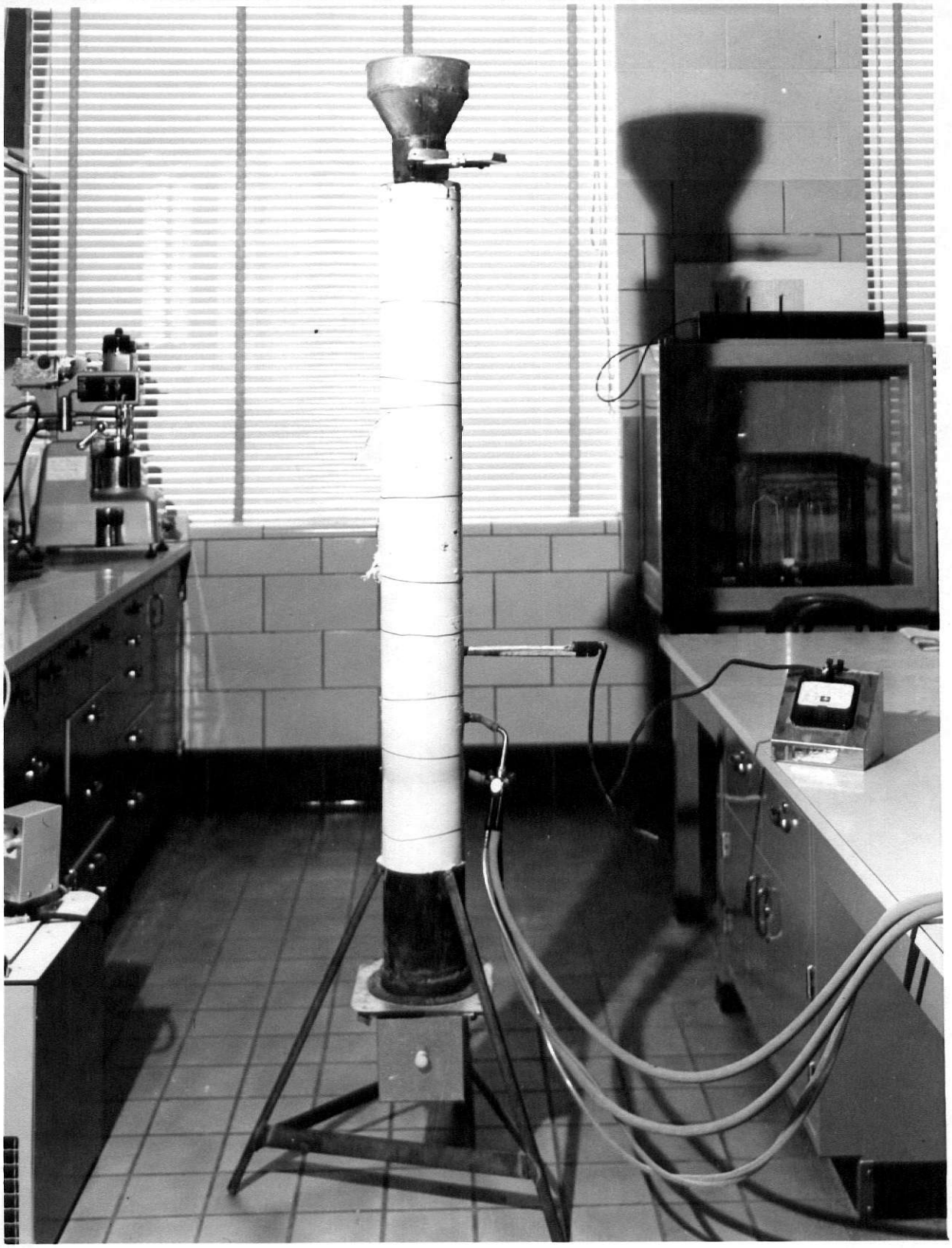

Plate 1. Flash heater

Farinograms were used to determine absorption of flour and other physical characteristics related to baking. "Pup" loaf procedure has been used to test baking characteristics of flour. AACC method 54-21 and 10-10 were used for Farinogram and "Pup" loaf procedure, respectively (32).

Another part of this study was made as an attempt to store damp wheat in large quantities. Two 3-bushel samples of 18% moisture content wheat, one treated with flash heat between 700°to 800°C, once, and the other as a control, were stored for 15 days in insulated barrels. Total count of microorganisms was made of these samples twice, once, just after treatment and the other after 15 days of storage at room temperature (75°F). Same methods as used for the small samples (5-pounds) was used to count the number of microorganisms of large samples. During the period of storage, temperature of grains inside the barrels was recorded daily by a thermometer inserted into each barrel. Air was supplied to both samples from a compressed air cylinder. All treated samples were brought to the same temperature of untreated samples before storage.

Germination of seeds was performed for all samples to test viablity of grains by planting 100 grains of each treatment in moist petri dish. Moist petri dish was prepared by placing three filter papers in the bottom of the dish with 10 ml. of distilled water. Petri dishes including grain samples were incubated at 25°C for 5 days.

RESULTS & DISCUSSION

Total Count of Microorganisms

A- Small (5-pounds) Samples Studies

Two different moisture level wheats were used in these studies, one with original moisture content (12%) and other with 18% moisture content. Each wheat was divided into seven 5-pounds samples as they indicated under materials and methods.

Mold counts of the 12% moisture content wheat and total count (mold, bacteria and yeast) of the 18% moisture content wheat were determined. They are given in Tables 1-3.

The 12% and 18% moisutre wheat samples were used to test ability of flash heat treatment and its effectiveness to retard development of microorganisms on stored wheat. Data in Table 1 show that at 0.05 level of significant, control treatment differed significantly from all samples treated with flash heat. Treatment with flash heat once at 600°C differed significantly from flash heat treatments once at 700°C, once at 800°C, twice and 700°C and twice at 800°C, but it had no significant difference with flash heat treatment twice at 600°C. Treatment with flash heat twice at 600°C differed significantly from flash heat treatments once at 800°C, twice at 700°C and twice at 800°C, while there were no significant differences between this treatment and flash heat treatments once at 600°C and once at 700°C. There were no significant differences between flash heat treatments once at 700°C, once at 800°C, twice at 700°C and twice at 800°C. Temperature of grain

Table 1. Mold count and temperature of 12% moisture content wheat before and after treatment with flash heat.

No. of Treatment	Treatment	Temperature of grains after treatment	Mold colonies/I gm wheat
1	Control	26°C	1250
2	Treated with flash heat once at 600°C.	42-43°C	130
3	Treated with flash heat once at 700°C.	43-45°C	90
4	Treated with flash heat once at 800°C.	45-47°C	70
5	Treated with flash heat twice at 600°C.	42-44°C	125
6	Treated with flash heat twice at 700°C.	45-46°C	70
7	Treated with flash heat twice at 800°C.	48-49°C	60

Significant mean difference = 37

after each treatment listed in Table 1 and showed it was between 42 and 49°C.

Mean of numbers of microorganisms in Table 2 indicated a highly significant difference between control treatment and all flash heated treatments. On the other hand, number of microorganisms of flash heat treatment at 600°C, once, was significantly higher than those of flash heat treatments once at 700°C, once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C. Number of microorganisms of flash heat treatment once at 700°C was significantly higher than those of flash heat treatments once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C. But there were no significant differences between treatments once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C. Least significant mean differences at 0.05 level of significant are presented in Tables 3 and 4.

Analysis of interaction between treatments and storage periods is given in Table 5. There were significant differences between the following treatments; control, flash heated once at 600°C and once at 700°C wheather they are before or after storage, while there were no significant differences between flash heat treatments once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C before or after 10 days of storage.

B- Large (3-bushels) Samples Studies

A temperature of 700° to 800°C was selected to treat large quantities of damp grain with flash heat. Selection of this temperature depended

Table 2. Means of numbers of microorganisms per 1 gm wheat of 18% moisture before and after 10 days of storage combined together

No. of Treatment	Treatment	Mold colonies/1 gm wheat	Bacteria + yeast colonies/1 gm wheat
1	Control	114654	319416
2	Treated with flash heat once at 600°C.	6267	143083
3	Treated with flash heat once at 700°C.	3568	136166
4	Treated with flash heat once at 800°C.	664	40187
5	Treated with flash heat twice at 600°C.	226	21687
6	Treated with flash heat twice at 700°C.	89	9129
7	Treated with flash heat twice at 800°C.	22	7208

Significant mean difference for mold = 1621.2

Significant mean difference for Bacteria + yeast = 20025

Protection level = 0.05

Table 3. Total Count of microorganisms (mold, bacteria and yeast) and temperature of 18% moisture content wheat samples after treatment.

No. of Treatment	Treatment	Temperature of grains after treatment	Mold Colonies/ 1 gm wheat	Bacteria + yeast Colonies/ 1 gm wheat
1	Control	26°C	4308	142333
2	Treated with flash heat of 600°C, once	41-42°C	2060	116333
3	Treated with flash heat of 700°C, once	42-44°C	2050	104666
4	Treated with flash heat of 800°C, once	46-48°C	752	27625
5	Treated with flash heat at 600°C, twice	42-43°C	232	20500
6	Treated with flash heat at 700°C, twice	45-47°C	77	8133
7	Treated with flash heat at 800°C, twice	48-50°C	10	7041

Table 4. Total Count of Microorganisms (mold, bacteria and yeast) of 18% moisture content wheat samples. (After 10 days of storage)

No. of treatment	Treatment	Mold Colonies/1 gm wheat	Bacteria + yeast Colonies/1 gm wheat
1	Control	225000	496500
2	Treated with flash heat at 600°C, once	10475	169833
3	Treated with flash heat at 700°C, once	5087	167666
4	Treated with flash heat at 800°C, once	576	52750
5	Treated with flash heat at 600°C, twice	220	22875
6	Treated with flash heat at 700°C, twice	101	10125
7	Treated with flash heat at 800°C, twice	35	7375

Table 5. Interaction of treatments and storage periods of 18% moisture wheat samples.

No. of treatment	Storage Before or After	Means of Numbers of Microorganisms: Molds Colonies per 1 gm wheat	Difference	Bacteria + yeast Colonies per 1 gm wheat
1	Before	4308	<-- Sig. Diff. -->	142333
1	After	225000		496500
2	Before	2060	<-- Sig. Diff. -->	116333
2	After	10475		169833
3	Before	2050	<-- Sig. Diff. -->	104666
3	After	5087		167666
4	Before	752	<-- Non-Sig. Diff -->	27625
4	After	576		52750
5	Before	232	<-- Non-Sig. Diff -->	20500
5	After	220		22875
6	Before	77	<-- Non-Sig. Diff -->	8133
6	After	101		10125
7	Before	10	<-- Non-Sig. Diff -->	7041
7	After	35		7375

Significant range of mold = 2292.7

Significant range of Bacteria + yeast = 28319.8

Protection level = 0.05

upon two factors; first, preliminary evidence indicated that this treatment would kill maximum number of microorganisms on the grain surface, and second the temperature would has no significant change on the physical and baking characteristics of flour milled from treated wheat samples.

Two 3-bushels samples of 18% moisture content wheat, one control and other treated with flash heat at 700° to 800°C, once, were used in these studies. Number of microorganisms of both samples was determined before and after 15 days of storage at room temperature (about 75°F). The data are summarized in Table 6. Control sample had very high number of molds, bacteria and yeasts compared to the treated sample in both cases before and after 15 days of storage.

Microorganisms in both small (5-pounds) and Large (3-bushels) samples were less in number when samples of wheat were subjected to flash heat. This is apparently so because most of the microorganisms found on the surface of grains have been killed by the intense of heat when they passed through flash heat instrument. Sharp reduction of microorganisms occured when a high temperature of flash heat was applied.

Samples of wheat with high moisture contents were invaded by a higher number of microorganisms comparing to those samples of low moisture contents samples. Many investigators have found a positive relationship between moisture content of stored grains and mold population in their studies (3,5,7,8,9,10,11,13,14). High moisture grains

Table 6. Total Count of mold, bacteria and yeast of 18% moisture large samples (3-bushels).

Treatment	Molds Colonies per 1 gm wheat	Bacteria + yeast Colonies per 1 gm wheat
a-Before storage		
1- Control	4350	142000
2- Treated with flash heat at 700° - 800°C, once	202	38200
b- After 15 days of storage		
3- Control	445000	905000
4- Treated with flash heat at 700° - 800°C, once	8150	332500

provide molds and other microorganisms with their favorable conditions to grow causing deterioration to the stored grains.

Actually, number of molds and other microorganisms increased when grains were stored at room temperature. In this study, control treatments showed sharp increases of microorganisms during storage, while microorganisms population increased much slower in the treated samples. In some of the treated samples the number of microorganisms remained constant or decreased during storage. This was caused by the action of flash heat which prevented development of microorganisms during storage.

Temperature of grains of flash heated samples was between 40-50°C after treatment, but grains samples were cooled in a cold room (5°C) until they reached temperature of control treatment. During storage, temperature of grains was recorded periodically. Barrels were insulated with 3-inches fiberglass batting from the outside as indicated before. There was a sharp increase in the temperature of control sample, while sample treated with flash heat at 700° to 800°C, once, recorded almost an imperceptible increase in the temperature (Figure 1). Because of high number of microorganisms which invaded control sample, temperature of grain increased during storage by microbial respiration causing the grain to heat. Christensen and Gordon (5) noticed that temperature and mold population increased in the moist grain during storage.

Figures 2-5 show a heavy growth of mold, bacteria and yeast in the control sample but slight growth in the samples given a flash heat treatment before storage. The same organisms in the control sample sharply increased in number after 10 and 15 days of storage, while in

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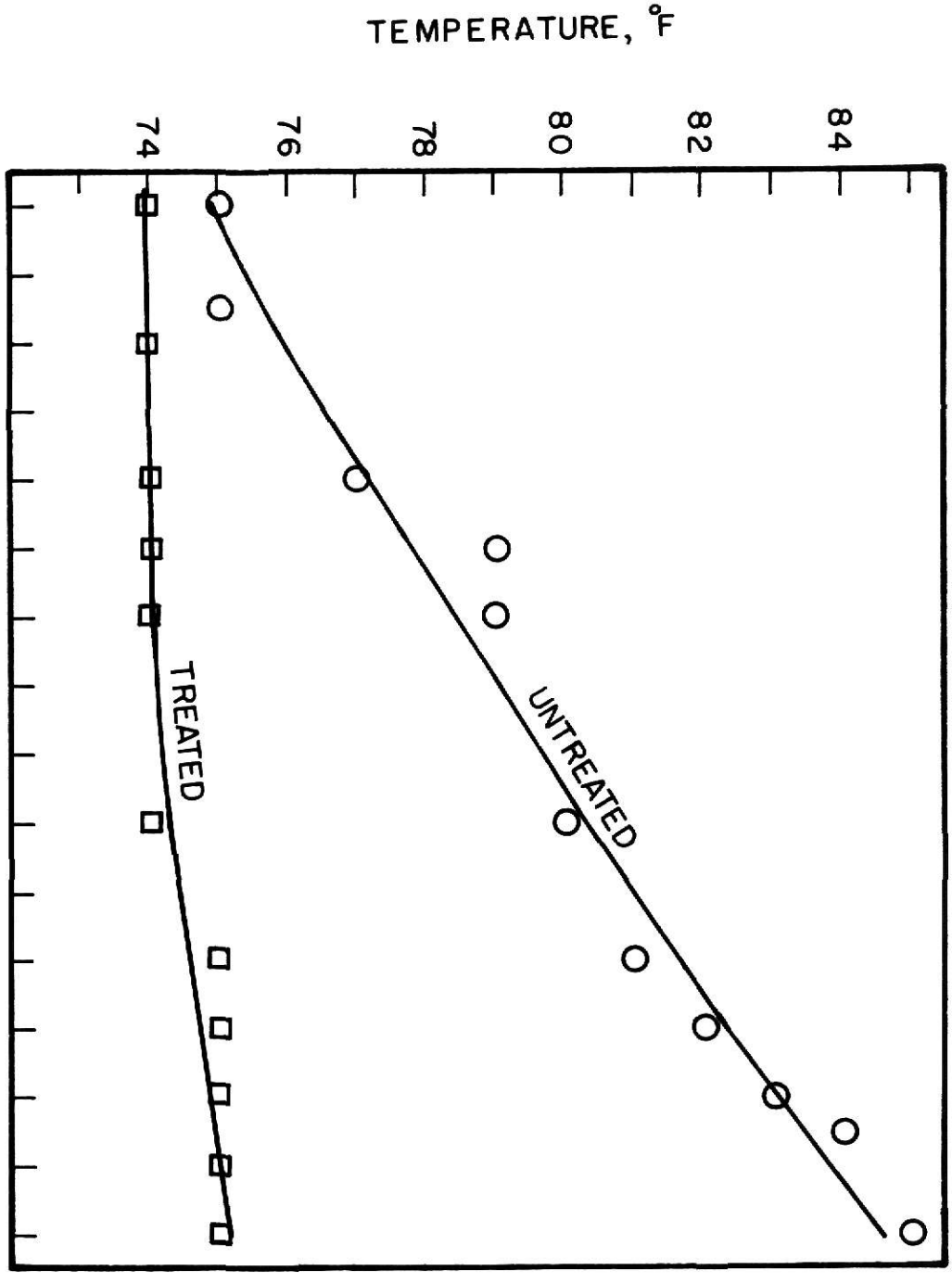

Figure 1. Temperature change during storage of large (3-bushels) wheat samples at room temperature (75°F) for 15 days.

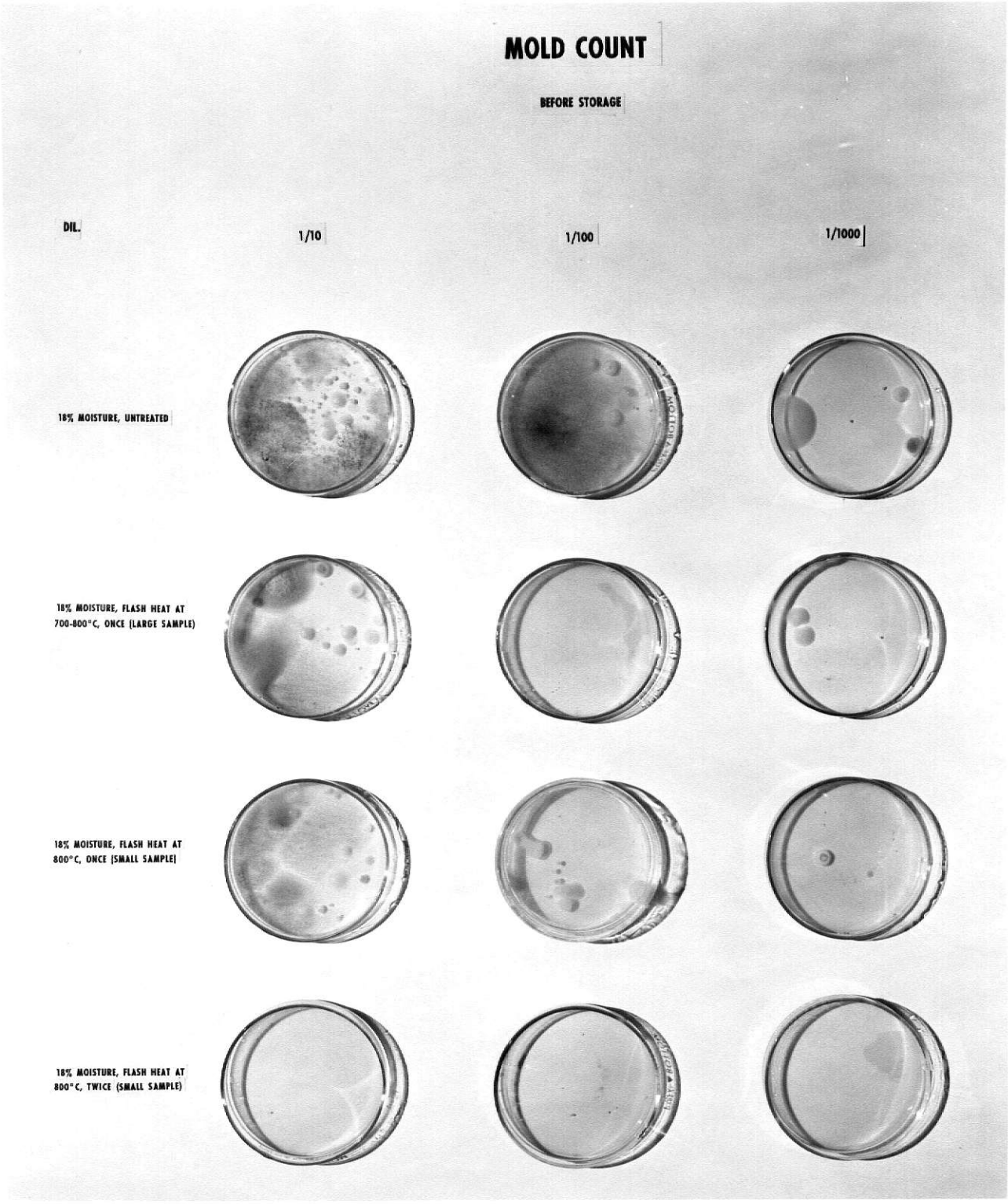

Figure 2. Different dilutions of mold count of control and wheat samples treated with flash heat before storage.

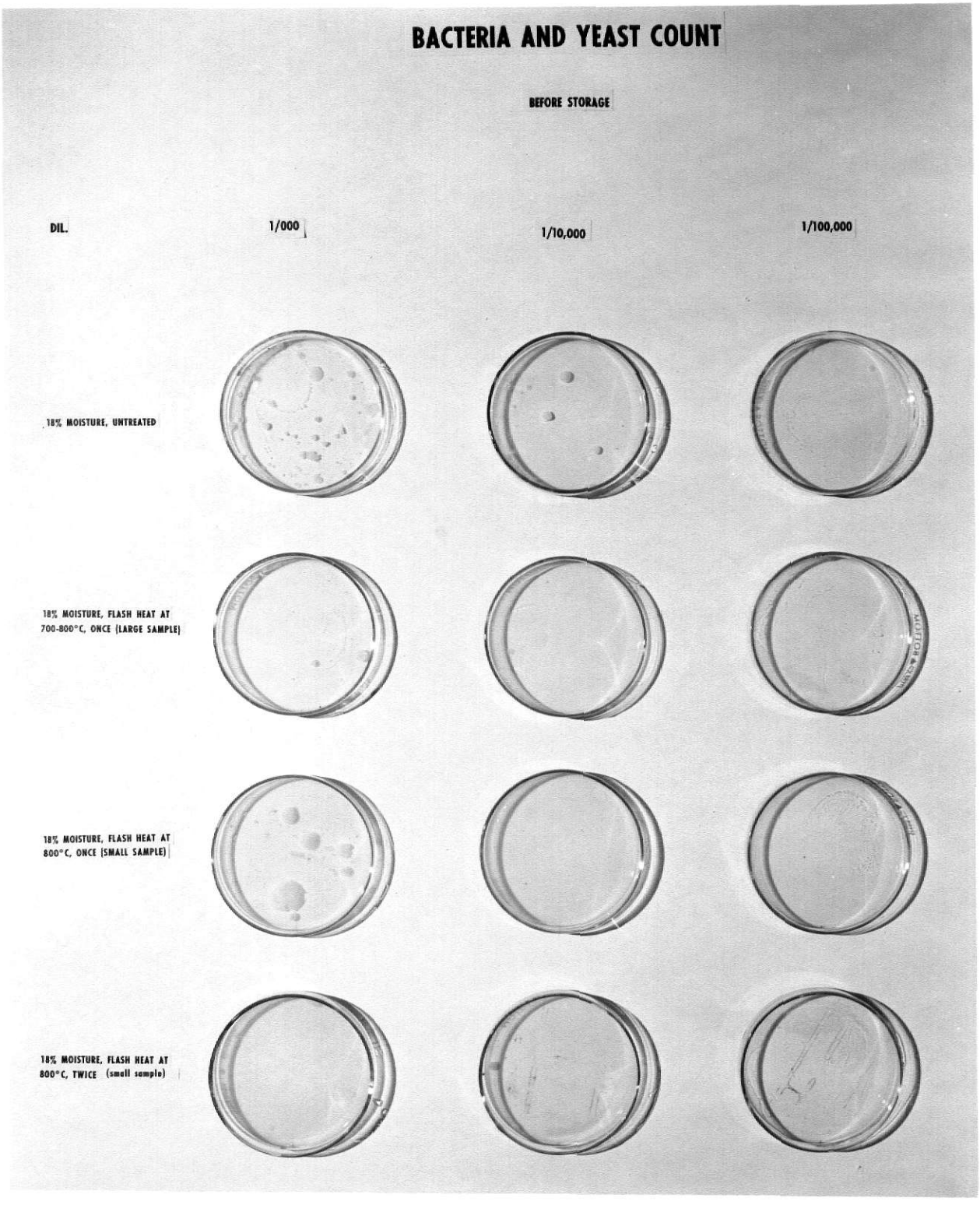

Figure 3. Different dilutions of bacteria and yeast count of control and wheat samples treated with flash heat before storage.

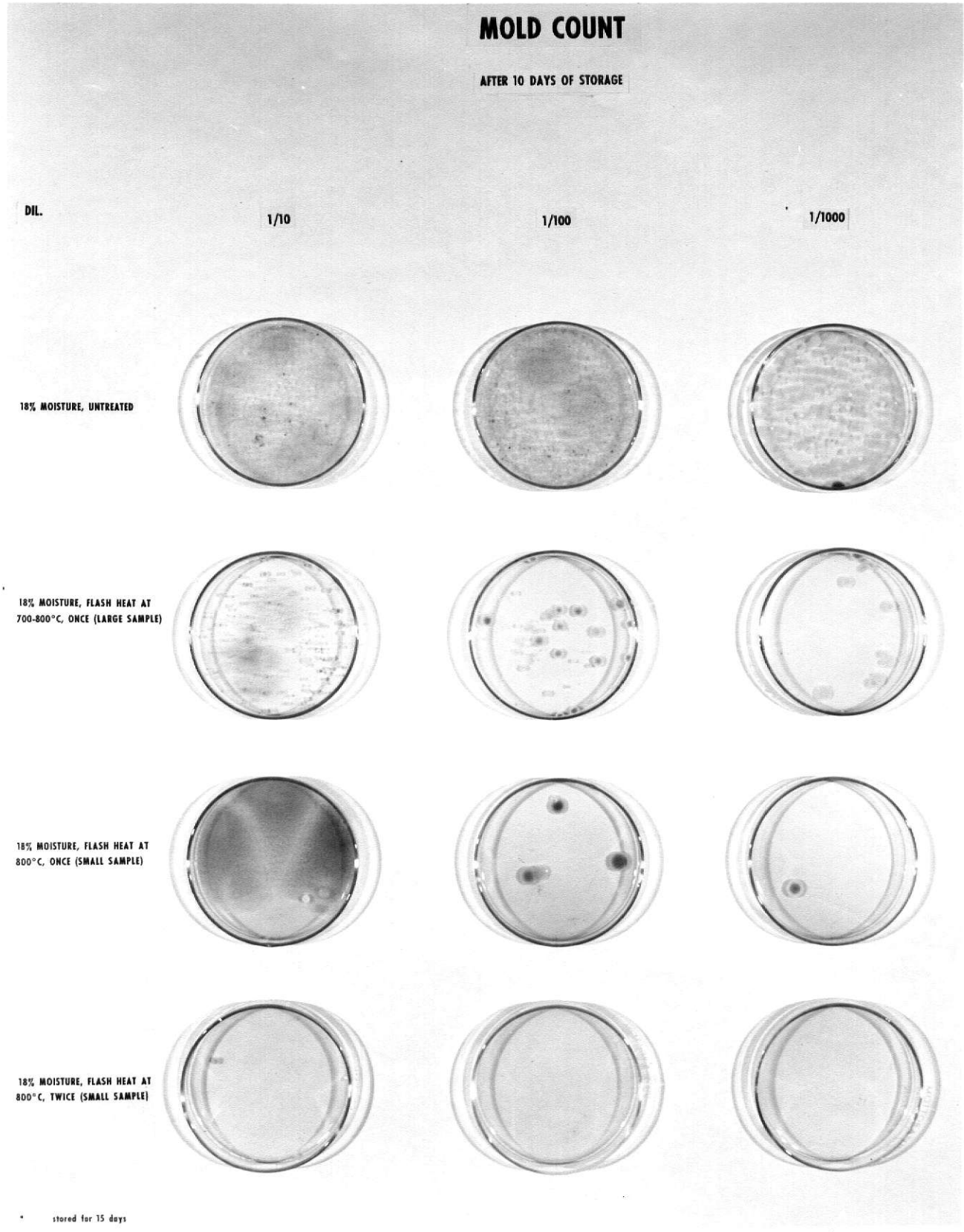

Figure 4. Different dilutions of mold count of control and wheat samples treated with flash heat after storage.

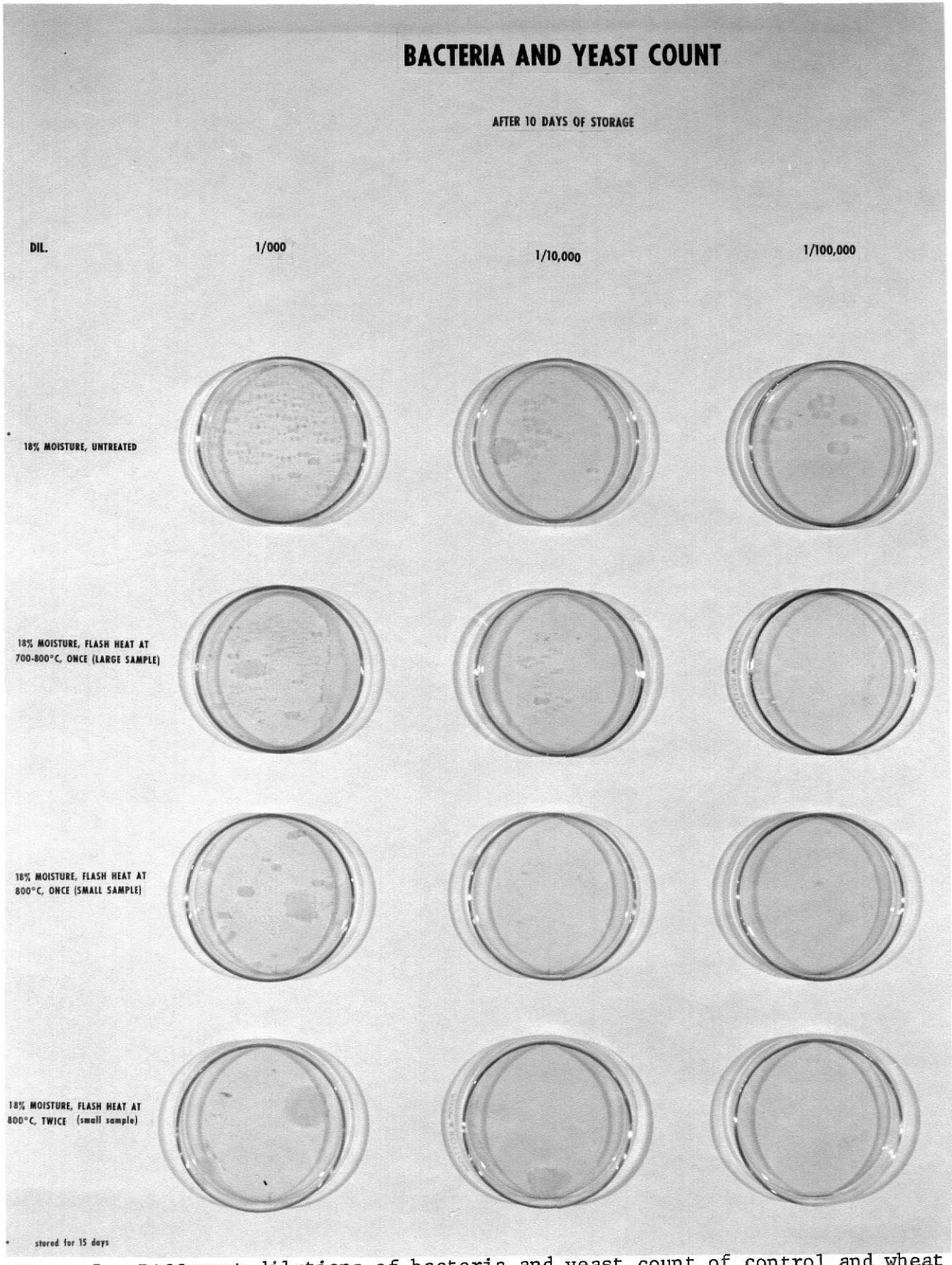

Figure 5. Different dilutions of bacteria and yeast count of control and wheat samples treated with flash heat after storage.

samples which were flash heated once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C (small 5-pound samples) and those samples flash heat treated at 700° to 800°C, once, (3-bushels samples) showed a lower number of mold, bacteria and yeast after 10 and 15 days of storage.

From the above data and figures, it may be observed that the action of flash heat treatment may be used as a successful method to prevent or minimize development of microorganisms on damp grains. Grains may be stored safely in silos for a longer period of time without considerable microbial damage after treatment of the grain with flash heat at 700° to 800°C.

Farinogram and Baking Studies

Farinograms of small sample treatments were determined after milling of wheat into flour. These were made to determine wheather there was any change in the physical and absorption characteristics of flour. Figures 6-7 show no significant differences between control treatment and flash heated treatments once at 600°, once at 700°C, once at 800°C, twice at 600°C and twice at 700°C, but there was a slight difference in the flash heated treatment at 800°C, twice, of 18% moisture wheat.

Water absorption of all treatments was determined with the Farinogram, Table 7. It is evident that there was no significant change in the absorption as a result of treatment.

A sample of flour of each treatment was baked using a "Pup" loaf procedure to test if there is any significant affect of flash heat treatment on baking quality of the bread. Score of bread of these treatments is shown in Table 8. There were no significant changes in

FARINOGRAMS
12 % MOISTURE WHEAT

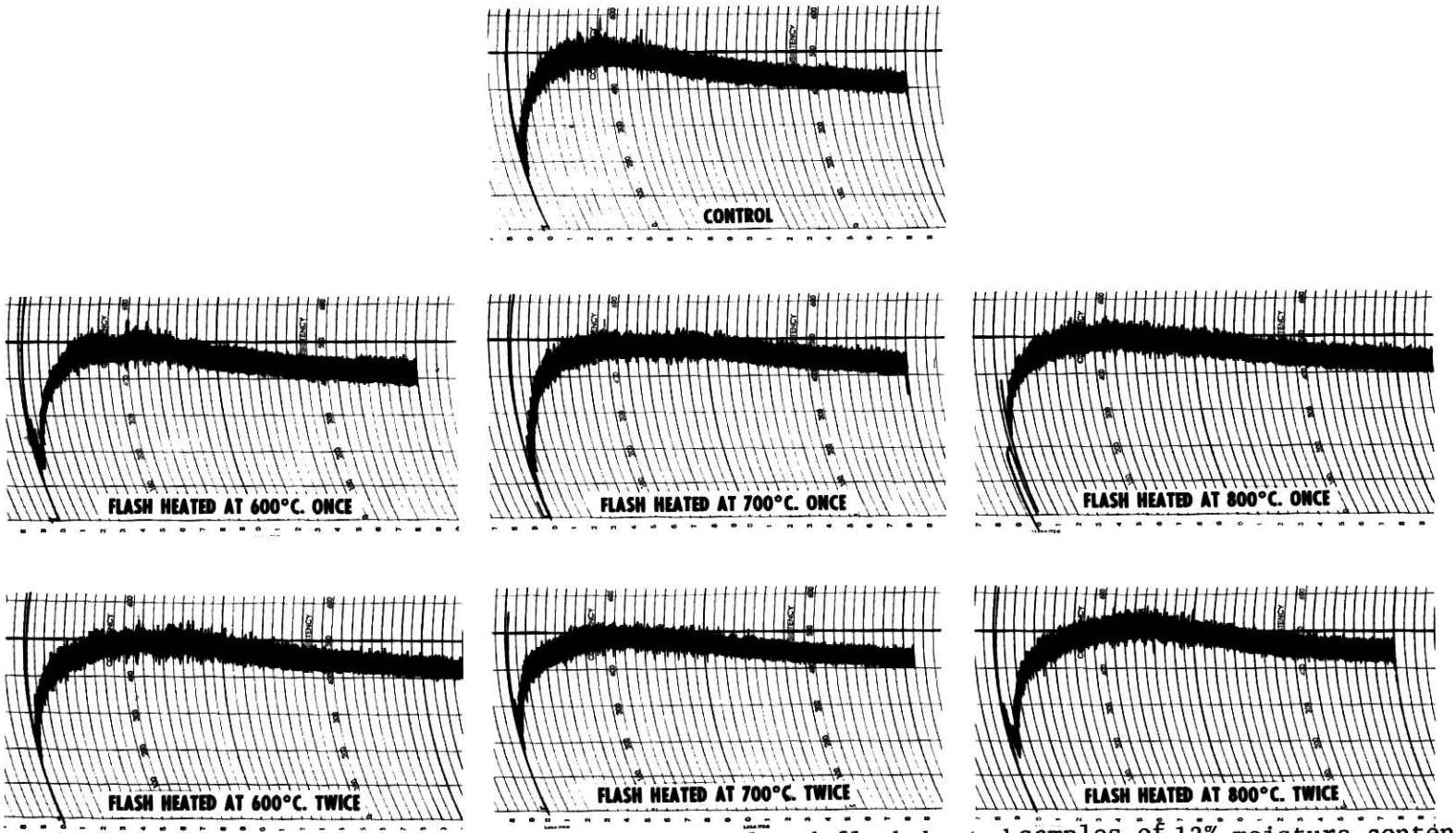

Figure 6. Farinographs of flours milled from control and flash heated samples of 12% moisture content wheat.

FARINOGRAMS
18 % MOISTURE WHEAT

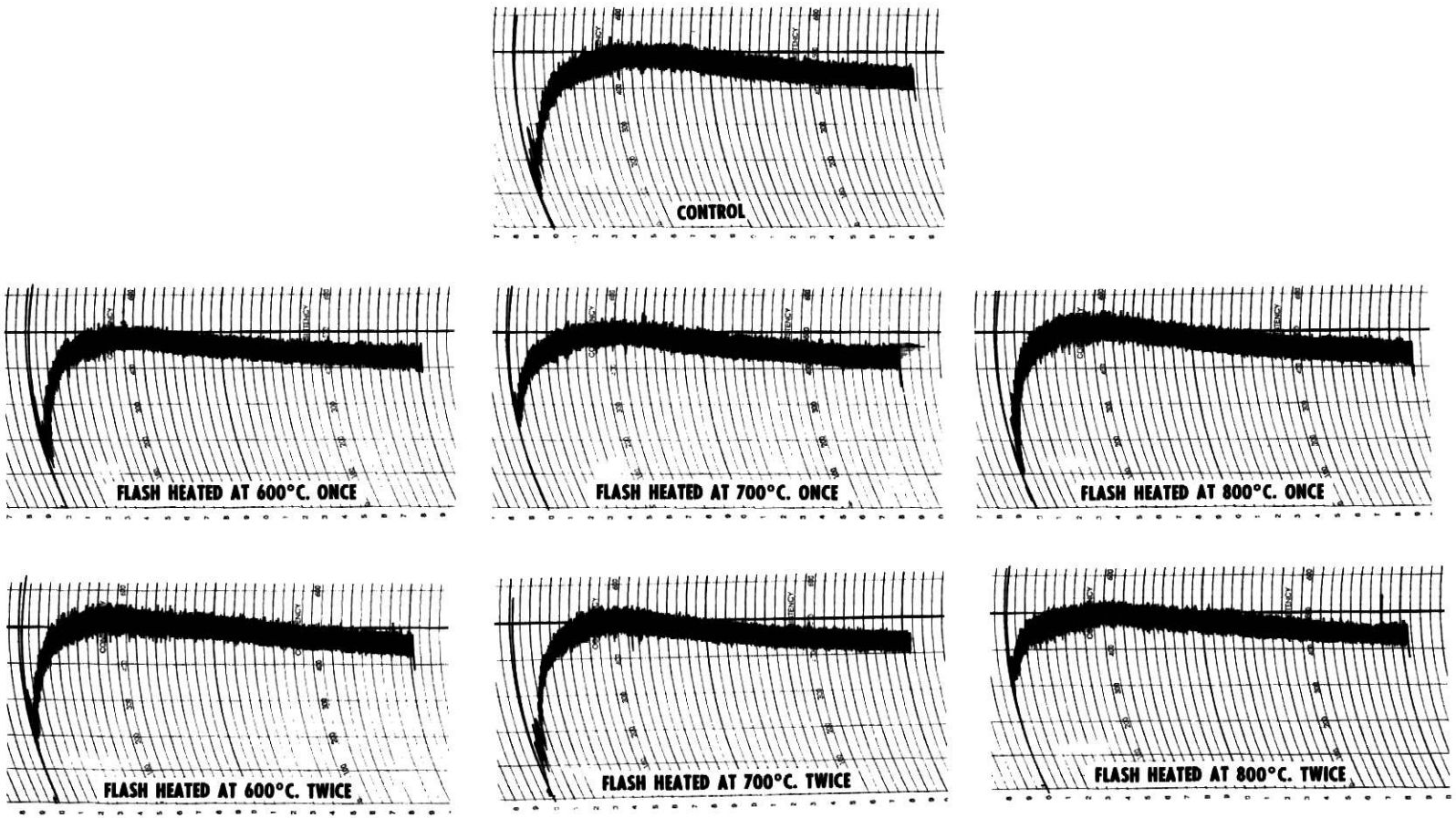

Figure 7. Farinographs of flours milled from control and flash heated samples of 18% moisture content wheat.

Table 7. Water absorption of flours milled from different treatments.

	% Water Absorption	
No. of treatment	12% moist. sample	18% moist. sample
1	67	66.2
2	66.2	66.6
3	65.8	66.4
4	66	66.2
5	66	66.4
6	66	66.3
7	65.9	66.3

Table 8. Bread Scoring table

	No of treatment	Weight of loaf gm	Volume of loaf ml	Crust color	Crumb color	Texture	Grain	Break and Shread
Actual moisture samples	1	134	750	9	10	9	9	8
	2	132	770	9	10	8	9	8
	3	133	780	9	10	8	8	7
	4	133	800	9	10	9	9	8
	5	135	820	8	10	9	9	8
	6	133	800	8	10	7	7	8
	7	133	770	8	9	7	7	9
18% moisture samples	1	133	770	9	10	9	9	9
	2	133	762	9	10	9	9	9
	3	135	742	9	10	8	8	9
	4	135	735	9	9	8	8	9
	5	134	770	9	9	7	7	9
	6	134	747	9	10	8	8	9
	7	134	740	9	10	8	8	9

Table 9. Seeds Germination of different treatment

Treatment	% Germination
1- Control	100
2- Treated with flash heat at 600°C, once	82
3- Treated with flash heat at 700°C, once	80
4- Treated with flash heat at 800°C, once	68
5- Treated with flash heat at 600°C, twice	69
6- Treated with flash heat at 700°C, twice	8
7- Treated with flash heat at 800°C, twice	3
8- Treated with flash heat at 700° - 800°C, once [large sample (5-bushels)	80 - 81

the quality of bread baked from flash heat treated samples. There was no adverse affect of flash heat treatment on the physical and baking quality when temperature was between 700^{o} and 800^{o}C.

Germination of seeds shows in Table 9. These data shown a decrease in germination with increasing of flash heat temperature or number of times grains passed through instrument.

Summary

Wheats with 12% and 18% moisture contents were divided into seven 3-pounds samples. One sample of each wheat was used as a control and others were subjected to the flash heat treatment at different temperatures through an instrument called flash heater. Total count of mold, bacteria and yeast after treatment showed high number of microorganisms on the control sample and considered growth on the samples treated with flash heat once at 600°C and 700°C. Low number of microorganisms were found on the samples treated with flash heat once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C. Samples of 18% moisutre were stored at room temperature for 10 days with air supply. Number of microorganisms increased greatly in control sample after storage, while treated samples showed a little development of microorganisms growth.

A temperature of 700°C to 800°C was selected to treat large quantities of damp grains with flash heat as a procedure to store them in silos without deterioration. Data of this study indicated significant difference in the number of microorganisms between control samples and flash heat treated samples. When temperature of grain was checked during storage period, control sample showed a sharp increase in temperature, while temperature of treated sample increase was almost imperceptible.

Farinogram and baking characteristics of flour milled from control and treated samples were studied. There were no significant changes in both tests. Germination of seeds was reduced 20% after treatment with flash heat once at 700° to 800°C.

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STORAGE OF HIGH MOISTURE WHEAT AFTER TREATMENT WITH FLASH HEAT

by

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STORAGE OF HIGH MOISTURE WHEAT AFTER TREATMENT WITH FLASH HEAT

Abstract

Safe storage of cereals is an important biological problem. The average loss caused by heating of cereals during storage is great. Heating of cereal grains depends mainly on the moisture content and microflora of grains. Growth of microorganisms in moist grains is the most important factor related to safe storage as pointed out by many investigators.

In this investigation, an attempt was made to sterilize damp wheat by flash heat. The treated and untreated samples of wheat were examined for microbiological population before and after storage. Samples were also examined for any changes in physical and baking characteristics.

Wheats with 12% and 18% moisture contents, respectively, were divided into seven 5-pounds samples. First sample of each wheat was used as control and others were subjected to the flash heat at different temperatures. Samples of 18% moisture wheat were examined for microbiological count before and after 10 days of storage at room temperature, samples were supplied with air during storage, while molds count was performed for samples with 12% moisture to test the ability of flash heat treatment and its effectiveness to kill maximum numbers of microorganisms.

There were significant differences between control and treated samples, especially those treated with flash heat once at 800°C, twice at 600°C, twice at 700°C and twice at 800°C. Storage of 18% moisture wheat for 10 days showed high number of microorganisms in the control samples while the number was very low in the last four treated samples.

Farinogram and baking tests of flours milled from all samples were performed. There were no significant differences between samples indicating that there were no significant changes in the physical and baking characteristic of treated wheat.

A temperature of 700° to 800°C was selected to treat a larger quantity of damp wheat with flash heat. Selection of this temperature depended on killing maximum number of microorganisms on the grains without causing any changes in the physical and baking qualty of wheat. Two 3-bushels samples of 18% moisture wheat, one control and the other treated with flash heat at 700° to 800°C, once, were stored into two insulated barrels for 15 days at room temperature with oxygen supplied. Microbiological count of control showed 146, 350 colonies before storage and 1,350,000 colonies after storage, while sample treated with flash heat was invaded by 36,400 colonies before storage and 340,650 colonies after storage. Thermometers which were inserted into barrels to measure temperature of grains during storage indicated high increase in the temperature of control and almost imperceptible change in the treated sample temperature.

Germination of seeds was reduced 20% after wheat was treated with flash heat at 700 to 800°C, once.