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# STUDIES ON IMPROVING THE SHELF LIFE OF CHAPATIS AND NAN

by 1264

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# INTRODUCTION

Chapatis and nan are staple food items for both the rich and poor in West Pakistan. They are prepared from coarsely ground wheat flour, which is locally called "atta". Chapatis are generally baked in the home. They are baked at moderate temperatures in a thinly flattened round shape on an ungreased convex iron pan. The chapati somewhat resembles the English pan-cake. The dough for chapatis is not fermented; the flour used for making them can be and usually is of rather coarse granulation. The dough is flattened both by means of the rolling-pin and with the help of the palms of the baker's hands. The thickness of the chapati varies from one-fourth to one-half inch depending on the consumer's preference.

Usually, fresh, warm chapatis are consumed but they can be safely kept in tight containers for at least 12 hr without any noticeable staling.

Nan is the usual commercial bread of Pakistan where it is baked mostly in the so-called country restaurants. The baking technique is to "plaster" the flattened dough on the inside surface of a deep-dug earthen oven, called a "tandoor". This oven is internally heated by burning firewood. For baking nan, fermented dough is used. Atta for nan therefore is made with finer granulation than that for the atta used for chapatis because the finer the granulation, the more rapid is the process of fermentation. The nan has greater bulk than the chapati but has a round flattened shape like that of the chapati. The common name for both chapatis and nan is "roti". Chapatis, nan and raised leavened bread are all different types of roti. The last, that is the raised leavened bread of English type, is called "double roti". It has been estimated that out of a total 6.3 million long tons of wheat produced in Pakistan (1) approximately 90% is milled into atta, and consumed

in the form of chapatis and nan. Chapatis and nan constitute more than 70% of the total daily food intake of over 43 million people in West Pakistan. In extreme cases, chapati and nan may constitute as much as or more than 92% of the total daily food intake of these people (2).

The annual losses of wheat and its products are 18,974 thousand maunds (702,740.74 tons) due to defective packing, handling and storage (3). Such wastage is noticed in advanced countries also, but Pakistan suffers from a severe food shortage and cannot afford to waste even a small usable portion of any product. If the annual wastage of rice and wheat were prevented nearly 11 million more people could be fed for a year at the existing rates of consumption of cereals (4).

At present, chapatis and nan are produced, stored and consumed in a matter of a few hours because they stale soon after baking.

Pakistani breads (chapatis and nan) have very poor shelf life and as a result each household has to prepare them twice a day, thereby wasting millions of hours every day on making bread alone. Our government is very anxious that an enriched roti with a good storage life should be developed to save huge losses now arising through wastage of time in making bread daily and human mortality through poor diet (5).

Asia, more than any other continent, is the land of hunger (6). Throughout the Far East people are ill nourished (7). Food consumption in the Far East involves a major portion of the wage-earner's income to obtain the entire diet which even then is inadequate for himself and his family. All the diets contain very low levels of protective foods. In countries such as Pakistan, the number of calories derived from cereals constitutes 73% of the total (8).

No other class of food of the normal diet in Pakistan so cheaply provides as many calories per unit weight as roti. In addition, no other food stuff

can even partially replace bread/roti as a major item in the foreseeable future.

There is a dire need to preserve chapatis and nan because their staling is a critical problem confronting both the defense forces and the civilians in Pakistan. This considerable loss of chapatis and nan if properly prevented could help in improving the food economy of the country. Moreover, preserved chapatis and nan could be supplied to people who, as often happens, become surrounded in flood stricken areas.

The hardening of the crumb of a loaf within a few hours, commonly called staling, is not simply due to loss of moisture. Because even if bread is stored under conditions that preclude loss of moisture it still will become stale (9). Staling is therefore a complex phenomenon that unfortunately results in substantial monetary losses.

During staling two changes take place in the physical appearance of chapatis: first, dryness of the product and second, the appearance of mold growth on the surface of the product. It is an everyday observation that when chapatis or nan are exposed to atmospheric conditions, they become dry soon after baking due to moisture losses. Secondly, if the chapatis or nan are wrapped or packed in a container, the moisture losses are arrested to some extent but mold growth results in deterioration and off flavors. Both changes make chapatis and nan unfit for human consumption. Much work has been done on controlling microbial spoilage by adding either sodium or calcium propionate in western countries. Many softening agents have been found to be successful in keeping leavened bread soft (10, 11, 12).

There have been few attempts made on chapati preservation, but as regards to nan no work has been reported.

The work carried out in the west is not very useful for the people of this sub-continent, because of great differences between the western bread (leavened bread) and our chapatis (unleavened bread).

The purpose of this present study was to evolve new methods and techniques for improving the shelf-life of chapatis and nan. Different levels of anti-microbial, antioxidant and softener were used for this purpose. The international laws about food additives were kept in view while carrying out these experiments.

# REVIEW OF LITERATURE

## Milling of Wheat for Atta

The raw material used for the preparation of chapatis and nan is called "atta". This term is extensively used in India and Pakistan to designate coarsely ground wheat although the process of milling varies considerably from area to area. Atta is one of the few words common to multilingual populations of India and Pakistan. There is no standard procedure for the milling of wheat to form atta. A variety of methods are employed. The equipment varies from primitive stone grinders to the modern steel roller mill. Five different types of milling systems are mostly used, as described by Aziz and Bhatti (2):

a. Manually operated stone grinders called "chaki".

b. Animal driven stone mills called "karas".

c. Water driven stone mills called "gharat".

d. Engine-powered or electric motor-driven stone grinders.

e. Modern steel roller mill.

The attas produced by different processes vary considerably in color, granulation and composition. An extensive survey of the characteristics of atta was reported by Aziz (13). On the basis of this survey the following grade designations and definitions of quality of atta were prescribed:

Types and Characteristics of Atta

| Grade Designation | Type of Processing | Ash Content (Calculated on moisture free basis) Min. % | Max. % | General Characteristics |
|---|---|---|---|---|
| Special Agmark | Washed, conditioned & roller milled | 1.25 | 2.0 | The atta shall be the coarsely ground product of sound well cleaned wheat and shall be of good keeping quality, free from taint or objectionable flavor. |
| Agmark | Roller milled | 1.25 | 2.0 | The coarse particles of bran up to 5% of the total product may be removed by sieving but no bran shall be added. |
| Agmark Chaki | Stone ground | 1.75 | 2.5 | The fibre content calculated on a moisture free basis, shall exceed 1.5% but shall not exceed 2.5%. |

In villages and small towns atta is made by grinding wheat between mill stones. In this case the wheat is ground in one operation. It yields a whole wheat atta from which no bran is removed during or after the grinding process; the yield of atta is therefore 100%; this is the true whole-meal. However, the consumers in their homes screen out some of the large particles of bran through hand sieves before kneading the atta for domestic baking. The quantity of bran screened out may be 2 to 3% or more depending on personal taste and preference.

Yield of atta in a roller flour mill is about 95%, that is, 5% bran is separated as offal. But this varies from time to time depending on the availability of wheat produced in the country. In case of poor crop conditions and

consequent shortage of wheat stocks, it may be necessary to forego quality factors and mill atta of 97% extraction. The above yield figures are for "straight-run" atta only. But if maida (fine flour) is also being packed simultaneously, then the yield will be comprised of the weights of atta and maida taken together. In the case of steel roller mills, the system of milling to produce atta is a closely guarded secret. Prior to 1968, this system of milling was controlled by the government and it was required that the rate of extraction be 15% fines (maida), 5% bran and 80% atta. Currently there are no limits and the mills do what they want and do not give any information.

In order to investigate the optimum up to which the "fines" may be extracted during milling without materially affecting the acceptability and palatability of the remaining stock, ten types of atta were experimentally milled on a Wolf Experimental Mill and 0, 5, 8, 10, 15, 20, 25, 30, 35 and 40% fines were taken out (13). In all cases 3% bran was sifted out. The attas were experimentally baked into chapatis. It was found that the extraction of up to 15% fines resulted in no appreciable deterioration of chapatis, but with higher proportions, the chapatis became harsher and harsher with a tendency toward rapid drying. Higher extractions resulted in marked harshness of chapatis and these could not be considered as tolerable and acceptable.

A number of observations on the granulation of atta have been reported. Aziz and Bhatti (2) reported that the percentage of atta passing through a 50-mesh sieve varies with the milling system and is from 93.7% from gharat atta to 62.7% in the case of atta prepared by the roller mill. As observed by Sinha (14) the granularity of atta is such that it passes through a 40-mesh sieve.

While working on the preservation of chapatis Yasin, et al. (15) were able to obtain an atta yield of 96%. They used a 25-mesh sieve to obtain the atta used for their work. Murty and Austin (16) were able to obtain yields of 87.1 to 95.5% atta. They used a hand-driven stone grinder and passed the atta through a 36-mesh sieve to obtain the final atta yield. Chaudhry (17) used a 40-mesh wire screening to obtain atta of 80% and 95% extraction. For the production of atta of 95% extraction, 5% bran was removed. In the case of 80% extraction, in addition to 5% bran, 15% fines were also removed.

Preparation of Chapatis and Nan

No uniform and standardized method of preparation of chapatis in the home exists and the technique varies in detail from place to place, even from person to person. In general, the atta is made into dough of the desired consistancy by the addition of enough water. Chapati dough is much slacker than bread dough. The water absorption of atta from Pakistani wheat varieties has been reported to range from 70-76% (2). In some cases a small amount of common salt, sugar and/or fat may also be added. Dough is prepared by hand kneading and is left for an hour for resting. Two reasons are given for allowing this rest period for chapatis dough. Firstly, the rest period permits maximum hydration of the various constituents of atta such as starch, protein, etc., without which optimum development of dough needed to make good pliable chapatis cannot take place. Secondly, the rest period stimulates enzyme activity, which tends to break down the starch-protein complex into simpler aggregates. Dough portions of 100 g were used by Aziz and Bhatti (2); they used a specially designed iron plate heated by electricity to cook chapatis.

Yasin, et al. (15) used 320 g of sieved flour and kneaded it after adding a sufficient volume of water until a dough of moderately stiff consistency was

obtained. One hour rest was given at room temperature (30°C) so that the moisture absorption could become uniform. Dough was divided into four equal portions.

Sinha (14) reported that approximately 45 ml of water is required to make a chapati dough from 50 g of atta. He suggested a rest period of 45 min for all wheats except durum in which case the period should be increased to 60 min. He used dough pieces of 47.5 g and made a chapati of 15 cm diameter. In a study on Indian wheats, Murty and Austin (16) reported the water absorption to be in the range of 60 to 74%. A rest period of 30 min was allowed. The diameter of the finished chapati was kept to 15 cm.

Qureshi (18) reported that the water absorption capacity of wheat grown in the state of Washington varied from 60-74%. In his opinion the duration of optimal rest period of dough is a specific varietal characteristic.

While working on chapatis, Imtiaz (19) used 223 g of flour, 1/2 tsp salt and 3/4 cup of water for the preparation of dough. A rest period of 25 min was allowed in these studies. The dough was divided into 6 equal portions and each portion was rolled into a chapati of 7.5 to 8 in diameter.

Baines, et al. (20) used a 25 g dough piece and flattened it out as far as possible without breaking or tearing the chapati. Rao, et al. (21) kept the water addition for dough making at 625 to 650 ml per kilo of wheat flour. The weight of each dough piece was 45 g and the diameter of the chapati was kept between 6.5 to 7 in and cooked at 220-240°C, and total time was 2 min for baking and 1 min for puffing (which was also done on the hot plate).

Chaudhry (17) suggested 70-73% water to make a dough of proper consistency. The dough was kneaded by hand, divided into dough balls weighing 50 g each and each ball was rolled into a chapati of 6 to 7 in diameter with the help

of a rolling pin and was cooked on a hot plate, the temperature of which was kept at 290 to 300°C; the time was 2 min for cooking and puffing each chapati.

Preservation of Chapatis and Nan

Pakistani breads (chapatis and nan) have very poor shelf-life and as a result each household has to bake twice a day. Thereby, in the country millions of hours are wasted everyday on making bread alone. To overcome this problem a Pakistani firm has placed an order with a designing institute of Tiblisi, Capital of the Georgian Republic of USSR, for a mechanized bakery for producing nan.

Pakistani nan is similar to Georgian bread in taste and technology of preparation (22). The President of Pakistan recently urged the establishment of such bakeries in the country so as to free the womenfolk from the drudgery of preparing nan at home.

The staling of chapatis and nan is a critical problem confronting both the defense forces and the civilians in Pakistan. An attempt was made by Khan and Bhatti to solve the problem (23). They observed that roties containing .2% sorbic acid, 4% nonfat dry milk and 2% glyceryl monostearate could be kept for three days at room temperature and for 30 days at refrigeration temperature without any noticeable changes in composition and organoleptic qualities. Hussain and Satti (24) developed a prototype roti which remained quite palatable for 72 hours at 35°C. As expected by these workers GMS (glycerol monostearate) was found to make the roti soft but on the other hand it adversely affected the pliability of the roties. The effect of addition of GMS on the physical dough characteristics was also studied. To counteract this effect either wet wheat gluten or freeze-dried wheat gluten was incorporated.

Both forms of gluten increased the resistance of the dough on the Brabender Extensograph to a peak value of 1000 mm. Roties prepared with an increased amount of gluten remained very soft and resiliant up to 72 hours. Sorbic acid was not found to be a suitable mycostatic agent for use in rotis as it imparted a bitter after taste.

Rao, et al. (21) reported that preserved chapatis packaged and heat-sealed in paper-foil-polyethylene pouches kept satisfactorily and remained acceptable for six months under diverse tropical conditions. During storage the fat acidity increased slightly, the reducing sugars increased and nonreducing sugars decreased. Free sorbic acid was found to be a better preservative than its potassium salt. It was further reported that potassium sorbate is recommended as a preservative in food stuffs that contain a high percentage of water. It was therefore substituted for sorbic acid in equivalent quantity (0.64% of flour weight) while the sodium chloride was kept at 2% of flour weight. Chapatis prepared with only sorbic acid incorporated into the dough at 0.3% level did not keep satisfactorily for mold growth occurred within a month in some of them. That established that sodium chloride, which was originally added only to improve the taste was required for satisfactory preservation. Shah and Bhatti (25) found that treatment of whole wheat flour by irradiation checked the growth of molds and yeast during storage. Bacterial number remained unaffected by the treatment.

Khan and Bhatti (23) reported that polyethylene bags and lacquered tin cans kept the rotis in good condition for one day at room temperature and ten days at refrigeration temperature. These authors recommended polyethylene bags for packing tanoori rotis (chapatis baked in a mud oven) for two reasons. Firstly, polyethylene bags are cheaper in cost than lacquered tin cans and secondly, polyethylene bags are available on the local market.

While working on the effect of preservatives on the keeping quality of chapatis, Yasin, et al. (15) found that the incorporation of nonfat dry milk in combination with propionate or sorbate had a good effect on the quality of stored chapatis. It also improved the loaf volume and texture. Moreover, the addition of milk solids also improved the flavor of the chapatis. These workers used .15% propionate, which was found to be sufficient to check the mold growth. The use of .15% sorbic acid was found to be equally effective as a fungistatic agent and did not affect the organoleptic quality of the stored chapatis. The use of oxalic acid did not give encouraging results and work with it was discontinued. As regards storage temperature, an increase from room temperature to 37°C increased the rate of loss of moisture. Various samples retained the desired quality charactors for 72 hours at 37°C and 120 hours at room temperature. Loss of moisture adversely affected the softness of chapatis, making them hard, dry and brittle. It was also observed that the rate of loss of moisture corresponded to the rate of loss of freshness. The loss of moisture was noted to be comparatively low in chapatis when glyceryl monostearate and milk were added.

Quality Evaluation and Nutritive Value of Chapatis and Nan

Chapatis and nan have always been subjectively evaluated in almost all the studies reported. A series of nan supplemented with fish flour was evaluated for color, flavor and texture by Sharif and Bhatti (26): up to 10% level fish flour could be consumed in the nan as far as color and flavor were concerned but for texture up to 15% fish flour was acceptable. Four different experimental nan were evaluated for their nutritional value. Nan enriched with 10% fish flour were rated the best nutritionally. The protein content was raised from 13.16% (MFB) in the control nan to 20.34% (MFB) in the nan

enriched with 10% fish flour. It was observed by Bhatti and Riaz (27) that 2% leaf protein, 5-7% whole or skimmilk solids, 6% vegetable ghee, 6% corn oil, 3-5% fish flour, 2-6% guar flour, 2.5-5% defatted corn germ meal, either in combination or alone, could satisfactorily be employed for enhancing the nutritive value of roti. It was suggested by Ahmed (28) that the quality of chapatis depends upon the type of wheat from which the atta is milled, any treatment given to atta after milling, the method of kneading the dough, and the shaping of chapatis before cooking.

Sinha (14) reviewed a number of desirable characteristics of chapatis, including color, texture, taste and flavor. Rao, et al. (21) reported that preserved chapatis were found to be as acceptable to soldiers as fresh chapatis. Chapatis were described as "highly sweetish to taste". The physical characteristics desired in a good chapati, such as white to creamy color, soft and silky touch, ease of chewing, sweetish taste, flexibility and resistance to staling, were described by Aziz (13). Sinha (14) considered the puffing ability of chapatis as a measure of quality. Chapatis were described as "normal", "below normal", "better than", "good" by Qureshi (18). Puffing ability, appearance, texture and taste as quality criteria for chapatis were used by Murty and Austin (16).

Qureshi (18) determining the suitability of white club wheat varieties grown in the state of Washington for chapati making, concluded that the flour milled from Burt variety resulted in best chapati. The varieties that yielded the better chapatis also gave flours of higher water absorption.

Commonly in Pakistan the commercial mills remove some bran and fine flour and the remainder is used as atta. Aziz (13) kept the bran removal constant at 3% and removed from 0% to 40% of fines. It was observed that the extraction of fines up to 15% did not lower the quality of chapatis noticeably but at

higher levels, the chapati qualities were affected appreciably, the resultant chapatis being considered unpalatable and unacceptable. Chapatis are a very important item of food, as a source of energy and of vitamins, minerals, and proteins. In an average diet chapatis have been reported to constitute more than 70% of the total intake of the people of Pakistan (29). In extreme cases, chapatis may constitute as much as or more than 90% of the total food intake.

Imtiaz (19) reported that chapatis prepared from wholewheat pastry flour with the addition of 15% medium-fat soybean flour and 10% dry milk gave the best balanced diet. It was suggested that this mix would have a good storage life and that it could be introduced into Pakistan as a prepared chapati mix.

Chaudhry (17) evaluated cooked chapatis for their color, flavor, texture and overall acceptability. The results showed no significant differences between chapatis prepared from attas of 95% extraction and those prepared from 80% extraction for all wheat used. Significant differences were observed when chapatis prepared from different wheats but from attas of the same extraction were compared. At both levels of extraction, the white wheats and the Pakistani wheats used in those studies were judged to be superior to the red wheats with regard to color, flavor and acceptability of chapatis.

Bhatti and Riaz (27) evaluated the cooked chapatis for color, texture, taste, flavor and palatability by serving to a panel of trained judges.

Yasin, et al. (15) used "discarded", "semi-stiff", "stiff", "slightly stale", "good acceptable smell", "very slightly stale", "moldy", "brittle", "good", "acceptable", "completely stale", "soft smooth pliable" and "soft smooth" to describe stored chapatis.

Parihar and Chathriji (30) found that the presence of gluten helped in gelatinization of starch during chapati making, but the presence of gelatin

retarded staling. In starch-gel bread, starch chapatis and wheat-flour chapatis, retrogradation of starch was found to be maximum at 2°C and decreased with increase in temperature.

Ali, et al. (31) found that wheat flour containing 2% shark meat flour would satisfy the protein requirement of growing children and that wheat flour containing about 3-5% shark meat flour would be suitable for nursing mothers.

Adding commercial bacterial amylase to a dough formula unsupplemented with sugar gave the largest loaf volume response, accompanied by a marked deterioration of crumb, grain, and texture at higher enzyme levels (above 20 SKB units per 100 g of flour). Cereal amylases improved loaf volume and baked quality to a significantly larger extent than did fungal amylases. Combinations of high levels of cereal amylases and low levels of bacterial enzyme gave best results. Cereal and fungal alpha-amylases were most effective when added to bread baked with 1-2% sugar. The effect was less pronounced in sugar-rich formulae and decreased with increase of sugar in the dough (32).

# MATERIALS AND METHODS

Chapatis and nan, as usually made, cannot be stored long at room temperature without spoilage. There are several methods of preventing the spoilage of these products, such as keeping at low temperature, adding 4% or more of sodium chloride, adding .2 to .3% sorbic acid. These either affect acceptability or are not practical under present conditions in Pakistan. Average ambient temperature in Pakistan is 24-35°C which is very conducive to spoilage of chapatis and nan by mold growth, whereas lower and higher temperatures are not. Several methods of prolonging storage life were investigated in the present study.

## Selection of Suitable Wrapping Material

The practice of bread wrapping was originally introduced for the twofold purpose of keeping the bread in a sanitary condition and reducing moisture loss to a minimum. Although wrapping bread does not retard staling, it does have a favorable effect in so far as it prolongs the shelf life by preserving the aroma, flavor and softness of the product far beyond the period for unwrapped bread. Chapatis and nan were prepared in accordance with the conventional method used in Pakistani homes by baking on a hot plate; for nan in place of the tanoor an electric oven was used. Prepared chapatis and nan were cooled for a few minutes and wrapped, one each in five different wrappers, namely polyethylene bag, wax paper wrap, foil wrap, saran wrap, and ordinary paper wrap.

One lot was stored unwrapped for comparison. Ten replicates were run. The samples were stored at 80 to 90°F. They were weighed daily and were observed for other characteristics.

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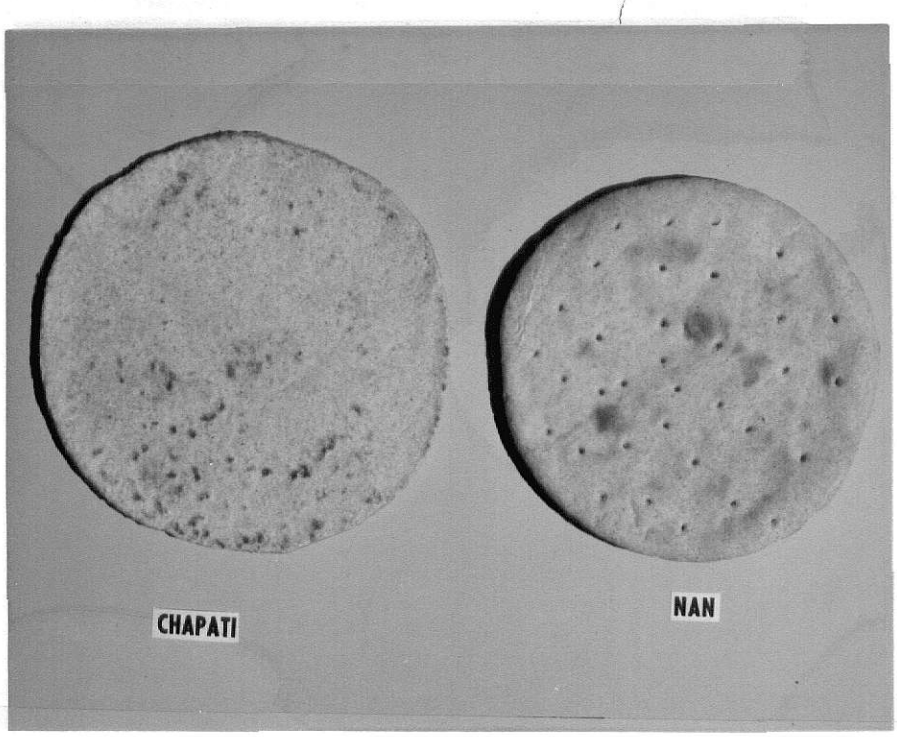
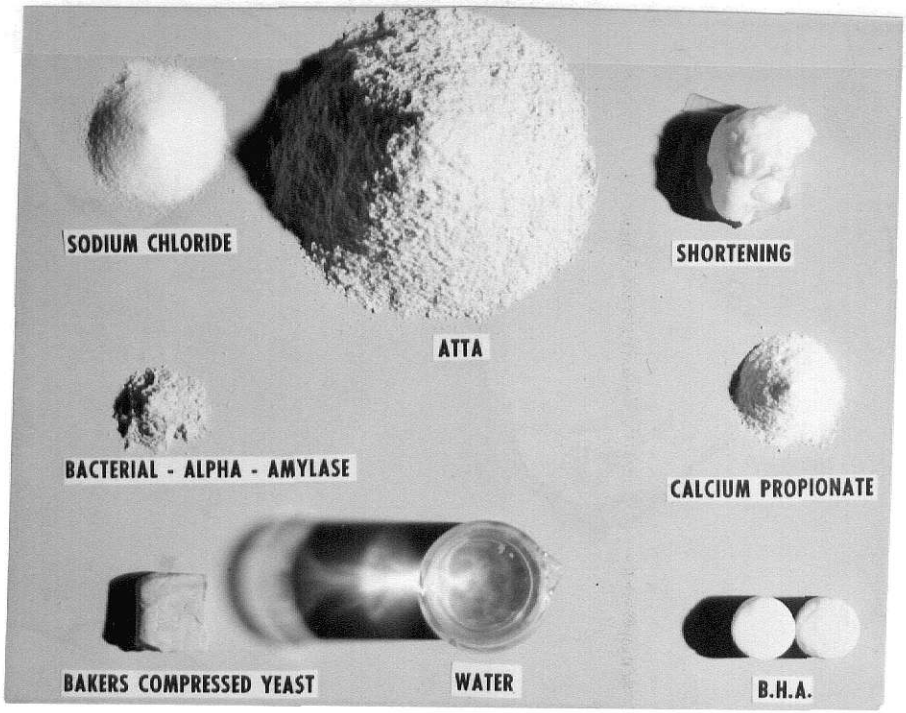



Fresh chapati and nan.




Ingredients used in preparing chapatis and nan.

The chapatis and nan wrapped in polyethylene bags lost only .52% and .14% moisture respectively in 5 days, unwrapped samples lost 9-16% moisture in 6 days, whereas chapatis and nan wrapped in brown paper wrap lost 13.5% weight in 7 days. The nan samples stored in saran wrap lost only 1.29% weight in 7 days.

The chapatis stored in saran wrap and foil wrap lost no moisture up to 5 days storage. It was observed that warm wrapping at about 110-115°F gave the best keeping quality, but the odor and taste were affected. When the products were cooled before wrapping the keeping quality was poor but odor and taste remained good.

In view of the above observations and taking into consideration the availability and price of these wrapping materials in Pakistan, it was decided to use polyethylene bags and ordinary paper bags for conducting the storage studies.

Microbiological Study at Various Stages of Production of Chapatis and Nan

The microbiological study was divided into two parts: firstly, determination of the approximate number of viable spores of bacteria, yeast, and molds in raw material (atta), dough and prepared chapatis and nan before wrapping; secondly, identification of typical molds. Ten grams of each sample was comminuted 2 min in 90 ml of sterile water in a blender. One ml of this well-mixed sample was used for 1:10 dilution and plated on three different media, suggested for growing bacteria, yeast and molds. Further dilutions were made up to $1:10^{10}$ and similarly plated. From one or more of these dilutions 1-ml aliquots were removed and put into each of two sterile petri dishes containing agar medium, and the dishes were swirled to distribute the sample evenly. The dishes were kept at 37°C in case of bacteria, but for yeasts and molds plated

material was kept at room temperature. The counting was done after 48 hr for bacteria, and on the 3rd and 4th, 5th and 6th days for yeasts and molds. The counts of these organisms were recorded and calculated on "per-g of original sample" basis. Colonies of Aspergillus and Penicillium were transferred to Czapek's agar and/or Blakeslee's malt agar for species identification, which was made by use of descriptions given by Raper and Fennell (33) and Raper and Thom (34).

## Standardization of Processing Conditions

In packaging and storage studies, large quantities of chapatis and nan had to be made in different lots. For the data from chemical analyses to be comparable during the storage studies it was important to minimize inherent variation in values that might have been caused by variations in processing conditions. Toward this end the following conditions were standardized. Only one type of wheat, Gaines variety (white club wheat) was selected for use in this study. The selection of this wheat was based on the fact that the sample had approximately 11% crude protein which is comparable to the protein content of Pakistani wheats. Moreover, during the preliminary studies Gaines variety was found to possess very desirable characteristics for making chapatis and nan. The milling and the process for making chapatis were as developed by Chaudhry (17). The grain was ground into flour by one procedure, passing flour through No. 32 wire mesh and removing 5% bran as offal. The water required and time of mixing for proper dough consistency were found by using farinograph standard method 54-21 in Cereal Laboratory Methods (35). The water required was 60 to 65% on flour weight basis, and mixing time was 5 min (Fig. 1). In all samples of chapatis and nan, 1.5% sodium chloride was added. In the case of nan, 2% compressed bakers yeast was found to give satisfactory fermentation.

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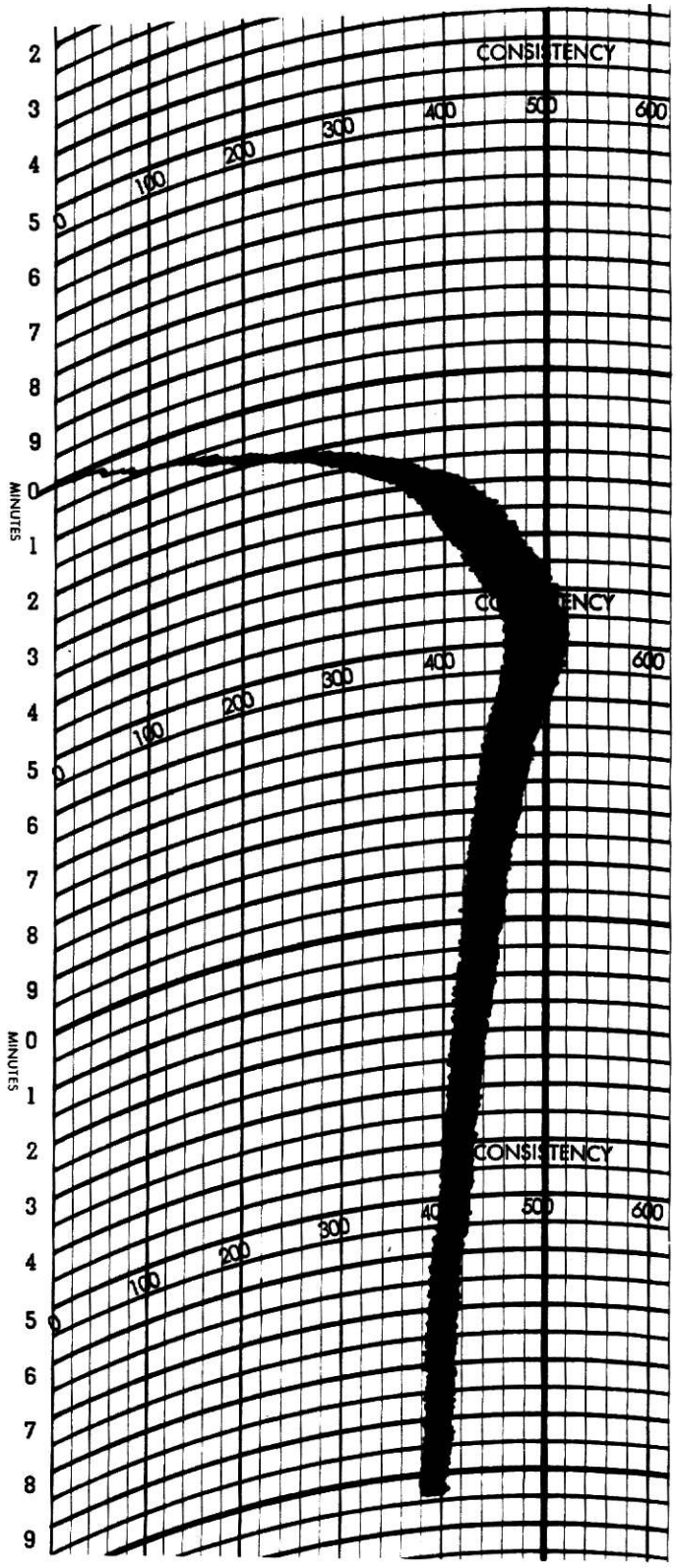



Fig. 1. Farinogram of atta of 95% extraction from Gaines variety wheat.

The required rest period was found to be 60 min in the case of chapatis and 75-90 min in the case of nan. The weight of each para (dough piece) was kept at 50 g for a chapati and 120 g for nan and the diameter of the disc at 6.5 to 7 in, for the chapati and 6 to 6.5 in for nan, which automatically fixed the thickness of each disc. The temperature of the hot plate was 280 to 290°C; for nan, oven temperature was kept at 290 to 300°C. The oven was humidified by a special device, providing a constant rate of evaporative flow of distilled water into the oven chamber. The total time was 2.5 min for baking and puffing the chapatis. The total time for baking nan was 5 min.

## Cleaning of Wheat

The Gaines variety wheat was fumigated and then cleaned on a Hart-Carter Dockage Tester using the riddle, screens, feed rate and the air setting on the aspirator recommended by the manufacturer for cleaning white wheats. The cleaned wheat was placed in polyethylene bags until used.

## Conditioning

The cleaned wheat was conditioned by the addition of water to raise the moisture content to 15%. The amount of water needed for conditioning was calculated according to the following formula (36):

Let $W_1$ = Initial weight of wheat (grams).

$W_2$ = Final weight of wheat.

$M_1$ = Initial moisture content of wheat expressed as percent.

$M_2$ = Final moisture content of wheat expressed as percent.

The amount of dry matter in the grain remained constant so that:

$$\frac{100-M_1}{100}(W_1) = \frac{100-M_2}{100}(W_2) \qquad (W_2) = \frac{100-M_1}{100-M_2}(W_1)$$

Therefore, the weight of the water to be added must equal $W_2-W_1$. The wheat was conditioned in batches of 3,000 g by placing each one separately in an experimental rotating tempering device and adding the calculated amount of water in the form of spray. Five min were allowed for mixing of water with grain.

Grinding and Sifting

The conditioned wheat was held in polyethylene bags for 24-48 hr and then ground in Ross Experimental Roller Mills. The wheat was ground in five steps and the ground material was sifted through a series of sieves after each step in order to separate the fines and to pass the coarser fractions to the next grinding step. The milling flow sheet is shown in Fig. 2. The rolls used in the first four steps were corrugated and in the last step the middlings were ground through smooth rolls. The type of rolls, corrugations, spiral, speed of rolls and clearance between the rolls in each step are given in the flow sheet diagram. All the rolls except the smooth pair were of "Getchell" type and the grinding action was dull to dull. The sifting of the ground material was carried out on a Smico laboratory sifter using 32W, 42W and 10XX sieves. The overs of the 32W sieve were ground in the next step until the fourth step, at which point they were removed as bran. The time of sifting was 2 min, except in the fourth step where the time was from 30 to 45 sec, in order to obtain approximately 5% as overs of 32W. The overs of 42W from the first through the fourth were pooled and ground through the smooth rolls. After the removal of bran, the remaining streams were pooled and blended in a laboratory blender for 25 min. This yielded 95% extraction atta.

Preparation of Chapatis and Nan

Chapatis:

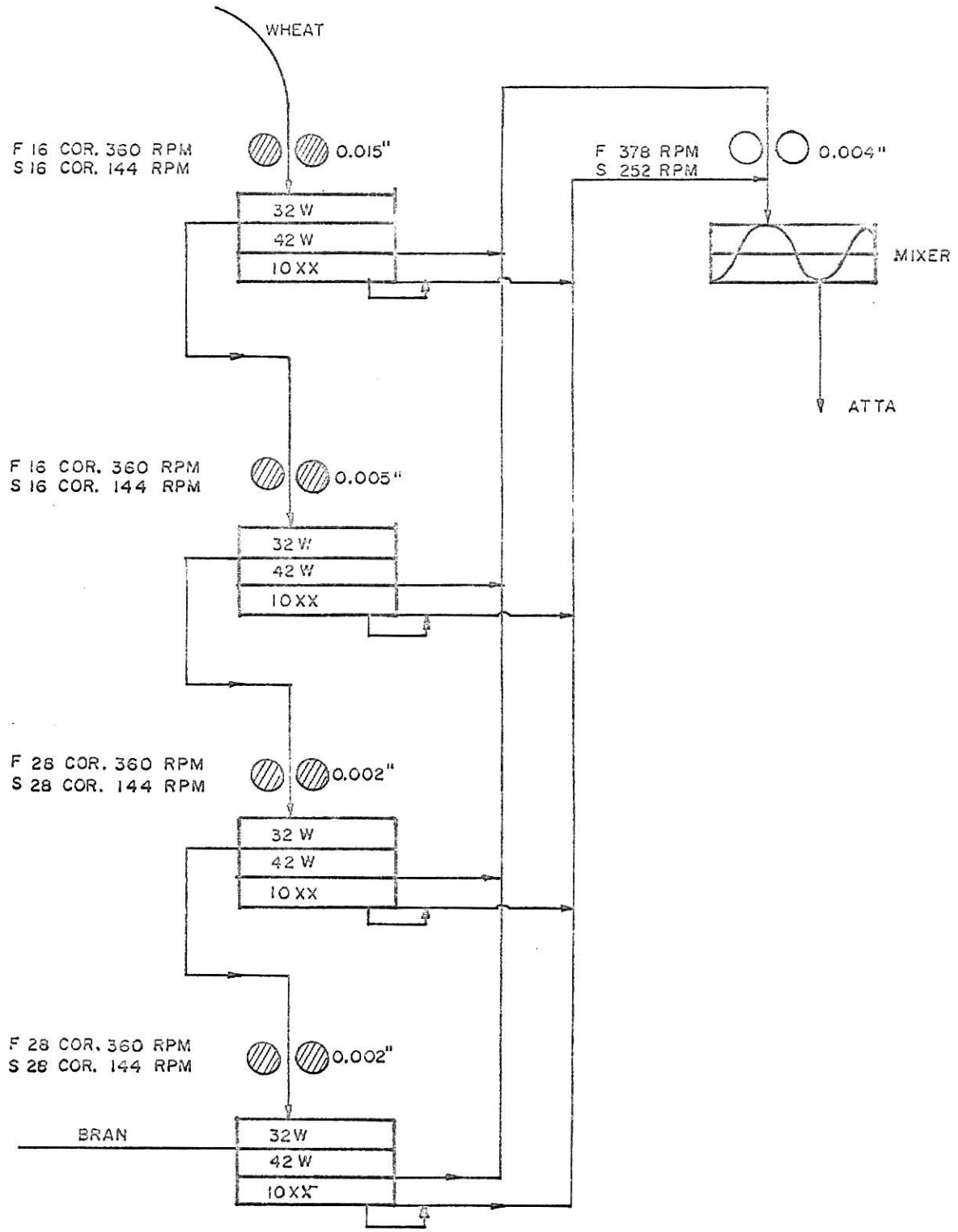



Fig. 2. A schematic flow sheet for milling of atta from Gaines variety wheat.

The chapatis were prepared in batches for each of which 200 g atta (dry basis) was used. The amount of water required to make a dough of proper consistency was in the range of 60-65%. In all preparations 1.5% salt (based on dry wt of atta) was added. Three levels of calcium propionate, viz; .1%, .2% and .3% were used. Butylated hydroxy anisole (B.H.A.) was used as an anti-oxidant at three different levels, viz, .01%, .015% and .02%. Shortening was used as a softening agent at 1%, 2% and 3% levels. Bacterial alpha-amylase was used at levels of 1, 2 and 3 SK units/100 g of flour (dry basis). The dough consisting of all the ingredients was mixed in a Hobart Mixer, Model N-50 (Fig. 3), for 4 to 5 min, at first speed for 1/2 min and then at the second speed. Mixed dough was allowed to rest for 60 min at room temperature. The dough temperature was kept between 78 and 80°F. The dough was divided into dough balls weighing 50 g each and each dough ball was rolled out into a chapati of 6.5 to 7 in diameter with the help of a rolling pin (Fig. 4).

The diameter automatically determined the thickness of each chapati. The chapatis were then cooked on a hot plate (Fig. 5), the temperature of which was from 280 to 290°C. It took approximately 2.5 min to cook and puff each chapati. After cooking, chapatis were allowed to cool for a few minutes, then were packed into polyethylene bags and ordinary paper bags. This experiment was run in triplicate with three replications.

The chapatis were stored in a high temperature storage room (80-90°F) for further studies. The stored chapatis were weighed and observed for other characteristics daily for seven days.

Nan:

The nan were prepared in batches, for which 500 g atta (dry basis) was used. The amount of water required to make a dough of proper consistency was

Fig. 3. Hobart Mixer Model N-50.

Fig. 4. Rolling equipment.

Fig. 5. Hot plate.

in the range of 60-65%. In each preparation 1.5% sodium chloride and 2% bakers compressed yeast (based on dry wt of atta) were added.

The levels of calcium propionate, butylated hydroxyanisole (B.H.A.), shortening and bacterial alpha-amylase, were the same as for chapatis. The dough was mixed in a Hobart Mixer, Model N-50 for 5 min. Mixed dough was allowed to rest for 75-90 min, at room temperature. The dough temperature was kept between 77 and 80°F. The dough was divided into dough balls weighing 120 g each, and each dough ball was rolled into a nan of 6-6.5 in diameter with the help of a rolling pin, which automatically fixed the thickness of each nan. The nan were then baked in an oven, the temperature of which ranged between 290-300°C. It took approximately 5 min to bake each nan and brown its top. After baking nans were allowed to cool for a few minutes, then packed into polyethylene bags and ordinary paper bags. Each experiment was run in triplicate with three replications.

The nan were stored in high temperature storage (80-90°F) for further studies. These nans were weighed and observed for general quality characteristics daily for seven days.

Determination of Proximate Composition of Atta, Dough, Prepared and Stored Chapatis and Nan

This study was designed to determine the effect of cooking and storage on the nutritive value of chapatis and nan. The samples of atta, dough, prepared and stored chapatis and nan were analyzed for moisture, crude protein, ash and crude fat, according to methods 44-15, 56-10, 08-10, and 30-20 respectively in Cereal Laboratory Methods (35). Crude protein was calculated by multiplying nitrogen by the factor 6.25. The fat acidity was determined by the AOAC method (37).

## Organoleptic Evaluation of Stored Chapatis and Nan

Chapatis and nan prepared under different treatments and stored for the period observed to be the best under particular storage conditions were evaluated for their color, texture, aroma, taste and over-all acceptance (eating qualities) by a panel of judges consisting of students from Pakistan and India who were familiar with chapatis and nan. The judges were briefed as to the method of scoring the different quality characteristics. The products were evaluated according to a scalar scoring system in which each characteristic was scored over a scale ranging from 0 to 10 points, 0 representing the poorest quality and 10 representing the best quality. The score sheet used for this evaluation is reproduced on page 30 .

## Statistical Procedures

The data on the organoleptic evaluation of the stored chapatis and nan were analyzed by analysis of variance as described by Fryer (38).

SCORE SHEET FOR ORGANOLEPTIC

EVALUATION OF CHAPATIS/NAN

NAME _____ DATE _____

Please examine the chapatis/nan samples provided (don't disturb the order) and score these for acceptability with respect to the qualities in question using the following 10 point scale.

Highest possible score - 10 points
Lowest possible score - 0 points

| Quality in question | SAMPLES | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| 1. Color | | | | | | |
| 2. Aroma | | | | | | |
| 3. Texture | | | | | | |
| 4. Eating Properties | | | | | | |

COMMENTS:

# RESULTS AND DISCUSSION

## Preliminary Studies

Five different wrapping materials, namely, polyethylene bags, wax paper, foil wrap, saran wrap and ordinary paper bags were tried with a non-wrapped lot as control. Saran wrap, foil wrap and polyethylene bags best retained moisture of chapatis and nan. Two kinds of wrapping material, polyethylene bags and ordinary paper bags were selected for further investigations, because they are available in Pakistan and their cost is low.

Ninety-five per cent whole wheat (95% extraction) atta produced better quality chapatis than 85% extraction atta, whereas 85% extraction atta produced better quality nan than 95% extraction. Finer atta produced better nan than coarser atta, but 95% extraction and 32 W mesh sieve were used to make atta because this is the combination used most commonly in Pakistan.

Shortening at 3% of the formula contributed to chapatis and nan nutritional qualities and lubricated the dough during handling, resting and fermentation. When compressed bakers yeast was used less than 1.5% (based on weight of atta to dough) gave nan a firm touch, higher levels (over 2%) deteriorated quality of nan produced. Probably excessive yeast depleted available sugar in the dough, which resulted in nan of rough texture and poor flavor quality. In these investigations 1.5 to 2% compressed bakers yeast (based on flour weight in dough) produced highest quality nan.

Adding water to the dough at 69% of the weight of the atta produced the best textured chapatis and nan. The high moisture percentage resulted in a soft texture that was retained longer than when lower percentages of water were used in the dough. Moisture content of chapatis and nan vitally affected their shelf-life. It is highly important to the quality of chapatis and nan to have the proper ratio of atta and water in the dough.

Preliminary studies indicated that salt serves as a multipurpose ingredient in preparing dough for chapatis and nan. It helps to regulate fermentation in nan dough, controls absorption, imparts flavor and acts as a gluten strengthening agent. Different levels of salt used in preliminary experiments indicated that 2% and 2.25% (based on weight of atta in dough) gave better moisture retention in chapatis and nan than lower levels. Less salt gave poor moisture retention and affected adversely the texture of chapatis and nan. However 1.5% salt is adequate to produce good quality chapatis and nan.

Spoilage of chapatis and nan results from mold growth. Bacterial spoilage would not preeede mold growth. Spoilage due to molds and fungi is readily visible. Nevertheless, plate counts for mold, bacteria and yeast were recorded and typical molds were identified. Results of plate counts are given in Table 1 and pictures of identified molds are shown in Fig. 7.

Effect of Packaging on Moisture Content

Loss of moisture from chapatis and nan made them hard, dry and brittle. Losses of moisture and of freshness were parallel. Packaged in polyethylene bags, chapatis and nan lost essentially no weight up to 5 or 6 days. When stored in ordinary paper bags both chapatis and nan became hard with brittle edges by the 2nd or 3rd day. After 3 or 4 days they were completely brittle regardless of formulation used.

Moisture losses were rapid from ordinary paper bags; however little moisture was lost by either chapatis or nan made with formulations containing high levels of bacterial alpha-amylase and shortening and packaged in polyethylene bags up to 7 days (Tables 2 and 4). Polyethylene bags were therefore judged best to package and to preserve chapatis and nan.

TABLE 1. PLATE COUNTS OF INDICATED ORGANISMS PER G OF MATERIAL USED.

| Material | Bacteria | Yeast | Molds |
|---|---|---|---|
| Atta | 23,000,000 | 1,000,000 | 935 |
| Dough of Chapati | 20,000,000 | 115 | 650 |
| Dough of Nan | 15,000,000 | 10,550,000 | 30 |
| Prepared Chapati | 160 | 485 | 20 |
| Prepared Nan | 30 | 700 | -- |

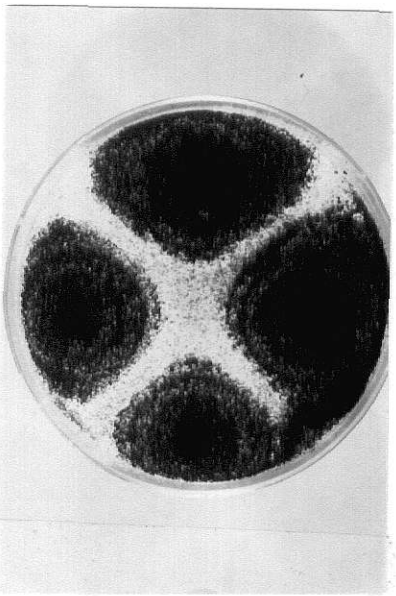
Ordinary paper bags did not give enough protection from moisture loss (Tables 3 and 5) and were considered poor packaging to preserve chapatis and nan, unless the paper could be treated so it would retain moisture better.

Regardless of packaging material tested, flavor of chapatis and nan deteriorated markedly after one week.

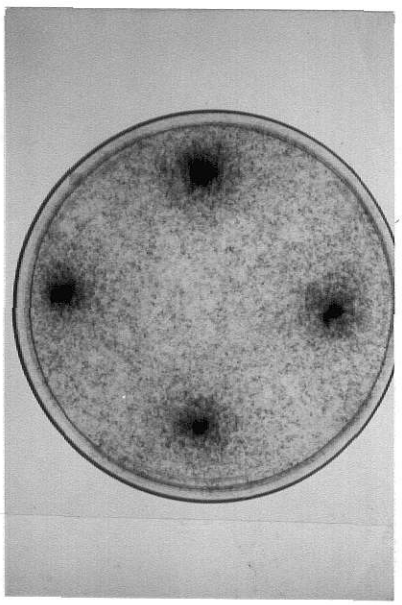
Effect of Additives on Shelf Life of Chapatis and Nan

Chapatis and nan prepared with .2 or .3% calcium propionate incorporated into the dough kept very well because no mold growth occurred up to 6 or 7 days storage; however .1% calcium propionate in the formula did not satisfactorily prevent mold growth after 4 to 5 days (Figs. 8, 9, 10, and 11).

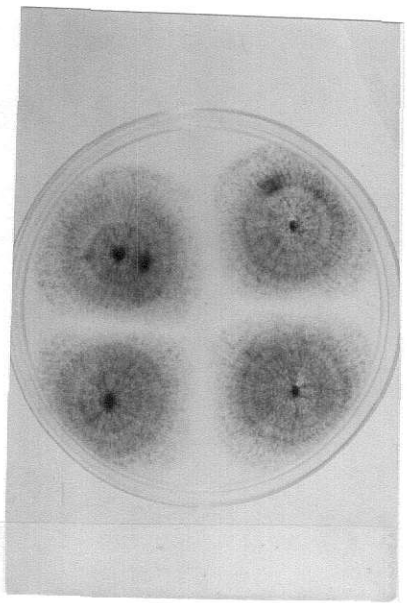
Adding .01% or .015% butylated hydroxy anisole (B.H.A.) also distinctly improved the keeping quality without affecting flavor of either chapatis or nan. Adding sodium chloride in the formulation increased the efficiency of calcium propionate as an antimicrobial agent. In addition to its synergistic action sodium chloride may have contributed to preservation by its anti-microbial action. If so, calcium propionate could be reduced by increasing the sodium chloride content to its acceptability limit.



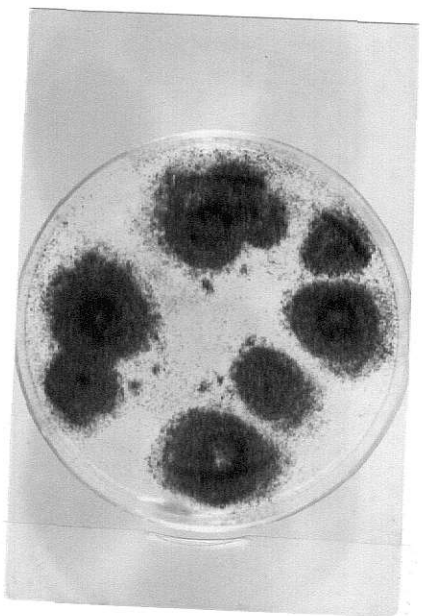
Aspergillus niger



Rhizopus Sp.

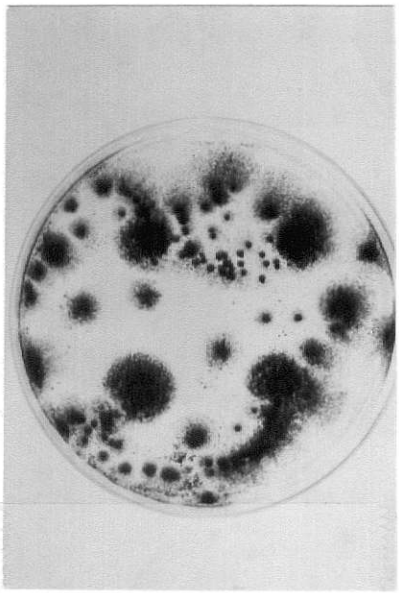


Aspergillus Sp.

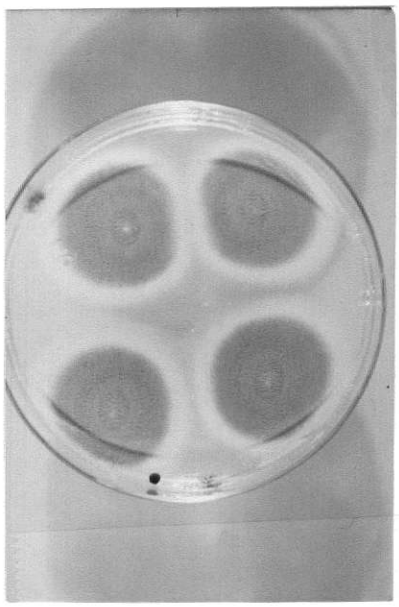


Aspergillus flavus

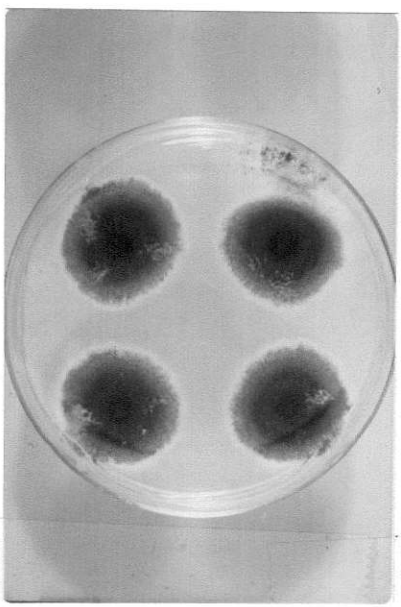
Fig. 7



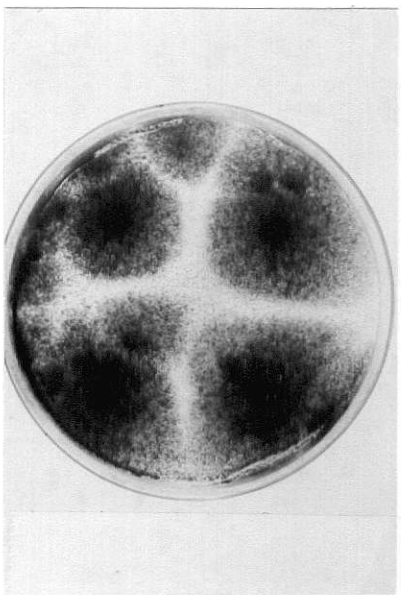
Penicillium sp.



Penicillium lilacium



Penicillium sp.



Aspergillus fumigatus

Fig. 7 (Cont)

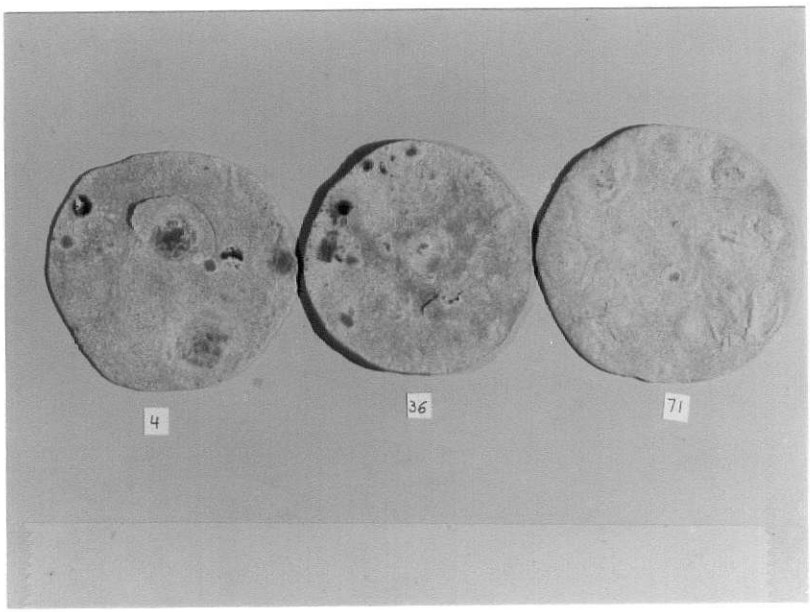



Fig. 8. Chapatis. 4-.1% Calcium propionate + .01% BHA.
36-.2% Calcium propionate + .01% BHA.
71-.3% Calcium propionate + .01% BHA.
(After 7 days storage).

Fig. 9. Chapatis. 5-.1% Calcium propionate + .01% BHA.
12-.2% Calcium propionate + .015% BHA.
22-.1% Calcium propionate + .02% BHA.
(After 7 days storage).

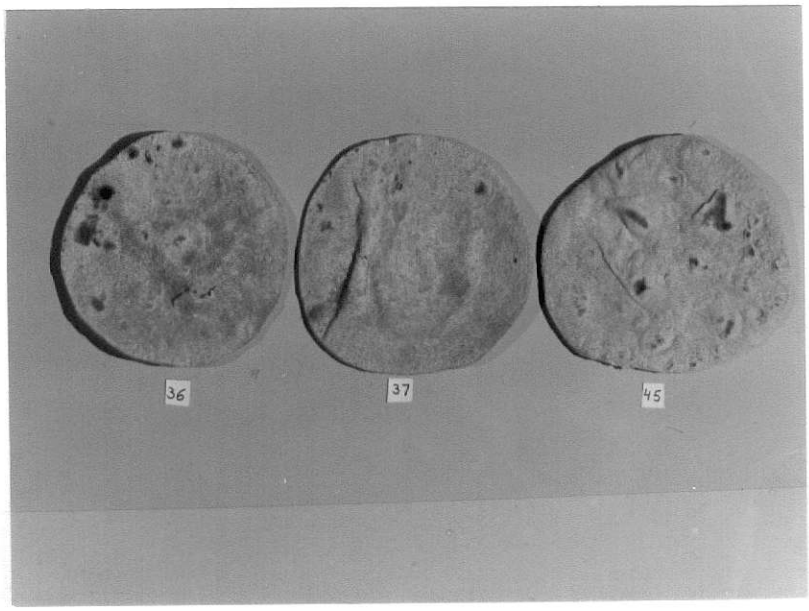



Fig. 10. Chapatis. 36-.2% Calcium propionate + .01% BHA.
37-.2% Calcium propionate + .015% BHA.
45-.2% Calcium propionate + .02% BHA.
(After 7 days storage).

Fig. 11. Chapatis. 61-.3% Calcium propionate + .01% BHA.
71-.3% Calcium propionate + .015% BHA.
81-.3% Calcium propionate + .02% BHA.
(After 7 days storage).

Coating the interior of bulk storage containers with dilute calcium propionate solution delayed microbial attack slightly.

No perceptible improvement in the keeping quality of chapatis and nan was obtained by using shortening levels up to 3% in the dough, but that amount of shortening improved overall chapati and nan quality. Three per cent shortening appears to be optimum in the dough formula for both chapatis and nan.

Bacterial alpha-amylase improved considerably the puffing quality of both chapatis and nan. Particularly in nan production 2 or 3 SK units per 100 g of atta in the dough preparation, regardless of other ingredients, resulted in remarkable puffing quality, as shown in Figs. 12 and 13. The enzyme effectively improved dough handling after the dough rest period, and also markedly improved the texture of chapatis. Bacterial alpha-amylase added at 2 or 3 SK units per 100 g atta in the dough, considerably improved keeping quality of chapatis and nan as judged by softness of the products.

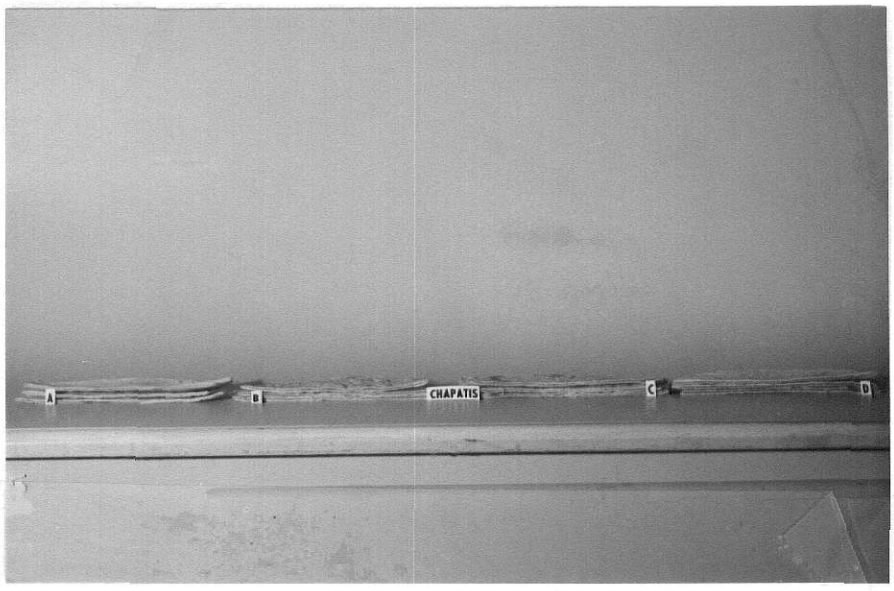



Fig. 12. Chapatis. A. Control
B. 1 SK unit
C. 2 SK units
D. 3 SK units bacterial alpha-amylase/100 g atta in dough.

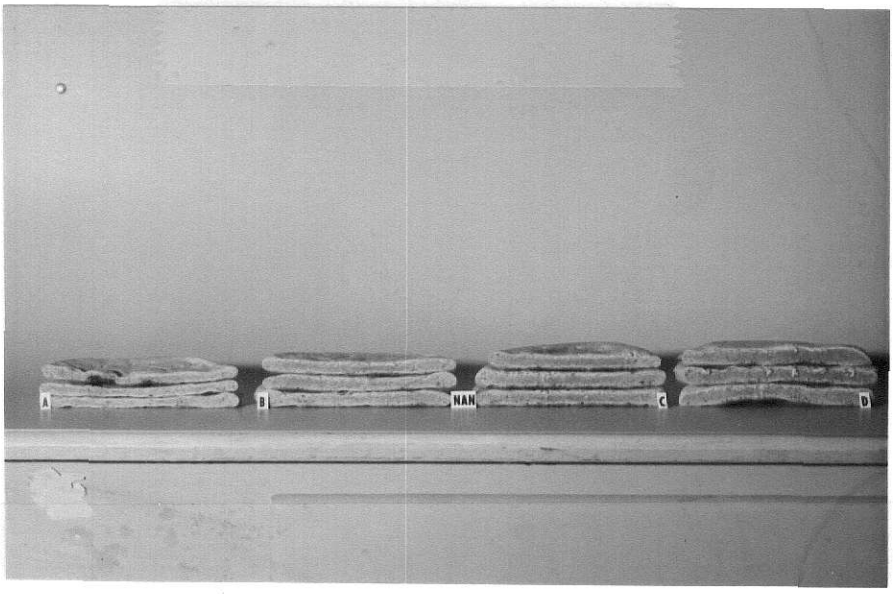



Fig. 13. Nan. A. Control
B. 1 SK unit
C. 2 SK units
D. 3 SK units bacterial alpha-amylase/100 g atta in dough.

THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH ILLEGIBLE
PAGE NUMBERS
THAT ARE CUT OFF,
MISSING OR OF POOR
QUALITY TEXT.

THIS IS AS RECEIVED
FROM THE
CUSTOMER.

TABLE 2. WEIGHT OF CHAPATIS STORED IN POLYETHYLENE BAGS (G) (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHORTENING %, BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G ATTA IN DOUGH).

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 45 | 44.5 | 44.5 | 44.5 | 44.5 | 44 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43.5 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 1 | | | | | | | | |
| 2 | | | | | | | | |
| CaP .1 | 43.5 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43.5 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Shg 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 2 | | | | | | | | |
| 3 | | | | | | | | |
| CaP .1 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 3 | | | | | | | | |
| 4 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .01 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| Shg 2 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43.5 |
| BA 1 | | | | | | | | |
| 5 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .01 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Shg 2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 |
| BA 2 | | | | | | | | |
| 6 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 45 | 45 | 45 | 44.5 | 44.5 | 44.5 |
| BHA .01 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45 | 45 |
| Shg 2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 3 | | | | | | | | |
| 7 | | | | | | | | |
| CaP .1 | 42.5 | 42.5 | 43 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 3 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 | 44 |
| BA 1 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BA 2 | | | | | | | | |
| 9 | | | | | | | | |
| CaP .1 | 41.5 | 41.5 | 41.5 | 42 | 41.5 | 41.5 | 41.5 | 41.5 |
| BHA .01 | 42 | 42 | 42 | 42 | 42 | 41.5 | 41.5 | 41.5 |
| Shg 3 | 44 | 44 | 44 | 44.5 | 44 | 44 | 44 | 43.5 |
| BA 3 | | | | | | | | |
| 10 | | | | | | | | |
| CaP .1 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46 |
| BHA .015 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| Shg 1 | 44 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44 | 44 |
| BA 1 | | | | | | | | |
| 11 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 1 | | | | | | | | |
| BA 2 | | | | | | | | |
| 12 | | | | | | | | |
| CaP .1 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 |
| BHA .015 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BA 3 | | | | | | | | |
| 13 | | | | | | | | |
| CaP .1 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 |
| BHA .015 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| Shg 2 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BA 1 | | | | | | | | |
| 14 | | | | | | | | |
| CaP .1 | 46.5 | 46.5 | 47 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 |
| BHA .015 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43.5 |
| Shg 2 | | | | | | | | |
| BA 2 | | | | | | | | |
| 15 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 45 | 44.5 | 44.5 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Shg 2 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| BA 3 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 16 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .015 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 3 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 1 | | | | | | | | |
| 17 | | | | | | | | |
| CaP .1 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43.5 | 43 | 43 |
| Shg 3 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 2 | | | | | | | | |
| 18 | | | | | | | | |
| CaP .1 | 40.5 | 40.5 | 40.5 | 40.5 | 41 | 40.5 | 40.5 | 40 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 3 | 44 | 44 | 4 | 4 | 44 | 44 | 44 | 43.5 |
| BA 3 | | | | | | | | |
| 19 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 44 | 44 |
| BHA .02 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 1 | | | | | | | | |
| 20 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 44.5 | 44.5 | 45 | 44.5 | 44.5 | 44 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| BA 2 | | | | | | | | |
| 21 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 45 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .02 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 |
| Shg 1 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 | 46.5 |
| BA 3 | | | | | | | | |
| 22 | | | | | | | | |
| CaP .1 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Shg 2 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 1 | | | | | | | | |
| 23 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 2 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44 |
| BA 2 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 24 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| BA 3 | | | | | | | | |
| 25 | | | | | | | | |
| CaP .1 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 42 | 41.5 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 3 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 | 46.5 |
| BA 1 | | | | | | | | |
| 26 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 3 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| BA 2 | | | | | | | | |
| 27 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .02 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 3 | | | | | | | | |
| BA 3 | | | | | | | | |
| 28 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 1 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 | 41 |
| BA 1 | | | | | | | | |
| 29 | | | | | | | | |
| CaP .2 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42 | 42 | 42 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Shg 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BA 2 | | | | | | | | |
| 30 | | | | | | | | |
| CaP .2 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47 | 47 |
| BHA .01 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| BA 3 | | | | | | | | |
| 31 | | | | | | | | |
| CaP .2 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47 |
| BHA .01 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Shg 2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BA 1 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 32 | | | | | | | | |
| CaP .2 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45 |
| BHA .01 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BA 2 | | | | | | | | |
| 33 | | | | | | | | |
| CaP .2 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45 | 45 |
| BHA .01 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 2 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 3 | | | | | | | | |
| 34 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 3 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 1 | | | | | | | | |
| 35 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43.5 |
| Shg 3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 2 | | | | | | | | |
| 36 | | | | | | | | |
| CaP .2 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 44.5 |
| BHA .01 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 |
| Shg 3 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| BA 3 | | | | | | | | |
| 37 | | | | | | | | |
| CaP .2 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Shg 1 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 | 45.5 |
| BA 1 | | | | | | | | |
| 38 | | | | | | | | |
| CaP .2 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50 |
| BHA .015 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Shg 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 2 | | | | | | | | |
| 39 | | | | | | | | |
| CaP .2 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50.5 | 50 |
| BHA .015 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 | 46.5 |
| Shg 1 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| BA 3 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 40 | | | | | | | | |
| CaP .2 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45 | 45 |
| BHA .015 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 2 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BA 1 | | | | | | | | |
| 41 | | | | | | | | |
| CaP .2 | 51.5 | 51.5 | 51.5 | 51.5 | 51.5 | 51.5 | 51.5 | 51.5 |
| BHA .015 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 |
| Shg 2 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 |
| BA 2 | | | | | | | | |
| 42 | | | | | | | | |
| CaP .2 | 50 | 50 | 50 | 50 | 50 | 49.5 | 49.5 | 49.5 |
| BHA .015 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 3 | | | | | | | | |
| 43 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44 | 44 |
| BHA .015 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| Shg 3 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| BA 1 | | | | | | | | |
| 44 | | | | | | | | |
| CaP .2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 |
| Shg 2 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 |
| BA 2 | | | | | | | | |
| 45 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44 |
| BHA .015 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 3 | | | | | | | | |
| 46 | | | | | | | | |
| CaP .2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 47 | 47 | 47 | 47 | 47 | 46.5 | 47 | 46.5 |
| BA 1 | | | | | | | | |
| 47 | | | | | | | | |
| CaP .2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 40.5 |
| Shg 1 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BA 2 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 48 | | | | | | | | |
| CaP .2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Shg 1 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| BA 3 | | | | | | | | |
| 49 | | | | | | | | |
| CaP .2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 1 | | | | | | | | |
| 50 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 |
| BHA .02 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 |
| Shg 2 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 2 | | | | | | | | |
| 51 | | | | | | | | |
| CaP .2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 3 | | | | | | | | |
| 52 | | | | | | | | |
| CaP .2 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44.5 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BA 1 | | | | | | | | |
| 53 | | | | | | | | |
| CaP .2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| Shg 3 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| BA 2 | | | | | | | | |
| 54 | | | | | | | | |
| CaP .2 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .02 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| Shg 3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| BA 3 | | | | | | | | |
| 55 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .01 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| BA 1 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44 |
| BA 2 | | | | | | | | |
| 57 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .01 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 3 | | | | | | | | |
| 58 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BHA .01 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 1 | | | | | | | | |
| 59 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 |
| Shg 2 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 2 | | | | | | | | |
| 60 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .01 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43 |
| Shg 2 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 | 45.5 |
| BA 3 | | | | | | | | |
| 61 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .01 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 3 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 |
| BA 1 | | | | | | | | |
| 62 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .01 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42 |
| Shg 3 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 2 | | | | | | | | |
| 63 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 |
| BHA .01 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.4 | 41 |
| Shg 3 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| BA 3 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 64 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 |
| BHA .01 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44 |
| Shg 3 | 42 | | 42 | 42 | 42 | 42 | 41.5 | 41.5 |
| BA 1 | | | | | | | | |
| 65 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 42.5 | 42.5 | 42 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 2 | | | | | | | | |
| 66 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BA 3 | | | | | | | | |
| 67 | | | | | | | | |
| CaP .3 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 | 41 |
| BHA .015 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| Shg 2 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 1 | | | | | | | | |
| 68 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 43.5 | 43.5 | 43 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 2 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| BA 2 | | | | | | | | |
| 69 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .015 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 |
| Shg 2 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 3 | | | | | | | | |
| 70 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 3 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 |
| BA 1 | | | | | | | | |
| 71 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BHA .015 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43.5 |
| Shg 3 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| BA 2 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 72 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .015 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 | 41.5 |
| Shg 3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 3 | | | | | | | | |
| 73 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 | 42.5 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| Shg 1 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| BA 1 | | | | | | | | |
| 74 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 1 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 |
| BA 2 | | | | | | | | |
| 75 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 | 43 |
| BHA .02 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42 |
| Shg 1 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 |
| BA 3 | | | | | | | | |
| 76 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43.5 |
| Shg 2 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 41.5 |
| BA 1 | | | | | | | | |
| 77 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43.5 | 43 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Shg 2 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 2 | | | | | | | | |
| 78 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BHA .02 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43.5 |
| Shg 2 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 |
| BA 3 | | | | | | | | |
| 79 | | | | | | | | |
| CaP .3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| BHA .02 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41.5 | 41 |
| Shg 3 | 47 | 47 | 47 | 47 | 47 | 47 | 46.5 | 46.5 |
| BA 1 | | | | | | | | |

TABLE 2 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 80 | | | | | | | | |
| CaP .3 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| BHA .02 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 42.5 |
| Shg 3 | 45 | 45 | 45 | 45 | 45 | 45 | 44.5 | 44.5 |
| BA 2 | | | | | | | | |
| 81 | | | | | | | | |
| CaP .3 | 43.5 | 43.5 | 43.5 | 43 | 43.5 | 43.5 | 43.5 | 43.5 |
| BHA .02 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Shg 3 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45.5 |
| BA 3 | | | | | | | | |

TABLE 3. WEIGHT OF CHAPATIS STORED IN ORDINARY PAPER BAGS (G) (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHORTENING %, BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G OF ATTA IN THE DOUGH).

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | | | | | | | | |
| CaP .1 | 44 | 44 | 43 | 39.5 | 39 | 36 | 36 | 34 |
| BHA .01 | 42 | 42 | 41 | 38.5 | 38 | 37 | 34.5 | 33.5 |
| Shg 1 | 45 | 45 | 42 | 42 | 41 | 39 | 37.5 | 34.5 |
| BA 1 | | | | | | | | |
| 2 | | | | | | | | |
| CaP .1 | 45 | 45 | 43 | 41.5 | 38.5 | 37 | 35 | 33.5 |
| BHA .01 | 44 | 44 | 42 | 41 | 38 | 36 | 36 | 34 |
| Shg 1 | 47 | 46 | 44 | 42 | 39 | 37.5 | 37 | 35 |
| BA 2 | | | | | | | | |
| 3 | | | | | | | | |
| CaP .1 | 44 | 44 | 43 | 39 | 38 | 37 | 36 | 35 |
| BHA .01 | 41 | 41 | 40 | 38 | 37 | 36 | 35 | 34 |
| Shg 1 | 43 | 43 | 42 | 40 | 39 | 37 | 37 | 36 |
| BA 3 | | | | | | | | |
| 4 | | | | | | | | |
| CaP .1 | 44 | 44 | 43 | 39 | 39 | 38 | 37 | 36 |
| BHA .01 | 42 | 42 | 41 | 38 | 37 | 37 | 35 | 34 |
| Shg 2 | 45 | 45 | 43 | 42 | 40 | 39 | 37 | 35 |
| BA 1 | | | | | | | | |
| 5 | | | | | | | | |
| CaP .1 | 45 | 45 | 44 | 40 | 40 | 37 | 37 | 35 |
| BHA .01 | 43 | 43 | 42 | 40 | 38 | 37 | 37 | 35.5 |
| Shg 2 | 41.5 | 41 | 40 | 40 | 39 | 38 | 37 | 34 |
| BA 2 | | | | | | | | |
| 6 | | | | | | | | |
| CaP .1 | 44.5 | 44.5 | 43.5 | 40 | 40 | 37.5 | 37 | 35 |
| BHA .01 | 42 | 42 | 41 | 39 | 38 | 37 | 36 | 34.5 |
| Shg 3 | 41 | 41 | 40 | 38 | 37 | 35 | 34 | 33 |
| BA 1 | | | | | | | | |
| 7 | | | | | | | | |
| CaP .1 | 44 | 43 | 41 | 40 | 39 | 38.5 | 37 | 36 |
| BHA .01 | 42 | 41.5 | 40 | 39 | 38 | 36 | 35 | 34 |
| Shg 3 | 41 | 41 | 40 | 38 | 37 | 35 | 34 | 33 |
| BA 1 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | | | | | | | | |
| CaP .1 | 43.5 | 43.5 | 41.5 | 38.5 | 37.5 | 35.5 | 34.5 | 34.5 |
| BHA .01 | 44 | 42 | 41 | 40 | 38 | 38 | 37 | 35.5 |
| Shg 3 | 43 | 43 | 42 | 39 | 38 | 37 | 36 | 34 |
| BA 2 | | | | | | | | |
| 9 | | | | | | | | |
| CaP .1 | 45 | 45 | 43 | 42 | 41 | 40 | 39 | 36 |
| BHA .01 | 42 | 41 | 40 | 39 | 38 | 37 | 35 | 34 |
| Shg 3 | 43 | 43 | 42 | 40 | 39 | 38 | 37 | 35 |
| BA 3 | | | | | | | | |
| 10 | | | | | | | | |
| CaP .1 | 44 | 43 | 42 | 42 | 40 | 37 | 36 | 34.5 |
| BHA .015 | 41.5 | 41 | 40 | 39 | 38 | 36 | 35 | 33 |
| Shg 1 | 42 | 41 | 40 | 39 | 37.5 | 36 | 35 | 34 |
| BA 1 | | | | | | | | |
| 11 | | | | | | | | |
| CaP .1 | 45 | 45 | 44.5 | 39 | 37.5 | 37 | 37 | 35.5 |
| BHA .015 | 43 | 42 | 42 | 41 | 40 | 38 | 37 | 35 |
| Shg 1 | 44 | 43 | 42 | 40 | 40 | 39 | 38 | 36 |
| BA 2 | | | | | | | | |
| 12 | | | | | | | | |
| CaP .1 | 44 | 43 | 39 | 38 | 37.5 | 37 | 36 | 35 |
| BHA .015 | 42 | 42 | 40 | 40 | 38 | 36 | 35 | 33.5 |
| Shg 1 | 41.5 | 41.5 | 40 | 39 | 37 | 36.5 | 34 | 32.5 |
| BA 2 | | | | | | | | |
| 13 | | | | | | | | |
| CaP .1 | 45 | 44 | 39 | 38 | 37.5 | 36.5 | 35 | 35 |
| BHA .015 | 42 | 41 | 40 | 38 | 37 | 36 | 35 | 34.5 |
| Shg 2 | 45 | 45 | 40 | 39 | 37 | 35.5 | 35 | 35 |
| BA 1 | | | | | | | | |
| 14 | | | | | | | | |
| CaP .1 | 44 | 43 | 42.5 | 41.5 | 39 | 39 | 38 | 36 |
| BHA .015 | 45 | 44 | 43 | 42 | 40 | 38 | 37 | 35 |
| Shg 2 | 42 | 42 | 40 | 39 | 37 | 37 | 36 | 34 |
| BA 2 | | | | | | | | |
| 15 | | | | | | | | |
| CaP .1 | 44 | 43 | 41 | 40.5 | 39 | 39 | 38 | 36 |
| BHA .015 | 43 | 43 | 42 | 40 | 39 | 38 | 37 | 34.5 |
| Shg 2 | 41.5 | 41 | 40 | 39 | 38 | 37 | 36 | 32.5 |
| BA 3 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 16 | | | | | | | | |
| CaP .1 | 45 | 44 | 43 | 42 | 42 | 40.5 | 38 | 36.5 |
| BHA .015 | 43 | 42 | 41 | 39 | 38 | 37 | 36 | 34 |
| Shg 3 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 35.5 |
| BA 1 | | | | | | | | |
| 17 | | | | | | | | |
| CaP .1 | 44 | 43 | 42 | 41 | 41 | 39 | 38 | 36 |
| BHA .015 | 42 | 41 | 40 | 39 | 38 | 37 | 37 | 35 |
| Shg 3 | 45 | 44 | 42 | 40 | 38 | 36 | 35 | 35.5 |
| BA 2 | | | | | | | | |
| 18 | | | | | | | | |
| CaP .1 | 43 | 42.5 | 42 | 41.5 | 41 | 40 | 38 | 36 |
| BHA .015 | 44 | 44 | 42 | 40 | 39 | 37 | 36.5 | 36.5 |
| Shg 3 | 43 | 42 | 41 | 40 | 39 | 38 | 38 | 35.5 |
| BA 3 | | | | | | | | |
| 19 | | | | | | | | |
| CaP .1 | 44 | 44 | 43 | 42 | 41 | 39 | 38 | 37 |
| BHA .02 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 36 |
| Shg 1 | 42 | 42 | 40 | 39 | 38 | 38 | 36 | 34 |
| BA 1 | | | | | | | | |
| 20 | | | | | | | | |
| CaP .1 | 45 | 45 | 41 | 40 | 40 | 39.5 | 37 | 36 |
| BHA .02 | 44 | 44 | 42 | 40 | 40 | 39 | 38 | 36.5 |
| Shg 1 | 43 | 43 | 41 | 41 | 39 | 38 | 37 | 35 |
| BA 2 | | | | | | | | |
| 21 | | | | | | | | |
| CaP .1 | 44 | 44 | 43 | 43 | 40 | 39 | 39 | 36 |
| BHA .02 | 43 | 43 | 41 | 40 | 38 | 37 | 36 | 34 |
| Shg 1 | 44 | 44 | 43 | 41 | 39 | 38 | 37 | 36 |
| BA 3 | | | | | | | | |
| 22 | | | | | | | | |
| CaP .1 | 44 | 42 | 41.5 | 38 | 38 | 37 | 36.5 | 35 |
| BHA .02 | 45 | 45 | 43 | 41 | 40 | 39 | 38 | 37 |
| Shg 2 | 42 | 42 | 40 | 38 | 37 | 37 | 36 | 35 |
| BA 1 | | | | | | | | |
| 23 | | | | | | | | |
| CaP .1 | 46 | 45 | 45 | 44 | 39.5 | 39 | 38 | 37 |
| BHA .02 | 44 | 43 | 42 | 40 | 38 | 37 | 37 | 35 |
| Shg 2 | 43 | 42 | 41 | 40 | 39 | 38 | 36 | 35 |
| BA 2 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 24 | | | | | | | | |
| CaP .1 | 47 | 46 | 45 | 44 | 39.5 | 39 | 38 | 37 |
| BHA .02 | 46 | 46 | 44 | 43 | 41 | 40 | 37 | 36.5 |
| Shg 2 | | | | | | | | |
| BA 3 | | | | | | | | |
| 25 | | | | | | | | |
| CaP .1 | 43 | 43 | 42.5 | 43 | 38.5 | 38 | 37 | 36.5 |
| BHA .02 | 44 | 44 | 43 | 42 | 41 | 40 | 39 | 38 |
| Shg 3 | 42 | 42 | 41 | 40 | 40 | 38 | 36 | 36 |
| BA 1 | | | | | | | | |
| 26 | | | | | | | | |
| CaP .1 | 45 | 43 | 41 | 40.5 | 38 | 38 | 37 | 37 |
| BHA .02 | 43 | 43 | 41 | 40 | 38 | 37 | 36 | 35 |
| Shg 3 | 44 | 44 | 42 | 41 | 40 | 39 | 36 | 36 |
| BA 2 | | | | | | | | |
| 27 | | | | | | | | |
| CaP .1 | 46 | 44 | 43.5 | 40 | 38 | 38 | 37.5 | 37 |
| BHA .02 | 44 | 44 | 42 | 40 | 39 | 38 | 36 | 35 |
| Shg 3 | 43 | 43 | 42 | 41 | 40 | 38 | 37 | 34 |
| BA 3 | | | | | | | | |
| 28 | | | | | | | | |
| CaP .2 | 44 | 42 | 42 | 41 | 40 | 39.5 | 38 | 37 |
| BHA .01 | 45 | 45 | 42 | 41 | 39 | 38 | 38 | 38 |
| Shg 1 | 43 | 43 | 41 | 40 | 38 | 37 | 37 | 36 |
| BA 1 | | | | | | | | |
| 29 | | | | | | | | |
| CaP .2 | 45 | 44 | 44 | 41 | 41 | 39 | 37 | 36 |
| BHA .01 | 43 | 43 | 43 | 40 | 39 | 38 | 36 | 34.5 |
| Shg 1 | 44 | 44 | 42 | 41 | 40 | 39 | 38 | 35 |
| BA 2 | | | | | | | | |
| 30 | | | | | | | | |
| CaP .2 | 47 | 46 | 46 | 42 | 40 | 39 | 37 | 36 |
| BHA .01 | 45 | 45 | 44 | 43 | 40 | 38 | 36 | 34 |
| Shg 1 | 43 | 43 | 41 | 40 | 39 | 37 | 36 | 33 |
| BA 3 | | | | | | | | |
| 31 | | | | | | | | |
| CaP .2 | 47 | 46.5 | 45 | 42 | 40 | 39 | 37 | 36 |
| BHA .01 | 44 | 44 | 43 | 40 | 39 | 38 | 36 | 34 |
| Shg 2 | 45 | 44 | 42 | 41 | 40 | 39 | 37 | 35 |
| BA 1 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 32 | | | | | | | | |
| CaP .2 | 41 | 40.5 | 40 | 39 | 38.5 | 38 | 37.5 | 37 |
| BHA .01 | 43 | 42 | 40 | 38 | 37 | 37 | 36.5 | 36 |
| Shg 2 | 47 | 46 | 44 | 42 | 40 | 38 | 37 | 37 |
| BA 2 | | | | | | | | |
| 33 | | | | | | | | |
| CaP .2 | 45 | 44 | 43.5 | 41 | 39 | 38 | 37 | 36 |
| BHA .01 | 44 | 43 | 42 | 39 | 38 | 36 | 36 | 35 |
| Shg 2 | 44 | 44 | 42 | 40 | 38 | 37 | 37 | 36.5 |
| BA 3 | | | | | | | | |
| 34 | | | | | | | | |
| CaP .2 | 43 | 43 | 42.5 | 42 | 41 | 40 | 39.5 | 38 |
| BHA .01 | 42 | 42 | 41.5 | 39 | 38 | 38 | 37 | 37 |
| Shg 3 | 45 | 42 | 40 | 40 | 39 | 38.5 | 38.5 | 38.5 |
| BA 1 | | | | | | | | |
| 35 | | | | | | | | |
| CaP .2 | 46 | 46 | 45 | 43 | 42 | 40 | 38 | 37 |
| BHA .01 | 45 | 43 | 42 | 40 | 39 | 39 | 38 | 36.5 |
| Shg 3 | 42 | 42 | 41 | 40 | 39 | 39 | 38 | 35 |
| BA 2 | | | | | | | | |
| 36 | | | | | | | | |
| CaP .2 | 45 | 44 | 43 | 42 | 39 | 39 | 37 | 36 |
| BHA .01 | 46 | 45 | 44 | 43 | 42 | 40 | 39 | 37 |
| Shg 3 | 45 | 44 | 43.5 | 41 | 39 | 38 | 37 | 36 |
| BA 3 | | | | | | | | |
| 37 | | | | | | | | |
| CaP .2 | 46 | 45.5 | 44 | 43 | 41 | 38 | 37 | 36 |
| BHA .015 | 47 | 46 | 45 | 44 | 42 | 40 | 38 | 37 |
| Shg 1 | 45 | 44 | 43 | 42 | 40 | 39 | 37 | 35.5 |
| BA 1 | | | | | | | | |
| 38 | | | | | | | | |
| CaP .2 | 46 | 46 | 43 | 40 | 38 | 36.5 | 36 | 36 |
| BHA .015 | 42 | 42 | 41 | 40 | 38 | 36 | 35 | 34 |
| Shg 1 | 45 | 44 | 42 | 41 | 40 | 39 | 37 | 36 |
| BA 2 | | | | | | | | |
| 39 | | | | | | | | |
| CaP .2 | 45 | 45 | 44.5 | 40 | 38 | 36.5 | 36 | 36 |
| BHA .015 | 46 | 45 | 43 | 43 | 41 | 38 | 37 | 37 |
| Shg 1 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 37 |
| BA 3 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 40 | | | | | | | | |
| CaP .2 | 46 | 46 | 44 | 40 | 40 | 39 | 38 | 37 |
| BHA .015 | 43 | 43 | 41 | 40 | 39 | 39 | 38 | 35 |
| Shg 2 | 42 | 42 | 40 | 39 | 38 | 38 | 37 | 34 |
| BA 1 | | | | | | | | |
| 41 | | | | | | | | |
| CaP .2 | 46 | 46 | 46 | 44 | 42 | 41 | 40 | 39 |
| BHA .015 | 45 | 45 | 44 | 40 | 38 | 37 | 36 | 36 |
| Shg 2 | 47 | 46 | 45 | 42 | 41 | 39 | 39 | 39 |
| BA 2 | | | | | | | | |
| 42 | | | | | | | | |
| CaP .2 | 46 | 44 | 43 | 40 | 39 | 39 | 38 | 38 |
| BHA .015 | 44 | 42 | 41 | 40 | 39 | 38 | 37 | 36 |
| Shg 2 | 46 | 45 | 44 | 41 | 40 | 39 | 38 | 38 |
| BA 3 | | | | | | | | |
| 43 | | | | | | | | |
| CaP .2 | 45 | 44.5 | 44 | 42 | 40 | 39 | 38 | 37 |
| BHA .015 | 46 | 45 | 45 | 42 | 40 | 38 | 38 | 36 |
| Shg 3 | 43 | 42 | 41 | 40 | 39 | 37 | 36 | 36 |
| BA 1 | | | | | | | | |
| 44 | | | | | | | | |
| CaP .2 | 45 | 43 | 40 | 39 | 39 | 38 | 38 | 37 |
| BHA .015 | 47 | 46 | 45 | 43 | 42 | 40 | 39 | 38.5 |
| Shg 3 | 44 | 44 | 42 | 41 | 40 | 39 | 37 | 36 |
| BA 2 | | | | | | | | |
| 45 | | | | | | | | |
| CaP .2 | 46 | 40 | 38 | 37 | 37 | 37 | 37 | 36 |
| BHA .015 | 43 | 41 | 40 | 39 | 38 | 37 | 36 | 34 |
| Shg 3 | 44 | 44 | 41 | 40 | 39 | 37 | 37 | 35 |
| BA 3 | | | | | | | | |
| 46 | | | | | | | | |
| CaP .2 | 46 | 46 | 39 | 38 | 37 | 37 | 36.5 | 36 |
| BHA .02 | 45 | 45 | 41 | 40 | 38 | 37 | 37 | 36.5 |
| Shg 1 | 46 | 45 | 42 | 40 | 39 | 38 | 37 | 36 |
| BA 1 | | | | | | | | |
| 47 | | | | | | | | |
| CaP .2 | 44 | 43 | 43 | 41 | 37 | 37 | 36 | 36 |
| BHA .02 | 45 | 44 | 43 | 42 | 40 | 39 | 36.5 | 36.5 |
| Shg 1 | 43 | 43 | 42 | 41 | 40 | 38 | 37 | 35 |
| BA 2 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 48 | | | | | | | | |
| CaP .2 | 46 | 45 | 44 | 42 | 38 | 38 | 37 | 36 |
| BHA .02 | 44 | 43 | 42 | 41 | 37 | 38 | 36 | 34.5 |
| Shg 1 | 44 | 42 | 42 | 40 | 39 | 37 | 36 | 35 |
| BA 3 | | | | | | | | |
| 49 | | | | | | | | |
| CaP .2 | 44 | 43 | 43 | 41 | 38 | 37 | 35 | 34 |
| BHA .02 | 45 | 44 | 42 | 40 | 39 | 38 | 36 | 35 |
| Shg 2 | 46 | 45 | 42 | 42 | 40 | 39 | 38 | 36 |
| BA 1 | | | | | | | | |
| 50 | | | | | | | | |
| CaP .2 | 50 | 48 | 48 | 45 | 41 | 39 | 39 | 38 |
| BHA .02 | 47 | 46 | 45 | 41 | 40 | 39 | 38 | 36 |
| Shg 2 | 46 | 45 | 44 | 42 | 41 | 38 | 37 | 35 |
| BA 2 | | | | | | | | |
| 51 | | | | | | | | |
| CaP .2 | 44 | 43 | 42 | 39 | 38 | 37 | 37 | 36 |
| BHA .02 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 37 |
| Shg 2 | 45 | 44 | 43 | 42 | 41 | 40 | 38 | 36 |
| BA 3 | | | | | | | | |
| 52 | | | | | | | | |
| CaP .2 | 45 | 43 | 42 | 40 | 39 | 38 | 37 | 36 |
| BHA .02 | 44 | 43 | 42 | 41 | 40 | 39 | 37 | 36.5 |
| Shg 3 | 43.5 | 43 | 41 | 40 | 39 | 38 | 36 | 35 |
| BA 1 | | | | | | | | |
| 53 | | | | | | | | |
| CaP .2 | 46 | 45 | 45 | 41 | 40 | 39 | 39 | 37 |
| BHA .02 | 45 | 43.5 | 42 | 40 | 39 | 37 | 37 | 35.5 |
| Shg 3 | 45 | 44 | 41 | 41 | 38 | 37 | 36 | 36 |
| BA 2 | | | | | | | | |
| 54 | | | | | | | | |
| CaP .2 | 46 | 45 | 43 | 41 | 30 | 39 | 39 | 37 |
| BHA .02 | 45 | 44 | 42 | 40 | 39 | 38 | 37 | 36 |
| Shg 3 | 44.5 | 44 | 43 | 42 | 41 | 39 | 36 | 35 |
| BA 3 | | | | | | | | |
| 55 | | | | | | | | |
| CaP .3 | 46 | 45 | 44 | 42 | 40 | 39 | 38 | 37 |
| BHA .01 | 44 | 44 | 43 | 41 | 39 | 38 | 36 | 35 |
| Shg 1 | 44 | 43 | 42 | 40 | 38 | 38 | 37 | 35.5 |
| BA 1 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | | | | | | | | |
| CaP .3 | 51 | 50 | 49 | 44 | 43 | 41 | 40 | 38 |
| BHA .01 | 47 | 46 | 45 | 43 | 42 | 40 | 48 | 34 |
| Shg 1 | 44 | 44 | 43 | 42 | 40 | 37 | 36 | 35 |
| BA 2 | | | | | | | | |
| 57 | | | | | | | | |
| CaP .3 | 49 | 49 | 46 | 43 | 41 | 40 | 39 | 37 |
| BHA .01 | 46 | 46 | 43 | 40 | 38 | 37 | 36 | 35 |
| Shg 1 | 44 | 44 | 42 | 39 | 37 | 36 | 36 | 34 |
| BA 3 | | | | | | | | |
| 58 | | | | | | | | |
| CaP .3 | 48 | 46 | 44 | 42 | 40 | 39 | 39 | 37 |
| BHA .01 | 46 | 44 | 41 | 39 | 38 | 37 | 37 | 35 |
| Shg 2 | 43 | 41 | 39 | 37 | 36 | 36 | 35 | 32 |
| BA 1 | | | | | | | | |
| 59 | | | | | | | | |
| CaP .3 | 47 | 47 | 45 | 39 | 38 | 37 | 37 | 36 |
| BHA .01 | 45 | 45 | 43 | 37 | 36 | 35 | 35 | 34 |
| Shg 2 | 47 | 46 | 46 | 39 | 38 | 36 | 36 | 35 |
| BA 2 | | | | | | | | |
| 60 | | | | | | | | |
| CaP .3 | 50 | 50 | 47 | 43 | 43 | 41 | 40 | 39 |
| BHA .01 | 46 | 46 | 45 | 42 | 39 | 36 | 35 | 35 |
| Shg 2 | 46 | 46 | 44 | 39 | 38 | 37 | 36 | 35 |
| BA 3 | | | | | | | | |
| 61 | | | | | | | | |
| CaP .3 | 47.5 | 46 | 45 | 43 | 43 | 40 | 40 | 36 |
| BHA .01 | 45 | 45 | 44 | 42 | 41 | 39 | 38 | 34 |
| Shg 3 | 46 | 45 | 43 | 42 | 41 | 38 | 38 | 35.5 |
| BA 1 | | | | | | | | |
| 62 | | | | | | | | |
| CaP .3 | 46 | 45 | 44 | 43 | 42 | 40 | 38 | 37 |
| BHA .01 | 47 | 46 | 44 | 42 | 42 | 41 | 39 | 38 |
| Shg 3 | 46 | 45 | 43 | 42 | 41 | 39 | 38 | 36.5 |
| BA 2 | | | | | | | | |
| 63 | | | | | | | | |
| CaP .3 | 46 | 43 | 43 | 43 | 41 | 39 | 38 | 37 |
| BHA .01 | 46 | 44 | 42 | 41 | 39 | 38 | 38 | 37 |
| Shg 3 | 45 | 44 | 42 | 40 | 40 | 39 | 38 | 38 |
| BA 3 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 64 | | | | | | | | |
| CaP .3 | 47 | 44 | 44 | 44 | 43 | 41 | 38 | 37 |
| BHA .01 | 46 | 46 | 43 | 42 | 41 | 40 | 37 | 36 |
| Shg 3 | 45 | 45 | 42 | 40 | 40 | 39 | 38 | 36 |
| BA 1 | | | | | | | | |
| 65 | | | | | | | | |
| CaP .3 | 46 | 44 | 44 | 43 | 41 | 39 | 38 | 37 |
| BHA .015 | 47 | 47 | 43 | 42 | 40 | 38 | 37.5 | 37.5 |
| Shg 1 | 47 | 47 | 43 | 41 | 39 | 39 | 38 | 38 |
| BA 2 | | | | | | | | |
| 66 | | | | | | | | |
| CaP .3 | 47 | 46 | 45 | 43 | 43 | 41 | 40 | 37 |
| BHA .015 | 46 | 46 | 44 | 42 | 41 | 39 | 39 | 36 |
| Shg 1 | 45 | 45 | 43 | 41 | 39 | 38 | 37 | 35 |
| BA 3 | | | | | | | | |
| 67 | | | | | | | | |
| CaP .3 | 47 | 46 | 44 | 44 | 41 | 40 | 38 | 36.5 |
| BHA .015 | 46 | 46 | 45 | 43 | 40 | 39 | 37 | 35 |
| Shg 2 | 47 | 46 | 44 | 43 | 42 | 40 | 3 | |
| BA 1 | | | | | | | | |
| 68 | | | | | | | | |
| CaP .3 | 48 | 45 | 44 | 40 | 39 | 38 | 37 | 35 |
| BHA .015 | 47 | 46 | 43 | 41 | 40 | 39 | 36 | 35 |
| Shg 2 | 46 | 46 | 42 | 40 | 39 | 38 | 35 | 34 |
| BA 2 | | | | | | | | |
| 69 | | | | | | | | |
| CaP .3 | 48 | 45 | 44 | 43 | 41 | 38 | 37 | 35 |
| BHA .015 | 46 | 46 | 44 | 42 | 40 | 37 | 35 | 34 |
| Shg 2 | 47 | 47 | 46 | 44 | 40 | 39 | 37 | 35 |
| BA 3 | | | | | | | | |
| 70 | | | | | | | | |
| CaP .3 | 48 | 45 | 44 | 43 | 40 | 39 | 37 | 35 |
| BHA .015 | 47 | 46 | 43 | 42 | 39 | 38 | 32 | 34.5 |
| Shg 3 | 47 | 47 | 45 | 42 | 40 | 39 | 37 | 35 |
| BA 1 | | | | | | | | |
| 71 | | | | | | | | |
| CaP .3 | 45 | 44.5 | 42 | 42 | 41 | 39 | 38 | 36 |
| BHA .015 | 44 | 44 | 41 | 40 | 39 | 38 | 37 | 35 |
| Shg 3 | 42 | 42 | 40 | 39 | 38 | 37 | 36 | 34 |
| BA 2 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 72 | | | | | | | | |
| CaP .3 | 49 | 42 | 42 | 42 | 42.5 | 41 | 39 | 37 |
| BHA .015 | 48 | 47 | 44 | 43 | 41 | 40 | 39 | 36 |
| Shg 3 | 49 | 43 | 43 | 41 | 41 | 40 | 39 | 37 |
| BA 3 | | | | | | | | |
| 73 | | | | | | | | |
| CaP .3 | 48 | 48 | 46 | 45 | 43 | 41 | 40 | 38 |
| BHA .02 | 46 | 46 | 44 | 43 | 42 | 40 | 39 | 36 |
| Shg 1 | 45 | 45 | 43 | 41 | 40 | 39 | 36 | 35 |
| BA 1 | | | | | | | | |
| 74 | | | | | | | | |
| CaP .3 | 48 | 47 | 45 | 44 | 43 | 41 | 39 | 37 |
| BHA .02 | 46 | 46 | 44 | 43 | 41 | 40 | 38 | 36 |
| Shg 1 | 46 | 46 | 45 | 42 | 40 | 39 | 38 | 36 |
| BA 2 | | | | | | | | |
| 75 | | | | | | | | |
| CaP .3 | 44 | 43 | 43 | 41 | 41 | 39 | 37 | 37 |
| BHA .02 | 45 | 44 | 42 | 41 | 40 | 39 | 38 | 38 |
| Shg 1 | 44 | 44 | 42 | 41 | 39 | 38 | 37 | 37 |
| BA 3 | | | | | | | | |
| 76 | | | | | | | | |
| CaP .3 | 46 | 44 | 44 | 42 | 40 | 38 | 36 | 34 |
| BHA .02 | 45 | 44 | 43 | 41 | 39 | 37 | 35 | 35 |
| Shg 2 | 42 | 42 | 41 | 40 | 39 | 38 | 34 | 34 |
| BA 1 | | | | | | | | |
| 77 | | | | | | | | |
| CaP .3 | 47 | 45 | 42 | 41 | 40 | 38 | 36 | 34 |
| BHA .02 | 45 | 45 | 43 | 40 | 39 | 37 | 35 | 33 |
| Shg 2 | 44 | 44 | 42 | 41 | 39 | 38 | 37 | 36 |
| BA 2 | | | | | | | | |
| 78 | | | | | | | | |
| CaP .3 | 48 | 45 | 43 | 42 | 40 | 39 | 37 | 35 |
| BHA .02 | 46 | 45 | 42 | 40 | 39 | 38 | 36 | 34 |
| Shg 2 | 45 | 44 | 41 | 40 | 39 | 38 | 37 | 33 |
| BA 2 | | | | | | | | |
| 79 | | | | | | | | |
| CaP .3 | 47 | 45 | 43 | 41 | 41 | 39 | 37 | 35 |
| BHA .02 | 45 | 44 | 41 | 40 | 39 | 38 | 36 | 34 |
| Shg 3 | 46 | 46 | 42 | 41 | 39 | 37 | 37 | 35 |
| BA 1 | | | | | | | | |

TABLE 3 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 80 | | | | | | | | |
| CaP .3 | 47 | 46 | 42 | 40 | 40 | 38 | 36 | 35 |
| BHA .02 | 46 | 46 | 43 | 40 | 39 | 36 | 34 | 35 |
| Shg 3 | 43 | 43 | 42 | 40 | 38 | 37 | 37 | 33 |
| BA 1 | | | | | | | | |
| 81 | | | | | | | | |
| CaP .3 | 46 | 45 | 41 | 40 | 39 | 38 | 37 | 36 |
| BHA .02 | 46 | 45 | 40 | 39 | 37 | 37 | 36 | 36 |
| Shg 3 | 44 | 44 | 41 | 40 | 38 | 35 | 34 | 34 |
| BA 3 | | | | | | | | |

TABLE 4. WEIGHT OF NAN STORED IN POLYETHYLENE BAGS (G) (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHORTENING %, BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G OF ATTA IN THE DOUGH).

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | | | | | | | | |
| CaP .1 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| BA 1 | | | | | | | | |
| 2 | | | | | | | | |
| CaP .1 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104 |
| BHA .01 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 1 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BA 2 | | | | | | | | |
| 3 | | | | | | | | |
| CaP .1 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 94.5 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 1 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 |
| BA 3 | | | | | | | | |
| 4 | | | | | | | | |
| CaP .1 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 | 99 |
| BHA .01 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 |
| Shg 2 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105.5 |
| BA 1 | | | | | | | | |
| 5 | | | | | | | | |
| CaP .1 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 2 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97 |
| BA 2 | | | | | | | | |
| 6 | | | | | | | | |
| CaP .1 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98 |
| BHA .01 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 2 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 |
| BA 3 | | | | | | | | |
| 7 | | | | | | | | |
| CaP .1 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 3 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| BA 1 | | | | | | | | |
| 8 | | | | | | | | |
| CaP .1 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102 | 102 | 101.5 |
| BHA .01 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 |
| Shg 3 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101 |
| BA 2 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 9 | | | | | | | | |
| CaP .1 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 |
| BHA .01 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 3 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BA 3 | | | | | | | | |
| 10 | | | | | | | | |
| CaP .1 | 96.5 | 96.5 | 96.5 | 96.5 | 96.5 | 96.5 | 96 | 95.5 |
| BHA .015 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| Shg 1 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BA 1 | | | | | | | | |
| 11 | | | | | | | | |
| CaP .1 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BHA .015 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 1 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 |
| BA 2 | | | | | | | | |
| 12 | | | | | | | | |
| CaP .1 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102 | 102 |
| BHA .015 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 1 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| BA 3 | | | | | | | | |
| 13 | | | | | | | | |
| CaP .1 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 100.5 |
| BHA .015 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 2 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |
| BA 1 | | | | | | | | |
| 14 | | | | | | | | |
| CaP .1 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104 | 104 | 103.5 |
| BHA .015 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 |
| Shg 2 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102 |
| BA 2 | | | | | | | | |
| 15 | | | | | | | | |
| CaP .1 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103 |
| BHA .015 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 2 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103 |
| BA 3 | | | | | | | | |
| 16 | | | | | | | | |
| CaP .1 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 109.5 |
| BHA .015 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105 |
| Shg 3 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BA 1 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 17 | | | | | | | | |
| CaP .1 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106.5 |
| BHA .015 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| Shg 3 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 | 99 |
| BA 2 | | | | | | | | |
| 18 | | | | | | | | |
| CaP .1 | 105.5 | 105.5 | 105.5 | 105.5 | 105.5 | 105.5 | 105.5 | 105 |
| BHA .015 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 3 | 103 | 103 | 103 | 103 | 103 | 102.5 | 103 | 102.5 |
| BA 3 | | | | | | | | |
| 19 | | | | | | | | |
| CaP .1 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 | 107.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100 |
| Shg 1 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 |
| BA 1 | | | | | | | | |
| 20 | | | | | | | | |
| CaP .1 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 | 104.5 |
| BHA .02 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 1 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 |
| BA 2 | | | | | | | | |
| 21 | | | | | | | | |
| CaP .1 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 93.5 |
| BHA .02 | 98 | 98 | 98 | 98 | 98.5 | 98 | 97.5 | 97 |
| Shg 1 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 | 101 |
| BA 3 | | | | | | | | |
| 22 | | | | | | | | |
| CaP .1 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 |
| BHA .02 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 |
| Shg 2 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BA 1 | | | | | | | | |
| 23 | | | | | | | | |
| CaP .1 | 108.5 | 108.5 | 108.5 | 108.5 | 108.5 | 108 | 108 | 108 |
| BHA .02 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| Shg 2 | | | | | | | | |
| BA 2 | | | | | | | | |
| 24 | | | | | | | | |
| CaP .1 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106.5 |
| BHA .02 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 | 104.5 |
| Shg 2 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100 |
| BA 3 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 25 | | | | | | | | |
| CaP .1 | 114 | 114 | 114 | 114 | 114 | 114 | 113.5 | 113.5 |
| BHA .02 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 110.5 |
| Shg 3 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BA 1 | | | | | | | | |
| 26 | | | | | | | | |
| CaP .1 | 110 | 110 | 110 | 110 | 110 | 110 | 109.5 | 109.5 |
| BHA .02 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 3 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 |
| BA 2 | | | | | | | | |
| 27 | | | | | | | | |
| CaP .1 | 109 | 109 | 109 | 109 | 109 | 108.5 | 108.5 | 108.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 3 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 |
| BA 3 | | | | | | | | |
| 28 | | | | | | | | |
| CaP .2 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106.5 |
| BHA .01 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BA 1 | | | | | | | | |
| 29 | | | | | | | | |
| CaP .2 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BHA .01 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 |
| Shg 1 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100 |
| BA 2 | | | | | | | | |
| 30 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105.5 |
| BHA .01 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101 |
| Shg 1 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| BA 3 | | | | | | | | |
| 31 | | | | | | | | |
| CaP .2 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| BHA .01 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 | 101.5 |
| Shg 2 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 |
| BA 1 | | | | | | | | |
| 32 | | | | | | | | |
| CaP .2 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 2 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102 |
| BA 2 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 33 | | | | | | | | |
| CaP .2 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| BHA .01 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106.5 |
| Shg 2 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 |
| BA 3 | | | | | | | | |
| 34 | | | | | | | | |
| CaP .2 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BHA .01 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 | 103.5 |
| Shg 3 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 |
| BA 1 | | | | | | | | |
| 35 | | | | | | | | |
| CaP .2 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 108.5 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101.5 | 101.5 |
| Shg 3 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BA 2 | | | | | | | | |
| 36 | | | | | | | | |
| CaP .2 | 107 | 107 | 107 | 107 | 107 | 107 | 107 | 107 |
| BHA .01 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 | 102.5 |
| Shg 3 | 101 | 101 | 101 | 101 | 101.5 | 101.5 | 101 | 101 |
| BA 3 | | | | | | | | |
| 37 | | | | | | | | |
| CaP .2 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 | 107.5 |
| BHA .015 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| Shg1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BA 1 | | | | | | | | |
| 38 | | | | | | | | |
| CaP .2 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107 |
| BHA .015 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 | 95.5 |
| Shg 1 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 | 98.5 |
| BA 2 | | | | | | | | |
| 39 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| BHA .015 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 1 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BA 3 | | | | | | | | |
| 40 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105.5 |
| BHA .015 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 2 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 | 103 |
| BA 1 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 41 | | | | | | | | |
| CaP .2 | 111.5 | 111.5 | 111.5 | 111.5 | 111.5 | 111.5 | 111 | 111 |
| BHA .015 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101 |
| Shg 2 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 | 97 |
| BA 2 | | | | | | | | |
| 42 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105.5 |
| BHA .015 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 | 100 |
| Shg | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 | 96 |
| BA 3 | | | | | | | | |
| 43 | | | | | | | | |
| CaP .2 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| BHA .015 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 | 101.5 |
| Shg 3 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 | 99.5 |
| BA 1 | | | | | | | | |
| 44 | | | | | | | | |
| CaP .2 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 108 |
| BHA .015 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 | 101 |
| Shg 3 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 | 98 |
| BA 2 | | | | | | | | |
| 45 | | | | | | | | |
| CaP .2 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 |
| BHA .015 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 |
| Shg 3 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BA 3 | | | | | | | | |
| 46 | | | | | | | | |
| CaP .2 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 |
| BHA .02 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 1 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104 |
| BA 1 | | | | | | | | |
| 47 | | | | | | | | |
| CaP .2 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BHA .02 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 94.5 |
| Shg 1 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 | 97.5 |
| BA 2 | | | | | | | | |
| 48 | | | | | | | | |
| CaP .2 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102.5 | 102 |
| BHA .02 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 | 99.5 |
| Shg 1 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 |
| BA 3 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 49 | | | | | | | | |
| CaP .2 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 | 103 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 101.5 | 100.5 |
| Shg 2 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 | 102.5 |
| BA 1 | | | | | | | | |
| 50 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 105 |
| BHA .02 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 |
| Shg 2 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| BA 2 | | | | | | | | |
| 51 | | | | | | | | |
| CaP .2 | 104 | 104 | 104 | 104 | 104 | 104 | 103 | 103 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 2 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103 |
| BA 3 | | | | | | | | |
| 52 | | | | | | | | |
| CaP .2 | 106 | 106 | 106 | 106 | 106 | 102 | 101 | 101 |
| BHA .02 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| Shg 3 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 | 98.5 |
| BA 1 | | | | | | | | |
| 53 | | | | | | | | |
| CaP .2 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106.5 | 106.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 3 | 97 | 97 | 97 | 97 | 97 | 97 | 96.5 | 96.5 |
| BA 2 | | | | | | | | |
| 54 | | | | | | | | |
| CaP .2 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BHA .02 | 103 | 103 | 103 | 103.5 | 103 | 103 | 103 | 103.5 |
| Shg 3 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105.5 |
| BA 3 | | | | | | | | |
| 55 | | | | | | | | |
| CaP .3 | 104 | 104 | 104 | 104 | 104 | 103 | 103 | 103 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 1 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 | 104.5 |
| BA 1 | | | | | | | | |
| 56 | | | | | | | | |
| CaP .3 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 | 107.5 |
| BHA .01 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| Shg 1 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| BA 2 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 57 | | | | | | | | |
| CaP .3 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 99 |
| BHA .01 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| Shg 1 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101 |
| BA 3 | | | | | | | | |
| 58 | | | | | | | | |
| CaP .3 | 107 | 107 | 107 | 107 | 107 | 106 | 106 | 106 |
| BHA .01 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 |
| Shg 2 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 | 99.5 |
| BA 1 | | | | | | | | |
| 59 | | | | | | | | |
| CaP .3 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 2 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 104 |
| BA 2 | | | | | | | | |
| 60 | | | | | | | | |
| CaP .3 | 104 | 104 | 104 | 104 | 104 | 104 | 103.5 | 103 |
| BHA .01 | 97 | 97 | 97 | 97 | 97 | 97 | 98 | 96.5 |
| Shg 2 | 99 | 99 | 99 | 99 | 99 | 99 | 98.5 | 98 |
| BA 2 | | | | | | | | |
| 61 | | | | | | | | |
| CaP .3 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102 |
| BHA .01 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| Shg 3 | 105 | 105 | 105 | 105 | 105 | 105 | 104.5 | 104 |
| BA 1 | | | | | | | | |
| 62 | | | | | | | | |
| CaP .3 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104 |
| BHA .01 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 3 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BA 2 | | | | | | | | |
| 63 | | | | | | | | |
| CaP .3 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103 |
| BHA .01 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100 |
| Shg 3 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 |
| BA 3 | | | | | | | | |
| 64 | | | | | | | | |
| CaP .3 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| BHA .015 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102 |
| Shg 3 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 | 106 |
| BA 1 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 65 | | | | | | | | |
| CaP .3 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| BHA .015 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 |
| Shg 1 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BA 2 | | | | | | | | |
| 66 | | | | | | | | |
| CaP .3 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103.5 | 103 |
| BHA .015 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| Shg 1 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102 |
| BA 2 | | | | | | | | |
| 67 | | | | | | | | |
| CaP .3 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 |
| BHA .015 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 |
| Shg 2 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| BA 1 | | | | | | | | |
| 68 | | | | | | | | |
| CaP .3 | 107 | 107 | 107 | 107 | 107 | 107 | 107 | 106.5 |
| BHA .016 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| Shg 2 | 105 | 105 | 105 | 105 | 105 | 105 | 104 | 104 |
| BA 2 | | | | | | | | |
| 69 | | | | | | | | |
| CaP .3 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 |
| BHA .015 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 |
| Shg 2 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 |
| BA 3 | | | | | | | | |
| 70 | | | | | | | | |
| CaP .3 | 107 | 107 | 107 | 107 | 107 | 107 | 107 | 107 |
| BHA .015 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| Shg 3 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| BA 1 | | | | | | | | |
| 71 | | | | | | | | |
| CaP .3 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 |
| BHA .015 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 | 105 |
| Shg 3 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| BA 2 | | | | | | | | |
| 72 | | | | | | | | |
| CaP .3 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| BHA .015 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100.5 | 100 | 100 |
| Shg 3 | 97 | 97 | 97 | 97 | 97 | 97 | 96.5 | 96 |
| BA 3 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 73 | | | | | | | | |
| CaP .3 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 107.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 |
| Shg 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BA 1 | | | | | | | | |
| 74 | | | | | | | | |
| CaP .3 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 | 101.5 |
| BHA .02 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 1 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 |
| BA 2 | | | | | | | | |
| 75 | | | | | | | | |
| CaP .3 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 |
| BHA .02 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 95.5 |
| Shg 1 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| BA 3 | | | | | | | | |
| 76 | | | | | | | | |
| CaP .3 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 |
| BHA .02 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 |
| Shg 2 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| BA 1 | | | | | | | | |
| 77 | | | | | | | | |
| CaP .3 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 105.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 2 | 98 | 98 | 98 | 98 | 98 | 98 | 97 | 97 |
| BA 2 | | | | | | | | |
| 78 | | | | | | | | |
| CaP .3 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BHA .02 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 |
| Shg 2 | 102 | 102 | 102 | 102 | 102 | 102 | 101.5 | 101 |
| BA 3 | | | | | | | | |
| 79 | | | | | | | | |
| CaP .3 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 |
| BHA .02 | 103 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102 |
| Shg 3 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.5 |
| BA 1 | | | | | | | | |
| 80 | | | | | | | | |
| CaP .3 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 | 104.5 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100 |
| Shg 3 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 97.5 |
| BA 2 | | | | | | | | |

TABLE 4 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 81 | | | | | | | | |
| CaP .3 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107.5 | 107 |
| BHA .02 | 101 | 101 | 101 | 101 | 101 | 101 | 100.5 | 100.5 |
| Shg 3 | 103 | 103 | 103 | 103 | 103 | 102.5 | 102.5 | 102 |
| BA 3 | | | | | | | | |

TABLE 5. WEIGHT OF NAN STORED IN ORDINARY PAPER BAGS (G). (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHORTENING %, BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G AREA IN THE DOUGH).

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | | | | | | | | |
| CaP .1 | 109 | 105 | 100 | 98 | 98 | 92 | 91 | 90 |
| BHA .01 | 106 | 103 | 98 | 95 | 93 | 90 | 87 | 86 |
| Shg 1 | 105 | 103 | 101 | 98 | 97 | 97 | 96 | 95 |
| BA 1 | | | | | | | | |
| 2 | | | | | | | | |
| CaP .1 | 109 | 103 | 102 | 100 | 99 | 98 | 97 | 93 |
| BHA .01 | 108 | 106 | 104 | 103 | 100 | 99 | 97 | 95 |
| Shg 1 | 104 | 103 | 101 | 100 | 97 | 96 | 95 | 94 |
| BA 2 | | | | | | | | |
| 3 | | | | | | | | |
| CaP .1 | 110 | 106 | 105 | 104 | 103 | 98 | 97 | 96 |
| BHA .01 | 107 | 104 | 102 | 97 | 96 | 94 | 89 | 87 |
| Shg 1 | 105 | 102 | 101 | 100 | 98 | 98 | 95 | 95 |
| BA 3 | | | | | | | | |
| 4 | | | | | | | | |
| CaP .1 | 105.5 | 103.5 | 103 | 101 | 99 | 97 | 96 | 94 |
| BHA .01 | 109 | 104 | 101 | 101 | 100 | 97 | 94 | 94 |
| Shg 2 | 106 | 102 | 102 | 100 | 98 | 92 | 88 | 97 |
| BA 1 | | | | | | | | |
| 5 | | | | | | | | |
| CaP .1 | 110 | 108 | 107 | 104 | 98 | 96 | 96 | 95 |
| BHA .01 | 105 | 104 | 103 | 100 | 99 | 97 | 96 | 94 |
| Shg 2 | 111 | 110 | 106 | 105 | 104 | 99 | 97 | 95 |
| BA 2 | | | | | | | | |
| 6 | | | | | | | | |
| CaP .1 | 108 | 106 | 105 | 103 | 101 | 99 | 98 | 95 |
| BHA .01 | 107 | 103 | 102 | 100 | 97 | 95 | 88 | 88 |
| Shg 2 | 104 | 101 | 100 | 98 | 97 | 97 | 96 | 95 |
| BA 3 | | | | | | | | |
| 7 | | | | | | | | |
| CaP .1 | 114 | 111 | 105 | 104 | 99 | 97 | 96 | 95 |
| BHA .01 | 117 | 114 | 113 | 109 | 107 | 105 | 98 | 97 |
| Shg 3 | 105 | 103 | 102 | 98 | 96 | 94 | 98 | 86 |
| BA 1 | | | | | | | | |
| 8 | | | | | | | | |
| CaP .1 | 110 | 108 | 106 | 101 | 101 | 98 | 96 | 94 |
| BHA .01 | 102 | 100 | 98 | 94 | 94 | 91 | 89 | 88 |
| Shg 3 | 109 | 106 | 105 | 101 | 99 | 96 | 95 | 93 |
| BA 2 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 9 | | | | | | | | |
| CaP .1 | 110 | 108 | 107 | 101 | 101 | 100 | 97 | 96 |
| BHA .01 | 118 | 115 | 112 | 109 | 108 | 106 | 99 | 97 |
| Shg 3 | 103 | 101 | 100 | 93 | 93 | 92 | 89 | 89 |
| BA 3 | | | | | | | | |
| 10 | | | | | | | | |
| CaP .1 | 116 | 113 | 112 | 108 | 106 | 104 | 97 | 96 |
| BHA .015 | 105 | 102 | 101 | 99 | 97 | 95 | 89 | 87 |
| Shg 1 | 104 | 101 | 99 | 98 | 96 | 96 | 88 | 86 |
| BA 1 | | | | | | | | |
| 11 | | | | | | | | |
| CaP .1 | 98 | 98 | 94 | 93 | 92 | 92 | 89 | 89 |
| BHA .015 | 115 | 114 | 112 | 107 | 107 | 105 | 98 | 95 |
| Shg 1 | 109 | 107 | 106 | 101 | 100 | 99 | 96 | 94.5 |
| BA 2 | | | | | | | | |
| 12 | | | | | | | | |
| CaP .1 | 107 | 105 | 101 | 101 | 100 | 100 | 98 | 98 |
| BHA .015 | 113 | 112 | 104 | 103 | 98 | 97 | 95 | 94 |
| Shg 1 | 104 | 102 | 101 | 100 | 99 | 99 | 98 | 95 |
| BA 3 | | | | | | | | |
| 13 | | | | | | | | |
| CaP .1 | 110 | 107 | 106 | 104 | 103 | 102 | 99 | 98 |
| BHA .015 | 112 | 109 | 105.5 | 103 | 102 | 101 | 99 | 99 |
| Shg 2 | 114 | 111 | 108 | 107 | 106 | 105 | 105 | 100 |
| BA 1 | | | | | | | | |
| 14 | | | | | | | | |
| CaP .1 | 111 | 109 | 105 | 102 | 102 | 101 | 100 | 99 |
| BHA .015 | 104 | 102 | 98 | 95 | 94.5 | 94 | 93 | 92 |
| Shg 2 | 109 | 108 | 103 | 101 | 99 | 98 | 97 | 97 |
| BA 2 | | | | | | | | |
| 15 | | | | | | | | |
| CaP .1 | 111 | 109 | 102 | 101 | 101 | 101 | 100 | 99.5 |
| BHA .015 | 105 | 104 | 98 | 97 | 96 | 96 | 95 | 95 |
| Shg 2 | 107 | 104 | 101 | 100 | 98 | 97 | 97 | 96 |
| BA 3 | | | | | | | | |
| 16 | | | | | | | | |
| CaP .1 | 112 | 111 | 99 | 97 | 97 | 94 | 93 | 92 |
| BHA .015 | 106 | 104 | 100 | 99 | 98 | 97 | 96 | 95 |
| Shg 3 | 115 | 112 | 110 | 108 | 106 | 106 | 105 | 101 |
| BA 1 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 17 | | | | | | | | |
| CaP .1 | 113 | 110 | 108 | 106 | 106 | 105 | 104 | 103 |
| BHA .015 | 108 | 106 | 101 | 98 | 97 | 97 | 96 | 96 |
| Shg 3 | 102 | 100 | 97 | 96 | 95 | 95 | 94 | 94 |
| BA 2 | | | | | | | | |
| 18 | | | | | | | | |
| CaP .1 | 114 | 113 | 110 | 106 | 106 | 105 | 104 | 103 |
| BHA .015 | 103 | 101 | 99 | 97 | 96 | 96 | 95.5 | 95 |
| Shg 3 | 110 | 107 | 107 | 106 | 105 | 102 | 99 | 97.5 |
| BA 3 | | | | | | | | |
| 19 | | | | | | | | |
| CaP .1 | 106 | 104 | 103 | 102 | 102 | 100 | 100 | 97 |
| BHA .02 | 109 | 108 | 106 | 103 | 102 | 102 | 100 | 99 |
| Shg 1 | 113 | 110 | 108 | 107 | 106 | 104 | 102 | 102 |
| BA 1 | | | | | | | | |
| 20 | | | | | | | | |
| CaP .1 | 111 | 105 | 103 | 101 | 101 | 99 | 98 | 96 |
| BHA .02 | 107 | 101 | 100 | 98 | 97 | 97 | 96 | 94 |
| Shg 1 | 112 | 110 | 109 | 108 | 105 | 103 | 101 | 100 |
| BA 2 | | | | | | | | |
| 21 | | | | | | | | |
| CaP .1 | 113.5 | 110 | 107 | 107 | 107 | 104 | 102 | 101 |
| BHA .02 | 103 | 100 | 98 | 97 | 96 | 95 | 94 | 92 |
| Shg 1 | 108 | 107 | 107 | 104 | 103 | 102 | 101 | 100 |
| BA 3 | | | | | | | | |
| 22 | | | | | | | | |
| CaP .1 | 111 | 109 | 108 | 107 | 104 | 101 | 100 | 99 |
| BHA .02 | 114 | 111 | 110 | 108 | 107 | 106 | 103 | 103 |
| Shg 2 | 116 | 112 | 109 | 107 | 106 | 106 | 105 | 105 |
| BA 1 | | | | | | | | |
| 23 | | | | | | | | |
| CaP .1 | 110 | 108 | 107 | 103 | 103 | 102 | 100 | 99 |
| BHA .02 | 109 | 107.5 | 107 | 104 | 103.5 | 102 | 101 | 100 |
| Shg 2 | | | | | | | | |
| BA 2 | | | | | | | | |
| 24 | | | | | | | | |
| CaP .1 | 109 | 109 | 108 | 105 | 105 | 104 | 103 | 103 |
| BHA .02 | 113 | 112 | 110 | 108 | 107 | 105 | 102 | 101.5 |
| Shg 2 | 104 | 101 | 98 | 98 | 97 | 96 | 93 | 93 |
| BA 3 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 25 | | | | | | | | |
| CaP .1 | 111 | 109 | 108 | 106 | 104 | 102 | 101 | 100 |
| BHA .02 | 106 | 103 | 101 | 99 | 98 | 97 | 96 | 96 |
| Shg 3 | 108 | 107 | 105 | 103 | 102 | 101 | 100 | 98 |
| BA 1 | | | | | | | | |
| 26 | | | | | | | | |
| CaP .1 | 112 | 110 | 109 | 106 | 106 | 104 | 103 | 102 |
| BHA .02 | 103 | 101 | 98 | 95 | 95 | 94 | 93 | 92 |
| Shg 3 | 113 | 110 | 109 | 107 | 105 | 104 | 102 | 101 |
| BA 2 | | | | | | | | |
| 27 | | | | | | | | |
| CaP .1 | 110 | 109 | 108 | 106 | 105 | 104 | 104 | 103 |
| BHA .02 | 114 | 111 | 110 | 108 | 106 | 104 | 104 | 102 |
| Shg 3 | 106 | 104 | 102 | 100 | 98 | 98 | 97 | 96 |
| BA 3 | | | | | | | | |
| 28 | | | | | | | | |
| CaP .2 | 110 | 109 | 108 | 104 | 104 | 102 | 100 | 98 |
| BHA .01 | 105 | 103 | 103 | 102 | 101 | 99 | 98 | 94 |
| Shg 1 | 117 | 116 | 114 | 109 | 108 | 107 | 105 | 104 |
| BA 1 | | | | | | | | |
| 29 | | | | | | | | |
| CaP .2 | 106 | 104 | 103 | 101 | 99 | 98 | 97 | 96 |
| BHA .01 | 111 | 110 | 108 | 107 | 105 | 102 | 101 | 100 |
| Shg 1 | 113 | 109 | 109 | 108 | 106 | 105 | 102 | 100 |
| BA 2 | | | | | | | | |
| 30 | | | | | | | | |
| CaP .2 | 109 | 106 | 104 | 103 | 104 | 102 | 102 | 100 |
| BHA .01 | 110 | 108 | 107 | 107 | 105 | 104 | 103 | 103 |
| Shg 1 | 114 | 111 | 109 | 108 | 107 | 105 | 104 | 102 |
| BA 3 | | | | | | | | |
| 31 | | | | | | | | |
| CaP .2 | 111 | 108 | 106 | 104 | 102 | 100 | 99 | 98 |
| BHA .01 | 113 | 110 | 108 | 104 | 101 | 98 | 97 | 97 |
| Shg 2 | 107 | 104 | 102 | 100 | 98 | 97 | 96 | 94 |
| BA 1 | | | | | | | | |
| 32 | | | | | | | | |
| CaP .2 | 110 | 109 | 108 | 106 | 102 | 101 | 101 | 100 |
| BHA .01 | 106 | 103 | 101 | 99 | 98 | 98 | 97 | 96 |
| Shg 2 | 116 | 113 | 101 | 99 | 98 | 98 | 97 | 96 |
| Shg 2 | 116 | 113 | 110 | 106 | 104 | 101 | 100 | 99 |
| BA 2 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 33 | | | | | | | | |
| CaP .2 | 112 | 109 | 107 | 103 | 100 | 98 | 96 | 95 |
| BHA .01 | 114 | 111 | 109 | 105 | 103 | 101 | 99 | 98 |
| Shg 2 | 109 | 107 | 104 | 101 | 98 | 97 | 95 | 94 |
| BA 3 | | | | | | | | |
| 34 | | | | | | | | |
| CaP .2 | 108 | 106 | 105 | 104 | 101 | 96 | 94 | 93 |
| BHA .01 | 113 | 111 | 108 | 105 | 101 | 99 | 97 | 97 |
| Shg 3 | 105 | 102 | 100 | 98 | 97 | 97 | 96 | 95 |
| BA 1 | | | | | | | | |
| 35 | | | | | | | | |
| CaP .2 | 108 | 105 | 105 | 104 | 101 | 97 | 93 | 93 |
| BHA .01 | 111 | 108 | 107 | 104 | 103 | 100 | 99 | 96 |
| Shg 3 | 107 | 104 | 101 | 99 | 99 | 98 | 97 | 97 |
| BA 2 | | | | | | | | |
| 36 | | | | | | | | |
| CaP .2 | 108 | 107 | 106 | 101 | 99 | 96 | 97 | 95 |
| BHA .01 | 112 | 110 | 108 | 104 | 100 | 99 | 96 | 95 |
| Shg 3 | 115 | 103 | 101 | 107 | 103 | 101 | 99 | 98 |
| BA 3 | | | | | | | | |
| 37 | | | | | | | | |
| CaP .2 | 114 | 111 | 110 | 108 | 107 | 105 | 103 | 101 |
| BHA .015 | 110 | 107 | 106 | 105 | 103 | 102 | 99 | 97 |
| Shg 1 | 106 | 103 | 101 | 100 | 99 | 97 | 96 | 93 |
| BA 1 | | | | | | | | |
| 38 | | | | | | | | |
| CaP .2 | 111 | 108 | 106 | 104 | 103 | 100 | 99 | 98 |
| BHA .015 | 109 | 106 | 105 | 104 | 101 | 100 | 98 | 96 |
| Shg 1 | 105 | 102 | 100 | 98 | 97 | 96 | 95 | 92 |
| BA 2 | | | | | | | | |
| 39 | | | | | | | | |
| CaP .2 | 114 | 111 | 105 | 105 | 103 | 102 | 101 | 100 |
| BHA .015 | 107 | 105 | 102 | 101 | 100 | 96 | 91 | 91 |
| Shg 1 | 112 | 109 | 108 | 107 | 104 | 103 | 101 | 99 |
| BA 3 | | | | | | | | |
| 40 | | | | | | | | |
| CaP .2 | 116 | 113 | 110 | 109 | 108 | 106 | 104 | 102 |
| BHA .015 | 110 | 107 | 106 | 105 | 104 | 103 | 100 | 97 |
| Shg 2 | 105 | 102 | 100 | 99 | 98 | 96 | 95 | 92 |
| BA 1 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 41 | | | | | | | | |
| CaP .2 | 108 | 104 | 103 | 102 | 101 | 96 | 92 | 92 |
| BHA .015 | 109 | 106 | 103 | 102 | 102 | 98 | 93 | 93 |
| Shg 2 | 113 | 110 | 109 | 108 | 105 | 104 | 102 | 100 |
| BA 2 | | | | | | | | |
| 42 | | | | | | | | |
| CaP .2 | 107 | 106 | 106 | 106 | 105 | 102 | 101 | 99 |
| BHA .015 | 104 | 103 | 103 | 102 | 102 | 99 | 98 | 96 |
| Shg 2 | 106 | 103 | 101 | 100 | 99 | 97 | 96 | 93 |
| BA 3 | | | | | | | | |
| 43 | | | | | | | | |
| CaP .2 | 112 | 108 | 107 | 105 | 104 | 102 | 97 | 96 |
| BHA .015 | 110 | 104 | 99 | 99 | 98 | 97 | 94 | 93 |
| Shg 3 | 105 | 103 | 102 | 102 | 100 | 98 | 97 | 93 |
| BA 1 | | | | | | | | |
| 44 | | | | | | | | |
| CaP .2 | 108 | 104 | 103 | 102 | 101 | 97 | 96 | 93 |
| BHA .015 | 113 | 109 | 108 | 106 | 105 | 103 | 98 | 97 |
| Shg 3 | 106 | 104 | 102 | 102 | 101 | 99 | 98 | 94 |
| BA 2 | | | | | | | | |
| 45 | | | | | | | | |
| CaP .2 | 110 | 104 | 99 | 98 | 98 | 97 | 93 | 93 |
| BHA .015 | 107 | 105 | 103 | 102 | 102 | 100 | 99 | 95 |
| Shg 3 | 111 | 107 | 106 | 104 | 103 | 102 | 97 | 96 |
| BA 3 | | | | | | | | |
| 46 | | | | | | | | |
| CaP .2 | 106 | 104 | 103 | 102 | 96 | 96 | 95 | 94 |
| BHA 02 | 104 | 102 | 101 | 100 | 94 | 93 | 92 | 91 |
| Shg 1 | 112 | 108 | 107 | 105 | 104 | 103 | 98 | 97 |
| BA 1 | | | | | | | | |
| 47 | | | | | | | | |
| CaP .2 | 109 | 106 | 104 | 104 | 104 | 103 | 101 | 100 |
| BHA .02 | 105 | 103 | 102 | 101 | 95 | 94 | 93 | 92 |
| Shg 1 | 111 | 107 | 106 | 105 | 104 | 103 | 98 | 96 |
| BA 2 | | | | | | | | |
| 48 | | | | | | | | |
| CaP .2 | 108 | 105 | 104 | 104 | 103 | 102 | 100 | 99 |
| BHA .02 | 106 | 104 | 103 | 103 | 97 | 96 | 95 | 94 |
| Shg 1 | 111 | 107 | 106 | 105 | 104 | 103 | 98 | 96 |
| BA 3 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 49 | | | | | | | | |
| CaP .2 | 112 | 110 | 109 | 107 | 106 | 103 | 102 | 102 |
| BHA .02 | 114 | 108 | 105 | 99 | 98 | 98 | 97 | 96 |
| Shg 2 | 104 | 101 | 100 | 99 | 98 | 97 | 95 | 93 |
| BA 1 | | | | | | | | |
| 50 | | | | | | | | |
| CaP .2 | 108 | 106 | 104 | 103 | 102 | 100 | 99 | 96 |
| BHA .02 | 106 | 103 | 102 | 102 | 101 | 100 | 97 | 94 |
| Shg 2 | 111 | 109 | 108 | 106 | 105 | 104 | 101 | 100 |
| BA 2 | | | | | | | | |
| 51 | | | | | | | | |
| CaP .2 | 106 | 103 | 102 | 101 | 101 | 97 | 96 | 92 |
| BHA .02 | 113 | 107 | 104 | 100 | 97 | 96 | 96 | 95 |
| Shg 2 | 105 | 102 | 101 | 100 | 97 | 96 | 96 | 94 |
| BA 3 | | | | | | | | |
| 52 | | | | | | | | |
| CaP .2 | 113 | 107 | 105 | 99 | 99 | 98 | 95 | 95 |
| BHA .02 | 109 | 107 | 105 | 104 | 103 | 101 | 100 | 97 |
| Shg 3 | 112 | 110 | 109 | 106 | 105 | 105 | 102 | 101 |
| BA 1 | | | | | | | | |
| 53 | | | | | | | | |
| CaP .2 | 107 | 105 | 102 | 102 | 100 | 98 | 95 | 94 |
| BHA 02 | 106 | 103 | 103 | 102 | 101 | 100 | 98 | 93.5 |
| Shg 3 | 109 | 108 | 105 | 104 | 102 | 100 | 100 | 97 |
| BA 2 | | | | | | | | |
| 54 | | | | | | | | |
| CaP .2 | 107 | 104 | 103 | 103 | 102 | 101 | 98 | 93 |
| BHA .02 | 111 | 109 | 107 | 106 | 106 | 105 | 103 | 98 |
| Shg 3 | | | | | | | | |
| BA 3 | | | | | | | | |
| 55 | | | | | | | | |
| CaP .3 | 109 | 107 | 105 | 105 | 103 | 103 | 101 | 98 |
| BHA 01 | 111 | 109 | 103 | 100 | 99 | 99 | 98.5 | 99 |
| Shg 1 | 113 | 112 | 110 | 104 | 95 | 94 | 94 | 94 |
| BA 1 | | | | | | | | |
| 56 | | | | | | | | |
| CaP .3 | 112 | 110 | 108 | 105 | 105 | 104 | 104 | 102 |
| BHA .01 | 114 | 112 | 109 | 106 | 105 | 104.5 | 104.5 | 103 |
| Shg 1 | 105 | 103 | 101 | 99 | 98 | 97 | 96 | 96 |
| BA 2 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 57 | | | | | | | | |
| CaP .3 | 111 | 109 | 102 | 99 | 99 | 99 | 99 | 99 |
| BHA .01 | 108 | 104 | 101 | 98 | 98 | 97 | 96 | 96 |
| Shg 1 | 114 | 113 | 110 | 106 | 106 | 104 | 104 | 102.5 |
| BA 3 | | | | | | | | |
| 58 | | | | | | | | |
| CaP .3 | 114 | 112 | 108 | 103 | 102 | 96 | 96 | 96 |
| BHA .01 | 106 | 104 | 100 | 98 | 97 | 96 | 95 | 95 |
| Shg 2 | 110 | 108 | 102 | 100 | 99 | 98 | 98 | 97.5 |
| BA 1 | | | | | | | | |
| 59 | | | | | | | | |
| CaP .3 | 114 | 111 | 109 | 103 | 96 | 96 | 96 | 96 |
| BHA 01 | 109 | 108 | 102 | 100 | 99 | 98 | 97 | 97 |
| Shg 2 | 113 | 111 | 110 | 105 | 96 | 95 | 94 | 94 |
| BA 2 | | | | | | | | |
| 60 | | | | | | | | |
| CaP .3 | 111 | 106 | 103 | 102 | 99 | 98 | 97 | 95 |
| BHA .01 | 107 | 106 | 98 | 96 | 95 | 95 | 95 | 95 |
| Shg 2 | 106 | 105 | 103 | 99 | 98 | 97 | 96 | 95.5 |
| BA 3 | | | | | | | | |
| 61 | | | | | | | | |
| CaP .3 | 107 | 104 | 102 | 101 | 99 | 98 | 96 | 96 |
| BHA .01 | 110 | 107 | 106 | 104 | 102 | 100 | 99 | 98 |
| Shg 3 | 106 | 104 | 97 | 96 | 93 | 91 | 90 | 90 |
| BA 1 | | | | | | | | |
| 62 | | | | | | | | |
| CaP .3 | 108 | 105 | 103 | 102 | 100 | 99 | 98 | 96 |
| BHA .01 | 111 | 108 | 106 | 105 | 104 | 101 | 100 | 99 |
| Shg 3 | 109 | 106 | 105 | 103 | 101 | 99 | 99 | 97 |
| BA 2 | | | | | | | | |
| 63 | | | | | | | | |
| CaP .3 | 108 | 106 | 103 | 102 | 99 | 98 | 97 | 95 |
| BHA .01 | 113 | 109 | 107 | 106 | 105 | 102 | 101 | 100 |
| Shg 3 | 104 | 101 | 99 | 98 | 97 | 94 | 93 | 92 |
| BA 3 | | | | | | | | |
| 64 | | | | | | | | |
| CaP .3 | 107 | 105 | 96 | 95 | 91 | 90 | 90 | 90 |
| BHA .01 | 109 | 106 | 104 | 104 | 102 | 100 | 99 | 98 |
| Shg 3 | 112 | 109 | 107 | 106 | 104 | 101 | 100 | 100 |
| BA 1 | | | | | | | | |

TABLE 5 cont.

| Treatment | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 65 | | | | | | | | |
| CaP .3 | 105 | 100 | 96 | 95 | 91 | 90 | 90 | 90 |
| BHA .015 | 107 | 102 | 99 | 98 | 95 | 93 | 92 | 91 |
| Shg 1 | 115 | 110 | 108 | 106 | 106 | 104 | 102 | 101 |
| BA 2 | | | | | | | | |
| 66 | | | | | | | | |
| CaP .3 | 108 | 106 | 106 | 105 | 102 | 100 | 99 | 98 |
| BHA .015 | 114 | 110 | 108 | 107 | 106 | 103 | 101 | 101 |
| Shg 1 | 106 | 101 | 97 | 96 | 93 | 91 | 91 | 91 |
| BA 2 | | | | | | | | |
| 67 | | | | | | | | |
| CaP .3 | 108 | 107 | 107 | 104 | 103 | 101 | 100 | 99 |
| BHA .015 | 113 | 110 | 109 | 108 | 107 | 103 | 103 | 102 |
| Shg 2 | 106 | 105 | 105 | 103 | 101 | 100 | 99 | 98 |
| BA 1 | | | | | | | | |
| 68 | | | | | | | | |
| CaP .3 | 113 | 113 | 110 | 109 | 108 | 106 | 105 | 104 |
| BHA .015 | 115 | 114 | 112 | 110 | 109 | 107 | 106 | 106 |
| Shg 2 | 111 | 109 | 107 | 106 | 105 | 104 | 103 | 101 |
| BA 2 | | | | | | | | |
| 69 | | | | | | | | |
| CaP .3 | 105 | 104 | 104 | 101 | 100 | 99 | 98 | 97 |
| BHA .015 | 113 | 111 | 109 | 109 | 108 | 104 | 103 | 103 |
| Shg 2 | 107 | 105 | 104 | 104 | 102 | 101 | 100 | 100 |
| BA 3 | | | | | | | | |
| 70 | | | | | | | | |
| CaP .3 | 113 | 111 | 109 | 107 | 105 | 104 | 103 | 102 |
| BHA .015 | 109 | 108 | 106 | 105 | 104 | 102 | 101 | 100 |
| Shg 3 | 112 | 110 | 108 | 106 | 104 | 103 | 102 | 101 |
| BA 1 | | | | | | | | |
| 71 | | | | | | | | |
| CaP .3 | 113 | 111 | 109 | 107 | 105 | 104 | 103 | 102 |
| BHA .015 | 106 | 104 | 103 | 102 | 101 | 100 | 98 | 98 |
| Shg 3 | 108 | 107 | 106 | 104 | 104 | 103 | 101 | 99 |
| BA 2 | | | | | | | | |
| 72 | | | | | | | | |
| CaP .3 | 109 | 107 | 105 | 103 | 102 | 101 | 99 | 95 |
| BHA .015 | 107 | 106 | 104 | 103 | 102 | 102 | 100 | 97 |
| Shg 3 | 112 | 110 | 110 | 108 | 106 | 105 | 104 | 102.5 |
| BA 3 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 73 | | | | | | | | |
| CaP .3 | 113 | 110 | 107 | 101 | 98 | 97 | 94 | 92 |
| BHA .02 | 109 | 104 | 103 | 100 | 97 | 96 | 93 | 90 |
| Shg 1 | 111 | 107 | 105 | 99 | 98 | 96 | 94 | 91.5 |
| BA 1 | | | | | | | | |
| 74 | | | | | | | | |
| CaP .3 | 108 | 103 | 103 | 97 | 93 | 93 | 93 | 93 |
| BHA .02 | 115 | 111 | 109 | 104 | 100 | 99 | 93 | 94 |
| Shg 1 | 110 | 106 | 104 | 100 | 97 | 95 | 93.5 | 90 |
| BA 2 | | | | | | | | |
| 75 | | | | | | | | |
| CaP .3 | 108 | 107 | 107 | 102 | 101 | 99 | 97 | 96 |
| BHA .02 | 114 | 110 | 108 | 103 | 99 | 98 | 98 | 95 |
| Shg 1 | 106 | 101 | 99 | 97 | 96 | 95 | 93 | 91 |
| BA 3 | | | | | | | | |
| 76 | | | | | | | | |
| CaP .3 | 112 | 108 | 102 | 100 | 100 | 98 | 97 | 96 |
| BHA .02 | 113 | 109 | 106 | 102 | 99 | 97 | 96 | 95 |
| Shg 2 | 107 | 102 | 101 | 100 | 98 | 96 | 94 | 93 |
| BA 1 | | | | | | | | |
| 77 | | | | | | | | |
| CaP .3 | 110 | 109 | 106 | 104 | 102 | 101 | 99 | 98 |
| BHA .02 | 104 | 100 | 99 | 96 | 95 | 93 | 91 | 89 |
| Shg 2 | 111 | 107 | 105 | 100 | 98 | 97 | 95 | 92 |
| BA 2 | | | | | | | | |
| 78 | | | | | | | | |
| CaP .3 | 109 | 106 | 106 | 106 | 104 | 103 | 100 | 95 |
| BHA .02 | 113 | 110 | 107 | 103 | 100 | 98 | 97 | 96 |
| Shg 2 | 106 | 101 | 100 | 99 | 97 | 95 | 94 | 92 |
| BA 3 | | | | | | | | |
| 79 | | | | | | | | |
| CaP .3 | 112 | 110 | 109 | 107 | 104 | 101 | 99 | 99 |
| BHA .02 | 115 | 113 | 112 | 110 | 107 | 103 | 101 | 101 |
| Shg 3 | 107 | 105 | 104 | 102 | 99 | 96 | 95 | 94 |
| BA 1 | | | | | | | | |
| 80 | | | | | | | | |
| CaP .3 | 110 | 108 | 107 | 104 | 102 | 101 | 100 | 95 |
| BHA .02 | 106 | 104 | 103 | 101 | 98 | 95 | 93 | 92.5 |
| Shg 3 | 113 | 111 | 109 | 108 | 103 | 102 | 100 | 100 |
| BA 2 | | | | | | | | |

TABLE 5 cont.

| Treatments | Days of Storage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 81 | | | | | | | | |
| CaP .3 | 114 | 110 | 108 | 102 | 98 | 97 | 96 | 93 |
| BHA .02 | 108 | 106 | 105 | 103 | 100 | 98 | 96 | 96 |
| Shg 3 | 112 | 110 | 108 | 106 | 105 | 102 | 100 | 99 |
| BA 3 | | | | | | | | |

Effect of Storage on Chemical Constituents of Chapatis and Nan

Variation in chemical constituents was reduced considerably by standardizing processing conditions of chapatis and nan.

Chapatis and nan stored in polyethylene bags, which exhibited maximum storage life, were analyzed for protein, ash, crude fat and fat acidity (calculated as mg/KOH %, on 30% moisture basis).

Similar analysis were run on freshly baked chapatis and nan samples to observe any change in nutrients between fresh and preserved chapatis and nan (Tables 6 and 7).

Protein content and crude fat content of chapatis and nan samples did not change significantly during storage. Ash content of chapatis and nan remained essentially unchanged during storage. The same trends were observed in chapatis and nan wrapped in ordinary paper bags, but as mentioned before the products became dry, hard, and brittle due to tremendous loss of moisture in the first 2 or 3 days so further studies were discontinued on this wrapper.

TABLE 6. ANALYSIS OF CHAPATIS STORED IN POLYETHYLENE BAGS %. (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDRONY ANISOLE %, SHG = SHORTENING %, BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G ATTA IN DOUGH).

| Treatment | Days of Storage | Moisture % | Protein[a] % | Ash[a] % | Fat[a] % | Fat Acidity[b] mg/KOH % |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| CaP .1 | 0 | 31.6 | 11.6 | 2.4 | 2.8 | 0.0131 |
| BHA .015 | 2 | 31.6 | 11.6 | 2.4 | 2.8 | 0.0131 |
| Shg 3 | 5 | 31.3 | 11.7 | 2.3 | 2.7 | 0.0132 |
| BA 2 | 7 | 31.0 | 11.5 | 2.5 | 2.6 | 0.0133 |
| 2 | | | | | | |
| CaP .2 | 0 | 32.5 | 11.7 | 2.5 | 2.8 | 0.0132 |
| BHA .015 | 2 | 32.5 | 11.8 | 2.5 | 2.8 | 0.0132 |
| Shg 3 | 5 | 32.1 | 11.6 | 2.3 | 2.7 | 0.0133 |
| BA 2 | 7 | 32.1 | 11.6 | 2.5 | 2.7 | 0.0134 |
| 3 | | | | | | |
| CaP .3 | 0 | 33.4 | 11.5 | 2.3 | 2.9 | 0.013 |
| BHA .015 | 2 | 33.3 | 11.6 | 2.3 | 2.9 | 0.013 |
| Shg 3 | 5 | 33.3 | 11.6 | 2.3 | 2.9 | 0.013 |
| BA 2 | 7 | 33.0 | 11.6 | 2.4 | 2.7 | 0.0135 |
| 4 | | | | | | |
| CaP .3 | 0 | 35.2 | 11.5 | 2.4 | 2.8 | 0.0132 |
| BHA .01 | 2 | 35.1 | 11.5 | 2.4 | 2.8 | 0.0132 |
| Shg 3 | 5 | 35.0 | 11.7 | 2.4 | 2.6 | 0.0132 |
| BA 2 | 7 | 34.8 | 11.6 | 2.4 | 2.6 | 0.0134 |
| 5 | | | | | | |
| CaP .3 | 0 | 30.5 | 11.7 | 2.3 | 2.8 | 0.013 |
| BHA .015 | 2 | 30.2 | 11.6 | 2.3 | 2.8 | 0.013 |
| Shg 3 | 5 | 30.1 | 11.7 | 2.3 | 2.6 | 0.013 |
| BA 2 | 7 | 29.8 | 11.6 | 2.4 | 2.5 | 0.0135 |
| 6 | | | | | | |
| CaP .3 | 0 | 31.8 | 11.7 | 2.5 | 2.7 | 0.0125 |
| BHA .02 | 2 | 31.7 | 11.7 | 2.4 | 2.8 | 0.0125 |
| Shg 3 | 5 | 31.5 | 11.6 | 2.4 | 2.8 | 0.0125 |
| BA 2 | 7 | 31.2 | 11.7 | 2.4 | 2.7 | 0.0127 |
| 7 | | | | | | |
| CaP .3 | 0 | 33.5 | 11.6 | 2.3 | 2.1 | 0.012 |
| BHA .015 | 2 | 33.4 | 11.6 | 2.3 | 2.1 | 0.012 |
| Shg 1 | 5 | 33.2 | 11.7 | 2.4 | 2.0 | 0.012 |
| BA 2 | 7 | 32.9 | 11.6 | 2.4 | 2.0 | 0.0125 |

TABLE 6 cont.

| Treatment | Days of Storage | Moisture % | Protein[a] % | Ash[a] % | Fat[a] % | Fat Acidity[b] mg/KOH % |
|---|---|---|---|---|---|---|
| 8 | | | | | | |
| CaP .3 | 0 | 29.8 | 11.6 | 2.3 | 2.4 | 0.0125 |
| BHA .015 | 2 | 29.6 | 11.6 | 2.3 | 2.4 | 0.0125 |
| Shg 2 | 5 | 29.5 | 11.7 | 2.3 | 2.4 | 0.0125 |
| BA 2 | 7 | 29.2 | 11.5 | 2.4 | 2.3 | 0.013 |
| 9 | | | | | | |
| CaP .3 | 0 | 28.5 | 11.7 | 2.5 | 2.9 | 0.013 |
| BHA .015 | 2 | 28.5 | 11.7 | 2.4 | 2.8 | 0.013 |
| Shg 3 | 5 | 27.9 | 11.6 | 2.4 | 2.8 | 0.013 |
| BA 2 | 7 | 27.8 | 11.7 | 2.4 | 2.75 | 0.014 |
| 10 | | | | | | |
| CaP .3 | 0 | 30.8 | 11.6 | 2.3 | 2.8 | 0.013 |
| BHA .015 | 2 | 30.8 | 11.6 | 2.3 | 2.8 | 0.013 |
| Shg 3 | 5 | 30.7 | 11.5 | 2.4 | 2.8 | 0.013 |
| BA 1 | 7 | 30.7 | 11.6 | 2.3 | 2.7 | 0.0136 |
| 11 | | | | | | |
| CaP .3 | 0 | 33.5 | 11.5 | 2.4 | 2.9 | 0.0132 |
| BHA .015 | 2 | 33.5 | 11.5 | 2.4 | 2.9 | 0.0132 |
| Shg 3 | 5 | 33.4 | 11.45 | 2.3 | 2.8 | 0.0133 |
| BA 2 | 7 | 33.2 | 11.6 | 2.3 | 2.7 | 0.0135 |
| 12 | | | | | | |
| CaP .3 | 0 | 35.5 | 11.6 | 2.5 | 2.8 | 0.0133 |
| BHA .015 | 2 | 35.5 | 11.6 | 2.5 | 2.8 | 0.0133 |
| Shg 2 | 5 | 35.2 | 11.5 | 2.5 | 2.7 | 0.0134 |
| BA 3 | 7 | 35.2 | 11.7 | 2.55 | 2.6 | 0.0136 |

[a] Moisture free basis.

[b] On 30% moisture basis.

TABLE 7. ANALYSIS OF NAN STORED IN POLYETHYLENE BAGS %. (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHIGRU/MIC %, BA = BACTERIAL ALPHA-AMYLASE, SK UNITS/100G ATTA IN DOUGH).

| Treatment | Days of | Moisture % | Protein[a] % | Ash[a] % | Fat[a] % | Fat Acidity[b] mg/KOH % |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| CaP .1 | 0 | 32.5 | 12.5 | 2.3 | 2.8 | 0.013 |
| BHA .015 | 2 | 32.3 | 12.5 | 2.3 | 2.8 | 0.013 |
| Shg 3 | 5 | 32.0 | 12.6 | 2.3 | 2.7 | 0.013 |
| BA 2 | 7 | 31.8 | 12.6 | 2.4 | 2.7 | 0.0135 |
| 2 | | | | | | |
| CaP .2 | 0 | 35.2 | 12.7 | 2.5 | 2.9 | 0.013 |
| BHA .015 | 2 | 35.1 | 12.7 | 2.5 | 2.9 | 0.013 |
| Shg 3 | 5 | 34.9 | 12.6 | 2.5 | 2.9 | 0.013 |
| BA 2 | 7 | 34.6 | 12.6 | 2.4 | 2.7 | 0.014 |
| 3 | | | | | | |
| CaP .3 | 0 | 33.4 | 12.6 | 2.3 | 2.9 | 0.0125 |
| BHA .015 | 2 | 33.1 | 12.6 | 2.3 | 2.9 | 0.0125 |
| Shg 3 | 5 | 32.8 | 12.5 | 2.3 | 2.8 | 0.0125 |
| BA 2 | 7 | 32.6 | 12.6 | 2.4 | 2.7 | 0.013 |
| 4 | | | | | | |
| CaP .3 | 0 | 33.1 | 12.5 | 2.4 | 2.8 | 0.0132 |
| BHA .01 | 2 | 33.1 | 12.5 | 2.4 | 2.8 | 0.0132 |
| Shg 3 | 5 | 32.7 | 12.5 | 2.4 | 2.8 | 0.0132 |
| BA 2 | 7 | 32.6 | 12.6 | 2.35 | 2.6 | 0.0133 |
| 5 | | | | | | |
| CaP .3 | 0 | 34.1 | 12.6 | 2.4 | 2.8 | 0.013 |
| BHA .015 | 2 | 33.9 | 12.7 | 2.4 | 2.8 | 0.013 |
| Shg 3 | 5 | 33.8 | 12.6 | 2.5 | 2.7 | 0.0134 |
| BA 2 | 7 | 33.8 | 12.6 | 2.4 | 2.6 | 0.0135 |
| 6 | | | | | | |
| CaP .3 | 0 | 35.7 | 12.5 | 2.5 | 2.8 | 0.0132 |
| BHA .02 | 2 | 35.3 | 12.5 | 2.4 | 2.7 | 0.0132 |
| Shg 3 | 5 | 34.9 | 12.6 | 2.5 | 2.7 | 0.0133 |
| BA 2 | 7 | 34.8 | 12.5 | 2.5 | 2.6 | 0.0134 |
| 7 | | | | | | |
| CaP .3 | 0 | 33.2 | 12.4 | 2.5 | 2.1 | 0.012 |
| BHA .015 | 2 | 33.2 | 12.5 | 2.4 | 2.1 | 0.012 |
| Shg 1 | 5 | 33.0 | 12.5 | 2.5 | 2.0 | 0.012 |
| BA 2 | 7 | 32.8 | 12.5 | 2.5 | 2.0 | 0.013 |

TABLE 7 cont.

| Treatment | Days of | Moisture % | Protein[a] % | Ash[a] % | Fat[a] % | Fat Acidity[b] mg/KOH % |
|---|---|---|---|---|---|---|
| 8 | | | | | | |
| CaP .3 | 0 | 35.5 | 12.5 | 2.5 | 2.3 | 0.0130 |
| BHA .015 | 2 | 35.2 | 12.6 | 2.5 | 2.3 | 0.013 |
| Shg 2 | 5 | 35.2 | 12.5 | 2.4 | 2.3 | 0.013 |
| BA 2 | 7 | 35.0 | 12.5 | 2.5 | 2.2 | 0.0135 |
| 9 | | | | | | |
| CaP .3 | 0 | 36.3 | 12.7 | 2.5 | 2.8 | 0.0133 |
| BHA .015 | 2 | 36.3 | 12.6 | 2.5 | 2.8 | 0.0133 |
| Shg 3 | 5 | 36.1 | 12.6 | 2.5 | 2.7 | 0.0134 |
| BA 2 | 7 | 36.1 | 12.6 | 2.4 | 2.7 | 0.0135 |
| 10 | | | | | | |
| CaP .3 | 0 | 36.3 | 12.7 | 2.5 | 2.8 | 0.0134 |
| BHA .015 | 2 | 36.1 | 12.7 | 2.5 | 2.8 | 0.0134 |
| Shg 3 | 5 | 36.1 | 12.7 | 2.4 | 2.7 | 0.0134 |
| BA 1 | 7 | 35.8 | 12.6 | 2.4 | 2.6 | 0.0135 |
| 11 | | | | | | |
| CaP .3 | 0 | 35.7 | 12.6 | 2.4 | 2.7 | 0.0133 |
| BHA .015 | 2 | 35.5 | 12.6 | 2.3 | 2.7 | 0.0133 |
| Shg 3 | 5 | 35.1 | 12.6 | 2.4 | 2.7 | 0.0133 |
| BA 2 | 7 | 35.0 | 12.5 | 2.4 | 2.6 | 0.0135 |
| 12 | | | | | | |
| CaP .3 | 0 | 33.1 | 12.5 | 2.3 | 2.8 | 0.0132 |
| BHA .015 | 2 | 33.0 | 12.5 | 2.3 | 2.8 | 0.0132 |
| Shg 3 | 5 | 32.9 | 12.5 | 2.3 | 2.8 | 0.0133 |
| BA 3 | 7 | 32.6 | 12.5 | 2.4 | 2.7 | 0.0134 |

[a] Moisture free basis.

[b] On 30% moisture basis.

Acceptability of Stored Chapatis and Nan.

Effects of different levels of additives on the acceptability of stored chapatis and nan were evaluated by a panel of judges in which six students from India and Pakistan participated. The results of these tests are presented in Table 8. The data were analyzed statistically by the two-way analysis of variance with respect to color, aroma, texture and eating properties (Tables 9-10). It was observed that all these formulae were found to be acceptable by the members of the tasting panel. It can be concluded that chapatis and nan can be stored safely up to seven days by the addition of .2 or .3% calcium propionate, .01 to .015% butylated hydroxy anisole, 3% shortening and 2 or 3 SK units of bacterial alpha-amylase/100 g of atta in dough, 1.5% sodium chloride and, in the dough of nan, 2% compressed baker's yeast.

The chapatis and nan stored up to seven days were found to be absolutely free from off flavors and were organoleptically acceptable. However .15% butylated hydroxy anisole appears to be a limiting concentration from the view point of acceptability. Moreover product made from dough to which 1 SK unit of bacterial alpha-amylase/100 g was added was scored poor, which shows that 2 SK units of bacterial alpha-amylase is at or near the minimal level.

TABLE 8. RESULTS OF THE SCORING TEST ON THE ORGANOLEPTIC PROPERTIES OF CHAPATIS AND NAN STORED IN POLYETHYLENE BAGS. (CAP = CALCIUM PROPIONATE %, BHA = BUTYLATED HYDROXY ANISOLE %, SHG = SHORTENING %. BA = BACTERIAL ALPHA-AMYLASE SK UNITS/100G ATTA IN DOUGH).

| | | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | Judge | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 1 | | | | | | | | | |
| CaP .1 | 1 | 7 | 7 | 8 | 8 | 10 | 9 | 7 | 8 |
| | | 8 | 8 | 9 | 9 | 10 | 9 | 7 | 8 |
| BHA .015 | 2 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Shg 3 | 3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 |
| | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 7 |
| BA 2 | 4 | 9 | 9 | 8 | 6 | 8 | 8 | 8 | 8 |
| | | 9 | 10 | 9 | 8 | 8 | 8 | 10 | 8 |
| | 5 | 8 | 9 | 8 | 7 | 9 | 9 | 10 | 10 |
| | | 9 | 9 | 7 | 9 | 9 | 9 | 8 | 8 |
| | 6 | 8 | 8 | 8 | 6 | 9 | 9 | 7 | 6 |
| | | 8 | 7 | 8 | 8 | 9 | 9 | 7 | 7 |
| 2 | | | | | | | | | |
| CaP .2 | 1 | 7 | 6 | 8 | 7 | 9 | 10 | 9 | 9 |
| | | 8 | 7 | 9 | 8 | 9 | 10 | 9 | 9 |
| BHA .015 | 2 | 7 | 7 | 10 | 10 | 10 | 10 | 6 | 10 |
| | | 8 | 8 | 10 | 10 | 10 | 10 | 7 | 10 |
| Shg 3 | 3 | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 10 |
| BA 2 | 4 | 8 | 8 | 8 | 10 | 6 | 6 | 8 | 8 |
| | | 8 | 10 | 9 | 10 | 7 | 7 | 10 | 7 |
| | 5 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 9 |
| | | 8 | 9 | 7 | 9 | 9 | 9 | 7 | 8 |
| | 6 | 8 | 8 | 8 | 6 | 9 | 9 | 10 | 10 |
| | | 9 | 7 | 8 | 7 | 9 | 9 | 10 | 10 |

TABLE 8 cont.

| Treatment | Judge | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 3 | | | | | | | | | |
| CaP .3 | 1 | 8 | 7 | 9 | 8 | 9 | 9 | 8 | 10 |
| | | 9 | 8 | 10 | 8 | 9 | 9 | 8 | 10 |
| BHA .015 | 2 | 7 | 7 | 6 | 10 | 10 | 10 | 7 | 10 |
| | | 7 | 8 | 7 | 10 | 10 | 10 | 8 | 10 |
| Shg 3 | 3 | 8 | 8 | 7 | 10 | 8 | 8 | 10 | 7 |
| | | 8 | 8 | 7 | 10 | 8 | 8 | 10 | 7 |
| BA 2 | 4 | 8 | 8 | 9 | 9 | 6 | 6 | 8 | 7 |
| | | 8 | 10 | 9 | 9 | 7 | 7 | 10 | 6 |
| | 5 | 6 | 7 | 8 | 10 | 8 | 8 | 8 | 9 |
| | | 7 | 8 | 8 | 10 | 9 | 9 | 7 | 8 |
| | 6 | 8 | 8 | 9 | 9 | 5 | 6 | 9 | 8 |
| | | 8 | 8 | 9 | 9 | 9 | 7 | 9 | 8 |
| 4 | | | | | | | | | |
| CaP .3 | 1 | 9 | 7 | 8 | 8 | 9 | 5 | 8 | 7 |
| | | 10 | 8 | 10 | 9 | 9 | 6 | 10 | 7 |
| BHA .01 | 2 | 8 | 8 | 8 | 10 | 10 | 10 | 10 | 10 |
| | | 8 | 9 | 8 | 10 | 10 | 10 | 10 | 10 |
| Shg 3 | 3 | 10 | 10 | 10 | 10 | 10 | 10 | 7 | 6 |
| | | 10 | 10 | 10 | 10 | 10 | 10 | 6 | 5 |
| BA 2 | 4 | 10 | 10 | 9 | 8 | 8 | 8 | 7 | 7 |
| | | 10 | 8 | 9 | 7 | 8 | 8 | 7 | 7 |
| | 5 | 8 | 9 | 8 | 8 | 7 | 7 | 7 | 8 |
| | | 8 | 9 | 7 | 9 | 8 | 8 | 7 | 8 |
| | 6 | 8 | 8 | 9 | 8 | 9 | 9 | 8 | 7 |
| | | 8 | 6 | 8 | 9 | 8 | 10 | 8 | 8 |

TABLE 8 cont.

| Treatments | Judge | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 5 | | | | | | | | | |
| CaP .3 | 1 | 7 | 6 | 8 | 8 | 9 | 9 | 10 | 9 |
| | | 8 | 7 | 8 | 8 | 9 | 9 | 9 | 9 |
| BHA .015 | 2 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 10 |
| | | 10 | 9 | 10 | 9 | 10 | 10 | 8 | 9 |
| Shg 3 | 3 | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 9 |
| | | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 8 |
| BA 2 | 4 | 8 | 7 | 10 | 8 | 9 | 9 | 8 | 8 |
| | | 8 | 7 | 10 | 8 | 9 | 9 | 10 | 8 |
| | 5 | 7 | 8 | 10 | 8 | 7 | 7 | 8 | 9 |
| | | 8 | 9 | 10 | 9 | 8 | 8 | 7 | 9 |
| | 6 | 8 | 7 | 10 | 6 | 9 | 9 | 9 | 8 |
| | | 9 | 7 | 10 | 8 | 8 | 10 | 9 | 8 |
| 6 | | | | | | | | | |
| CaP .3 | 1 | 8 | 7 | 8 | 9 | 10 | 7 | 9 | 9 |
| | | 8 | 8 | 9 | 10 | 10 | 8 | 9 | 9 |
| BHA .015 | 2 | 10 | 8 | 8 | 10 | 10 | 10 | 8 | 10 |
| | | 10 | 10 | 9 | 10 | 10 | 10 | 8 | 10 |
| Shg 3 | 3 | 8 | 8 | 8 | 10 | 10 | 10 | 10 | 9 |
| | | 9 | 8 | 8 | 10 | 10 | 10 | 10 | 9 |
| BA 2 | 4 | 8 | 9 | 10 | 8 | 7 | 7 | 8 | 9 |
| | | 8 | 9 | 10 | 8 | 7 | 8 | 10 | 7 |
| | 5 | 7 | 7 | 9 | 9 | 8 | 8 | 9 | 9 |
| | | 8 | 8 | 9 | 10 | 9 | 9 | 8 | 8 |
| | 6 | 8 | 9 | 9 | 8 | 9 | 9 | 10 | 9 |
| | | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 10 |

TABLE 8 cont.

| Treatment | Judge | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 7 | | | | | | | | | |
| CaP .3 | 1 | 10 | 9 | 8 | 9 | 10 | 10 | 9 | 10 |
| | | 10 | 9 | 8 | 9 | 10 | 10 | 9 | 10 |
| BHA .015 | 2 | 10 | 8 | 8 | 8 | 6 | 8 | 9 | 9 |
| | | 9 | 8 | 8 | 9 | 8 | 7 | 9 | 9 |
| Shg 1 | 3 | 8 | 8 | 7 | 8 | 10 | 9 | 8 | 8 |
| | | 8 | 7 | 6 | 9 | 10 | 10 | 7 | 9 |
| BA 2 | 4 | 8 | 7 | 8 | 10 | 6 | 7 | 7 | 8 |
| | | 8 | 6 | 8 | 10 | 6 | 6 | 7 | 8 |
| | 5 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8 |
| | | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 10 |
| | 6 | 6 | 8 | 7 | 8 | 10 | 10 | 8 | 10 |
| | | 8 | 10 | 6 | 7 | 10 | 10 | 7 | 9 |
| 8 | | | | | | | | | |
| CaP .3 | 1 | 9 | 10 | 10 | 9 | 9 | 10 | 10 | 10 |
| | | 9 | 10 | 10 | 10 | 9 | 10 | 10 | 9 |
| BHA .015 | 2 | 9 | 7 | 8 | 8 | 6 | 7 | 8 | 9 |
| | | 8 | 8 | 8 | 9 | 7 | 6 | 7 | 9 |
| Shg 2 | 3 | 10 | 6 | 6 | 8 | 9 | 10 | 10 | 8 |
| | | 9 | 6 | 7 | 8 | 9 | 10 | 9 | 9 |
| BA 2 | 4 | 6 | 9 | 6 | 7 | 8 | 9 | 7 | 8 |
| | | 7 | 9 | 6 | 6 | 9 | 8 | 6 | 8 |
| | 5 | 7 | 8 | 9 | 8 | 8 | 9 | 8 | 8 |
| | | 8 | 7 | 8 | 8 | 9 | 8 | 7 | 10 |
| | 6 | 7 | 8 | 9 | 9 | 9 | 10 | 9 | 10 |
| | | 8 | 10 | 8 | 9 | 10 | 9 | 9 | 9 |

TABLE 8 cont.

| | | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | Judge | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 9 | | | | | | | | | |
| CaP .3 | 1 | 9 | 9 | 8 | 10 | 9 | 7 | 6 | 7 |
| | | 9 | 9 | 9 | 10 | 10 | 6 | 6 | 8 |
| BHA .015 | 2 | 9 | 7 | 8 | 7 | 8 | 5 | 7 | 8 |
| | | 8 | 8 | 7 | 9 | 6 | 5 | 6 | 7 |
| Shg 3 | 3 | 8 | 7 | 8 | 9 | 9 | 8 | 7 | 10 |
| | | 8 | 8 | 8 | 9 | 9 | 9 | 8 | 10 |
| BA 1 | 4 | 8 | 8 | 7 | 8 | 5 | 7 | 8 | 8 |
| | | 8 | 9 | 6 | 8 | 5 | 6 | 9 | 7 |
| | 5 | 8 | 8 | 8 | 9 | 8 | 8 | 7 | 6 |
| | | 9 | 8 | 8 | 10 | 7 | 7 | 7 | 6 |
| | 6 | 9 | 8 | 10 | 8 | 9 | 9 | 7 | 9 |
| | | 9 | 9 | 10 | 8 | 9 | 9 | 7 | 10 |
| 10 | | | | | | | | | |
| CaP .3 | 1 | 9 | 7 | 10 | 8 | 9 | 10 | 9 | 10 |
| | | 9 | 8 | 10 | 9 | 10 | 10 | 10 | 10 |
| BHA .015 | 2 | 9 | 7 | 8 | 9 | 9 | 7 | 8 | 9 |
| | | 8 | 9 | 7 | 8 | 8 | 6 | 7 | 8 |
| Shg 3 | 3 | 8 | 7 | 6 | 8 | 9 | 9 | 10 | 8 |
| | | 8 | 7 | 7 | 9 | 8 | 7 | 10 | 10 |
| BA 1 | 4 | 7 | 6 | 8 | 8 | 8 | 6 | 9 | 5 |
| | | 8 | 6 | 8 | 7 | 9 | 6 | 8 | 10 |
| | 5 | 7 | 9 | 8 | 9 | 7 | 8 | 8 | 7 |
| | | 8 | 8 | 6 | 8 | 8 | 6 | 6 | 9 |
| | 6 | 10 | 10 | 8 | 10 | 9 | 9 | 10 | 8 |
| | | 10 | 10 | 6 | 10 | 9 | 9 | 10 | 7 |

TABLE 8 cont.

| | | Chapatis | | | | Nan | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | Judge | Color | Aroma | Texture | Eating Properties | Color | Aroma | Texture | Eating Properties |
| 11 | | | | | | | | | |
| CaP .3 | 1 | 9 | 9 | 9 | 10 | 9 | 8 | 9 | 10 |
| | | 9 | 9 | 9 | 10 | 10 | 9 | 8 | 10 |
| BHA .015 | 2 | 10 | 9 | 8 | 8 | 9 | 8 | 9 | 10 |
| | | 9 | 9 | 8 | 9 | 10 | 7 | 8 | 10 |
| Shg 3 | 3 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 10 |
| | | 8 | 9 | 8 | 9 | 9 | 9 | 9 | 10 |
| BA 2 | 4 | 6 | 8 | 8 | 9 | 8 | 10 | 10 | 8 |
| | | 7 | 8 | 8 | 8 | 9 | 9 | 10 | 10 |
| | 5 | 7 | 9 | 7 | 8 | 8 | 8 | 8 | 7 |
| | | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 9 |
| | 6 | 7 | 9 | 9 | 9 | 9 | 10 | 10 | 10 |
| | | 8 | 9 | 9 | 9 | 10 | 9 | 9 | 9 |
| 12 | | | | | | | | | |
| CaP .3 | 1 | 10 | 8 | 9 | 9 | 10 | 8 | 9 | 10 |
| | | 10 | 8 | 9 | 9 | 10 | 8 | 9 | 10 |
| BHA .015 | 2 | 10 | 8 | 10 | 8 | 9 | 9 | 8 | 10 |
| | | 8 | 8 | 10 | 9 | 10 | 8 | 8 | 9 |
| Shg 3 | 3 | 8 | 9 | 8 | 8 | 10 | 10 | 9 | 9 |
| | | 9 | 7 | 9 | 9 | 10 | 9 | 9 | 10 |
| BA 3 | 4 | 8 | 9 | 8 | 10 | 8 | 9 | 9 | 8 |
| | | 8 | 8 | 9 | 10 | 9 | 9 | 10 | 9 |
| | 5 | 6 | 9 | 8 | 9 | 8 | 7 | 8 | 8 |
| | | 7 | 7 | 6 | 8 | 9 | 6 | 7 | 9 |
| | 6 | 9 | 8 | 10 | 8 | 10 | 10 | 10 | 10 |
| | | 9 | 7 | 10 | 8 | 10 | 10 | 9 | 7 |

TABLE 9. ANALYSIS OF VARIANCE FOR COLOR, AROMA, TEXTURE, AND EATING PROPERTIES OF CHAPATIS PREPARED WITH DIFFERENT FORMULATIONS AND STORED FOR SEVEN DAYS IN POLYETHYLENE BAGS.

| Source of Variation | Degree of Freedom | Mean Squares | | | |
|---|---|---|---|---|---|
| | | Color | Aroma | Texture | Eating Properties |
| Treatment | 11 | 1.628 | 2.020 | 4.030 | 1.077 |
| Judge | 5 | 6.200 | 1.127 | 2.600 | 5.412 |
| Treatment X Judge | 55 | 1.169 | 3.018 | 2.139 | 1.800 |
| Error | 72 | 0.260 | 1.402 | 0.277 | 0.368 |
| Total | 143 | | | | |
| F. Ratio for Treatments | | 6.172 | 1.440 | 14.509 | 2.927 |

Non Significant LSD groupings. (Sample Nos. are identical to those in Table 8).

Color[a]: 4 1 10 9 12 7 5 8 6 11 2 3

Aroma[b]: 7 1 11 4 6 9 8 10 3 12 2 5

Texture[c]: 5 12 1 6 2 4 3 9 11 8 7 10

Eating Properties[d]: 3 6 2 4 7 9 11 10 12 5 1 8

a. LSD of 0.295
b. LSD of 0.680
c. LSD of 0.302
d. LSD of 0.348

TABLE 10. ANALYSIS OF VARIANCE FOR COLOR, AROMA, TEXTURE, AND EATING PROPERTIES OF NAN, PREPARED WITH DIFFERENT FORMULATIONS AND STORED FOR SEVEN DAYS IN POLYETHYLENE BAGS.

| Source of Variation | Degree of Freedom | Mean Squares | | | |
|---|---|---|---|---|---|
| | | Color | Aroma | Texture | Eating Properties |
| Treatment | 11 | 2.157 | 3.850 | 3.353 | 3.876 |
| Judge | 5 | 14.312 | 10.545 | 6.311 | 6.327 |
| Treatment X Judge | 55 | 1.576 | 2.624 | 1.971 | 1.667 |
| Error | 72 | 0.354 | 0.368 | 0.430 | 0.416 |
| Total | 143 | | | | |
| F. Ratio for Treatments | | 7.106 | 10.461 | 7.788 | 9.303 |

Non Significant LSD groupings. (Sample Nos. are identical to those in Table 8).

Color[a]: 12 1 6 11 5 4 2 7 10 8 3 9

Aroma[b]: 1 5 2 8 6 7 11 12 4 3 10 9

Texture[c]: 6 1 2 5 10 1 12 3 8 7 4 9

Eating Properties[d]: 11 2 7 8 12 6 10 5 1 3 9 4

a. LSD of 0.341
b. LSD of 0.348
c. LSD of 0.376
d. LSD of 0.370

## SUMMARY

Keeping in view the present food shortage and nutritional inadequacy in our diet in Pakistan, it has become increasingly necessary to devote greater attention to exploring the possibilities of improving the shelf life of the basic local staple food derived from cereals. It was thought that this might be accomplished by the addition of preservatives.

The aim of the present investigation was to ascertain the possibilities of evolving some way to preserve chapatis and nan. In this regard five wrapping materials were tested and finally polyethylene bags were selected to use as a wrapping material because they afforded the maximum moisture arresting capacity; moreover they are available in Pakistan at low cost.

In microbiological studies Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Rhizopus sp. and Penicillium lilacium were identified as the molds causing spoilage. Gaines variety wheat was selected for use in these studies because it had approximately 11% crude protein which is comparable to the protein content of Pakistani wheats. Gaines variety wheat was also found to possess very desirable characteristics for making chapatis and nan. The grain was conditioned to 15% moisture content by the addition of an appropriate amount of water and then milled using a procedure previously developed in this department. Atta of 95% extraction was milled, using 32-wire sieve to remove 5% bran as offal.

Atta was analyzed to determine proximate composition, and physical characteristics of the dough were studied by means of the farinograph.

The processing conditions were standardized using 60% water to make the dough (atta weight basis) and 5 min mixing time.

One and one-half per cent sodium chloride was added to all samples. In the case of nan 2% compressed bakers yeast was found to give satisfactory fermentation. The optimum rest period was found to be 60 min in the case of chapati and

75-90 min in the case of nan dough. The weight of each para (dough piece) was kept at 50 g for chapatis and 120 g for nan, and the diameter of the disc at 6.5 to 7 in for chapatis and 6 to 6.5 in for nan. The temperature of the hot plate was 280 to 290°C for chapatis and for baking nan the oven temperature was 290-300°C. The total time was 2.5 min for baking and puffing the chapatis. The total time for baking nan was 5 min.

Three levels of calcium propionate, viz., .1%, .2% and .3% were used. Butylated hydroxy anisole (B.H.A.) was used as an antioxident at three levels, viz., .01%, .015% and .02%. Shortening was used as a softening agent at 1%, 2% and 3% levels. Bacterial alpha-amylase was used at levels of 1, 2 and 3 SK units/100 g atta in dough.

The chapatis and nan samples were stored for 7 days at a storage temperature of 80-90°F. It was observed that loss of moisture from chapatis and nan made them hard, dry and brittle. Losses of moisture and degree of freshness were parallel. Packed in polyethylene bags chapatis and nan lost essentially no weight up to 5 or 7 days. Ordinary paper bags gave no protection from moisture loss.

Chapatis and nan prepared with .2 or .3% calcium propionate incorporated into the dough kept very well up to 6 or 7 days storage. Adding .01% or .015% B.H.A. also distinctly improved the keeping quality without affecting flavor of the products. Adding sodium chloride in the formulations increased the efficiency of calcium propionate as an antimicrobial agent. It may have contributed to preservation by its antimicrobial action. If so calcium propionate could be reduced by increasing the sodium chloride content to its acceptability limit.

A shortening level of 3% in the dough seemed to be optimum for the overall quality of chapatis and nan. Bacterial alpha-amylase produced considerable improvement in the puffing quality of chapatis and the increase in volume of nan. Variation in chemical constituents was reduced considerably by standardizing processing conditions of chapatis and nan.

Chapatis and nan that had been stored in polyethylene bags and which exhibited maximum storage life were analyzed for protein, ash, crude fat and fat acidity. Similar analysis were run on freshly baked chapatis and nan to observe any change in nutrients between fresh and preserved products. It was observed that protein content of chapatis and nan on storage did not change significantly. In storage both had slight increases in fat acidity, with a correspondingly slight decrease in crude fat content. Ash content remained essentially unchanged during storage.

The chapatis and nan stored up to seven days were found to be absolutely free from off flavors and were organoleptically acceptable. However, .015% B.H.A. appeared to be the maximum allowable concentration as a larger amount produced unacceptable flavor. Moreover 2 SK units of bacterial alpha-amylase/100 g atta in dough was at or near the minimal effective level.

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# STUDIES ON IMPROVING THE SHELF LIFE OF CHAPATIS AND NAN

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

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Experiments were undertaken to improve the keeping quality of chapatis and nan.

Preliminary studies were made of five wrapping materials. Polyethylene bags were found to afford good protection of chapatis and nan against loss of moisture during storage for seven days at 80-90°F, and were therefore used in subsequent work. During the preliminary work the organisms causing spoilage of stored chapatis and nan were found to be Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Penicillium lilacium and Rhyzopus sp.

Gaines variety soft wheat was conditioned and milled to produce atta of 95% extraction that passed through a 32-wire mesh sieve, by a conditioning and milling method previously developed.

Proximate composition and physical dough characteristics of atta were determined. Processing conditions for chapatis and nan were standardized; 60% water absorption, 1.5% sodium chloride were found to produce the best quality products. A further addition of 2% compressed bakers yeast gave the best quality nan.

Variation in chemical constituents was reduced considerably by standardizing the processing conditions. Chapatis and nan produced with the incorporation of .2 or .3% calcium propionate in the formula had a storage life of seven days. Adding sodium chloride in formulations improved the efficiency of calcium propionate as an antimicrobial agent. The requirement of calcium propionate could probably be reduced by increasing the sodium chloride content to its acceptability limit.

Addition of .01 or .015% butylated hydroxy anisole (B.H.A.) improved the keeping quality without affecting the flavor of either chapatis or nan. However .015% B.H.A. appeared to be a limiting concentration for acceptability.

Shortening at 3% level in dough improved the overall quality of chapatis and nan, and helped in retention of freshness.

Puffing quality of chapatis and increase in volume of nan were markedly improved by adding 2 or 3 SK units of bacterial alpha-amylase per 100 g atta in dough, 2 SK units was at or near the minimum effective level. Chapatis and nan prepared with the additives and stored in polyethylene bags retained moisture well and showed only a very slight increase in fat acidity. Changes in protein and crude fat content were not significant. The ash content of chapatis and nan remained essentially unchanged during storage.

Chapatis and nan stored up to seven days were organoleptically acceptable.