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BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

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BULGUR WAFER AND ADJUNCTS
FOR FALLOUT SHELTER RATIONS

A report of research conducted July 1962 - June 1963
by the United States Department of Agriculture under
Work Order No. OCD-OS-62-54 for
Office of Civil Defense, U. S. Department of Defense.

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BULGUR WAFERS AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

ABSTRACT

Long-term (5-year) studies of the storage life of bulgur wafers and adjuncts (foods to serve with the wafers to vary fallout shelter menus) are in progress. In order to shorten the time required to obtain estimates of storage stability, methods to speed deterioration are being investigated. Chemical-physical analyses are being made in a search for an objective test that correlates with organoleptic evaluation. Components of the vapors from rancid bulgur have been isolated by use of gas-liquid chromatography; some components may be useful indicators of incipient rancidity. Natural antioxidants in wheat have been found to disappear early in the bulgur-making process. Tests of various bulgur-puffing techniques have been made and are reported, including processing effects on texture of the bulgur. Wafers formulated with materials reputed to alleviate radiation effects have been tested, and some flavoring additives have been tried. Fifty-eight adjuncts have been developed and evaluated. A plastic bag for mixing and dispensing adjuncts has been designed for use in the shelters.

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BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

SUMMARY

Initial developmental work on the bulgur wheat wafer (the basic fallout shelter ration) and adjuncts (foods to be served with the wafer) was reported in "Food Supply for Fallout Shelters," CDM-SR-60-62, Nov. 1960, and in "Bulgur Wafer and Adjuncts for Fallout Shelter Rations," OCD-OS-62-54, Oct. 1962.

Long shelf-life (stability), low cost, and palatability are of prime importance in a shelter ration; therefore, work during F.Y. 1963 has been directed toward (1) evaluating the storage stability of wafers and adjuncts, (2) developing rapid inexpensive methods to determine or predict stability (by accelerated deterioration or by physical-chemical tests), (3) developing a more economical bulgur process or an economical bulgur substitute, (4) varying wafer formulations, and (5) formulating new low-cost adjuncts with good flavor and long shelf-life.

Bulgur wafers prepared in different ways (2 types of wheat, 2 cooking processes, 2 kinds of binder for the wafers, and 2 package atmospheres) are undergoing a 5-year storage test at three temperatures: 40, 70, and 100°F. At the end of the first 4 months no differences were apparent except for a slight preference on the part of the taste panel for samples that had been atmospheric-cooked rather than pressure-cooked. It is too early in the study to correlate organoleptic tests with the chemical tests that are being run.

To speed up evaluation of storage stability, deterioration of wafers has been accelerated by holding them at 100° and at 145°F. Results were contradictory, possibly because the fat in the formulation is liquid at the higher temperature. The tests emphasized the difficulties encountered in interpreting accelerated storage tests.

The vapors arising from rancid bulgur have been analyzed by means of gas-liquid chromatography. Hexanal and a compound tentatively identified as pentanal are the principle carbonyls found, with acetaldehyde, isobutyraldehyde, isovaleraldehyde, 2-hexanal, nonanal, and octanal also present. Increase in hexanal in the vapors has served as a good indicator of bulgur rancidity, but some low-molecular-weight compounds (probably saturated hydrocarbons) were also detected, and they may prove to be better indicators. These low-molecular-weight compounds also appeared in a model system based on methyl linoleate, and they developed before rancid aroma appeared. If we can determine the time lapse between appearance of these compounds and the development of rancid odors in bulgur, we should be able to predict rancidity development long before it is organoleptically detectable.

Use of an oxygen bomb to accelerate rancidity was unsatisfactory because too much time is required to effect a change. Ultraviolet light and a mixture of fluorescent light and sunlight were also tried. UV offers some promise.

Wheat contains natural antioxidants, but they become ineffective during the soaking step in bulgur processing. If antioxidants are to be added they should be put into the system at this very early stage, a practice that seems impractical because excessive amounts of antioxidant would be required.

The expansion of bulgur (puffing) produces a kernel with texture suitable for wafer-making, but several process variables and, perhaps, wheat characteristics affect the degree and uniformity of puff obtained. In controlled experiments, greater expansion was achieved in bulgur that had been prepared by pressure-cooking than in that prepared by atmospheric cooking. A uniform puffing technique applied to various commercial samples of bulgur, however, did not reveal the same effect; other variables must also be contributing to degree of puff achieved.

A puff index (bulk density of bulgur before puffing/bulk density after puffing) used to define degree of puff is a poor index of suitability of a material for wafer production because it does not reflect textural properties that can be detected organoleptically, observed under a microscope, or measured by a hardness tester. A hardness tester has been obtained, and a standard technique has been developed.

Several puffing methods have been tested, and attempts have been made to combine or eliminate certain steps in the bulgur process. When the drying and puffing steps were combined by puffing raw wheat at various levels of moisture content and puffing temperature, maximum expansion did not meet current specifications, but ultimate evaluation of the method awaits organoleptic and hardness tests of the materials produced. The method could effect important cost savings.

Puffing of bulgur by immersion in hot oil was unsatisfactory, as was "bumping" (compression of kernels while they are in a plastic state, prior to puffing).

Gun-puffing, used in the breakfast cereal industry, shows much promise. A systematic study of process variables is underway.

Wafers have been formulated with additives reputed to moderate the effects of radiation: calcium carbonate, tribasic calcium phosphate, ascorbic acid, L-cysteine hydrochloride, potassium iodide, yeast, folic acid, methionine, and calcium citrate. In the quantities used, none of them affected wafer flavor, texture, or appearance.

Wafers have also been formulated with materials that might increase palatability or caloric content, or improve nutritional balance: dehydrated fruits, fruit extracts, cheese, honey, peanut butter, chocolate, and yeast. Satisfactory pressing conditions were found for most of these mixtures.

Fifty-eight formulas for adjuncts have been developed to date; 5 were eliminated because of lack of stability after 8-10 months storage in air at normal temperature. Changes in many formulations have been made to improve stability, and protein has been decreased whenever possible. Jellies and spreads have been changed to allow the use of materials currently available. Caloric value, protein content, and estimated costs of adjuncts have been determined. Cold-water jellies and a margarine-type fat spread are in the developmental stage. A 5-year storage study of 12 selected adjuncts has been planned. Adjuncts will be packed in tin cans with and without dessiccant, and in air or nitrogen atmospheres. They will be stored at three temperatures: 40, 70, and 100°F.

A plastic bag has been devised for mixing and dispensing adjuncts in the preparation of shelter meals.

BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

SECTION 1

STORAGE STABILITY OF BULGUR WAFERS

Storage stability may be the dominant factor in determining the true cost of stockpiling and maintaining shelter food supplies. Fundamentally, stability of a product must be evaluated on the basis of subjective judgment of its acceptability after storage under normal conditions. Frequently, estimates of stability can be made by accelerating deterioration by means of high-temperature storage but, again, acceptability of the product must be evaluated by subjective judgments. Objective chemical or physical-chemical tests that correlate with taste panel appraisals would reduce the cost of evaluation and, perhaps, eliminate certain inconsistencies that arise in organoleptic testing. Other problems are the long time required for "normal" storage and, when high temperatures are used, the initiation of other side reactions such as browning. Needed is a method for accelerating deterioration without accentuating the changes that are of minor consequences in normal storage, and an objective measurement of some factor produced or changed by the deterioration which will serve as an indicator of potential stability. In order to determine stability of the shelter wafer and to find a satisfactory surveillance technique, all three approaches have been used in our studies.

Contractural arrangements have been made with Oregon State University to conduct a 5-year study of storage stability of wafers at normal temperatures, with periodic evaluations by taste panels and with several chemical and physical-chemical tests performed to find an objective measurement that might correlate with the panel's judgment.

Accelerated storage tests at elevated temperatures have been started at this laboratory. Methods of accelerating development of rancidity (other than increasing temperature) are being investigated. Gas-liquid chromatography is the principal tool being used to detect changes that parallel the development of rancidity. The hexanal peaks on the aroma-grams may serve to predict potential stability of the shelter wafer.

Wheat contains some inherent antioxidants. A study has been made of their persistence through the bulgur process, in order to determine the point in the processing at which antioxidants should be applied to obtain maximum effectiveness.

Five-Year Storage at Normal Temperature

In order to determine the stability of the wafers in normal storage, a contract was let with Oregon State University on June 28, 1962. The contract provides for taste panel evaluations over a 5-year period of sixteen different types of bulgur wheat wafers stored at three temperatures (40°, 70°, and 100° F.). Physical-chemical tests are also performed, in an attempt to correlate objective tests with taste panel results. If correlations can be established, it may be possible to use chemical analyses to predict shelf life of the wafers.

Red wheat and white wheat with appropriate protein content were provided by the Fisher Flouring Mills Co., Seattle, Washington. They processed part of each lot into bulgur, using a pressure cooking process. The remainder was processed into bulgur by atmospheric cooking at the Armeno Cereal Co., Westboro, Massachusetts. All bulgur was puffed by the Van Brode Milling Co., Inc., Clinton, Massachusetts, and made into wafers incorporating the following treatments:

<u>Red Wheat:</u>	<u>White Wheat</u>
1 Pressure cooked, malt binder, nitrogen pack (REFERENCE).	9
2 Pressure cooked, malt binder, air pack.	10
3 Pressure cooked, corn syrup binder, nitrogen pack.	11
4 Pressure cooked, corn syrup binder, air pack.	12
5 Cooked in atmosphere, malt binder, nitrogen pack.	13
6 Cooked in atmosphere, malt binder, air pack	14
7 Cooked in atmosphere, corn syrup binder, nitrogen pack.	15
8 Cooked in atmosphere, corn syrup binder, air pack.	16

Taste-panel evaluation

One red wheat and one white wheat formulation, arbitrarily chosen, served as reference samples and also served as controls that were held at -18° F. Before storage, reference samples were evaluated by a taste panel of 160 students using a 9-point hedonic scale ranging from a value of 1 for the lowest to a value of 9 for the highest rating. Then each other formulation was compared with its appropriate reference sample (either red or white wheat) using a reference-preference test also on a 9-point scale. All formulations were acceptable with very slight but statistically significant differences between formulations (Table 1.1).

Throughout the 5-year study, the reference formulations stored at 40°, 70°, and 100° F. will be compared with the controls (-18° F. storage) by a panel of 40 students, using the reference-preference test, and the controls themselves will be scored on a

hedonic scale. Then each of the other formulations will be compared with its appropriate reference sample (40°, 70°, or 100° F. storage) by means of the reference-preference test.

After 4 months storage, the sixteen lots were evaluated with results as shown in Table 1.2. Wafers prepared under atmospheric conditions generally scored higher than those prepared under pressure conditions. No other significant differences were detected.

Chemical-physical determinations

Before storage each lot was analyzed to determine percent fat, peroxide number, thiobarbituric acid number, carbonyls (alkanals, alk-2-enals, alk-2,4 dienals), and diene value, and gas chromatography (aromagrams) were prepared. Nitrogen-packed cans with unusually high oxygen content were removed from the experiments, and replaced by cans satisfactory in that regard.

Results of the initial chemical-physical tests are listed in Tables 1.3 and 1.4. Previous work revealed that bulgur wafers held in storage under adverse conditions gave seven peaks in the aromagrams. The aromagrams reported in Tables 1.3 and 1.4 show only the first five peaks, peaks #6 and 7 being absent in all instances.

Storage at Elevated Temperatures

Three storage tests were set up: (1) storage of laboratory-produced wafers at 100° F., (2) storage of laboratory-produced wafers at 145° F. (Schall oven test), and (3) storage of commercially produced wafers at -10° F., 40° F., 72° F., 100° F., and 145° F. A panel of judges determined development of rancidity or other off-odors by olfactory tests. To estimate browning, a Gardiner-Hunter Color Meter was used to measure reflected light.

Wafers stored at 100° F. had generally developed off-odors in 275 to 374 days. Antioxidants somewhat suppressed odor development. Wafers made with corn syrup developed off-odors slightly less quickly than those made with malt syrup. Red wheat bulgur wafers developed off-odors significantly less rapidly than did white wheat bulgur wafers. Odor development increased inversely with bulgur particle size.

The Schall oven storage (145° F.) tests showed results just the opposite of those obtained at 100° F., possibly because the fat

Table 1.1
Initial flavor scores of bulgur wheat wafers

		Hedonic scale - mean scores			
		Red wheat		White wheat	
Cooking	Packaging	With malt	With corn:syrup	With malt	With corn syrup
	In nitrogen	5.25*	5.83	5.28*	4.98
Pressure	In air	5.53	5.08	5.17	4.75
	In nitrogen	5.28	5.30	5.85	5.45
Atmospheric	In air	5.63	4.95	5.45	5.25

* Reference samples
Least significant difference (.05) = 0.42

Table 1.3

Initial Chemical Determination

Red Wheat Treatments
Samples 1 through 8
(Avg. 2 replicates)
Treatments Numbers

Factors analyzed	1	2	3	4	5	6	7	8
Fat, %	9.99	10.13	10.14	9.89	9.37	9.40	9.77	9.96
POV (meg/kg fat)	9.54	6.95	6.73	4.50	2.44	2.45	1.06	3.98
TBA (mg Malonaldehyde/Kg sample)	2.53	2.14	1.26	1.22	2.68	2.53	2.19	2.00
Carbonyls (Millimoles/Kg fat)								
Total	5.32	4.04	3.91	5.25	4.64	4.23	5.25	3.33
Alkanals	0.68	0.55	0.52	0.63	0.57	0.67	0.63	0.47
Alk-2-enals	4.62	3.49	3.38	4.61	4.06	3.65	4.62	2.82
Alk-2,4-dienals	0.02	neg.	0.01	0.01	neg.	0.20	neg.	0.10
Diene value, %								
Conj. dienoic acid	0.22	0.21	0.22	0.24	0.27	0.27	0.26	0.26
Conj. dienoic ester	0.25	0.25	0.25	0.27	0.31	0.31	0.29	0.28
Aromagrams*, % Peak area								
1 - Peaks	19.39	19.29	21.31	20.70	25.13	23.46	25.18	24.83
2	2.66	1.49	2.06	2.71	3.69	3.34	3.27	3.74
3	25.76	28.83	30.11	29.44	31.29	31.05	31.24	31.08
4	1.88	2.60	2.52	3.31	4.60	5.04	5.03	4.98
5	50.30	47.78	43.90	43.82	35.16	36.64	35.40	35.48

* Relative retention times (Internal std. = ethyl formate)

Peak No.	Relative retention time
1	0.43
2	1.03
3	1.33
4	1.98
5	2.40

Table 1.4

White Wheat Treatments
 Samples 9 through 16
 (Avg. 2 replicates)

Initial Chemical Determination (Con't)

Factors analyzed	Treatments Numbers							
	9	10	11	12	13	14	15	16
Fat, %	9.66	9.61	8.77	9.24	9.60	9.86	9.65	9.84
POV (meg/Kg fat)	5.93	5.56	0.06	4.64	0.19	9.05	1.50	4.09
TBA (mg Malonaldehyde/Kg sample)	2.94	3.20	2.40	2.40	2.35	2.74	1.64	2.05
Carbonyls (Millimoles/Kg fat)								
Total	5.43	5.03	5.84	4.90	4.31	3.99	4.00	4.22
Alkanals	0.70	0.48	0.73	0.27	0.53	0.14	0.51	0.22
Alk-2-enals	0.73	4.55	5.11	4.64	3.87	3.86	3.50	4.01
Alk-2,4-dienals	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Diene value, %	0.29	0.27	0.31	0.27	0.27	0.23	0.26	0.22
Conj. dienoic acid	0.32	0.30	0.34	0.30	0.30	0.26	0.29	0.25
Conj. dienoic ester								
Aromagrams*, % Peak area								
1 - Peaks	21.58	20.75	21.25	22.45	24.44	28.03	29.15	29.68
2	3.75	3.30	3.81	2.75	3.56	3.55	3.99	2.88
3	32.11	32.36	30.95	31.89	30.60	29.46	30.00	29.30
4	3.91	3.11	4.85	3.67	5.67	5.85	5.94	4.49
5	38.67	39.82	39.14	38.74	35.72	33.12	30.92	33.61

* Relative retention times (Internal std. = ethyl formate)

Peak No.	Relative retention time
1	0.43
2	1.03
3	1.33
4	1.98
5	2.40

in the formulation is liquid at this temperature and some of its mass action effect is lost because it separates from the mixture. After 208 days, odor development was greatest in samples having added antioxidant and in those made with corn syrup instead of malt syrup. In contrast to results at 100° F., red wheat bulgur wafers developed off-odors significantly more rapidly than did white wheat bulgur wafers. Bulgur particle size had no distinguishable effect on odor development.

Color development at 145° F. was accelerated by finer grind of the bulgur and by use of malt syrup. White wheat bulgur wafers darkened more than red wheat bulgur wafers, but this may be only an apparent difference because the red bulgur wafers are normally quite dark.

In the storage study of commercially produced wafers, only the 145° F. storage temperature has shown any significant effect in 127 days. As expected, air-packed samples showed considerably more odor development than comparable samples packed under nitrogen. Other changes were similar to those occurring in the 145° storage series on laboratory-produced wafers.

While these tests are somewhat inconclusive, they do have some value in detecting gross differences in stability patterns. Perhaps of more importance, they point out the difficulty in interpreting results from elevated-temperature accelerated-storage techniques and the need to develop faster, more accurate, objective methods for determining storage stability.

Development of New Evaluation Methods

Components of bulgur vapors

We have attempted to develop a technique making use of gas-liquid chromatography (GLC) to measure rancidity in bulgur shelter wafers. In potato granules, an increase in hexanal content of the volatiles parallels the development of oxidative off-flavors (Agric. Food Chem., 9, 245 (1961)). Headspace gases above fresh and rancid bulgur also exhibit differences in their gas-liquid chromatograms, especially in two peaks which have been tentatively identified as pentanal and hexanal, by-products of fat autoxidation (Bulgur Wafer and Adjunct for Fallout Shelter Rations, OCD-OS-62-54, Feb.-June 1962, p. 16).

A vapor-sampling method has been devised which can be applied quickly and easily. It yields needed information on relative stabilities of wafer compositions and may be useful in surveillance testing. The method is as follows: 5 g of bulgur or wafer

mix is added to 100 ml of boiling water in a 250-ml Erlenmeyer flask with a special built-in glass side arm containing a thermometer (Fig. 1.1). The flask is quickly capped with aluminum foil and the mixture removed from the hot plate and swirled until the temperature of the aqueous mixture reaches 92° C. Then 3 ml of vapor is withdrawn into a syringe at room temperature and injected immediately into a GLC apparatus equipped with a dual hydrogen flame detector. The GLC column is a 7-ft by 1/8-in. stainless steel column containing ground firebrick coated with Apiezon M grease (deposited as a 10% solution in a volatile solvent).

The recorder tracing, "aromagram," produced by a vapor sample as it goes through the GLC apparatus is evaluated by calculating the approximate area of the peaks. The approximate area is calculated as (peak height) X (peak width at half-height). If we assume Gaussian-shaped peaks, the real area is equal to $2 \sqrt{\frac{\ln 2}{\pi}}$ or .941 of the above. The precision of this method for determining areas is about $\pm 10\%$. The method's sensitivity and qualitative and quantitative reproducibility satisfy the requirements of our work.

Influence of temperature of the aqueous mixture, sample-to-water ratio, and temperature of the syringe used for sampling have been investigated. At an arbitrarily chosen lower temperature of 72° (instead of 92°), volatiles in the vapor sample were insufficient to give a useful aromagram. The sample-to-water ratio was varied from 1 to 5 grams of sample for each 100 ml of water. Five-gram samples gave the best aromagrams; smaller samples did not have sufficient volatiles in them. The time required to bring the sample in the flask to the desired temperature makes no appreciable difference, nor does the rate of swirling of the flask. A syringe temperature higher than room temperature results in an aromagram with peaks in a higher boiling range. The higher molecular weight compounds producing these peaks are apparently not injected into the GLC apparatus with a syringe at room temperature, but are instead condensed or absorbed on the walls of the syringe. Fortunately, our primary interest is in the changes in peaks that appear early in the course of rancidification. The higher molecular weight compounds are not of particular interest at present; hence, use of syringes at room temperature is satisfactory and technical complications introduced by using a syringe kept at a higher temperature can be avoided.

The increase in the area of the hexanal peak in the aromagrams has been found to be a useful indicator of rancidification in bulgur and related products in the majority of our experiments. Since compounds other than hexanal may prove to be better

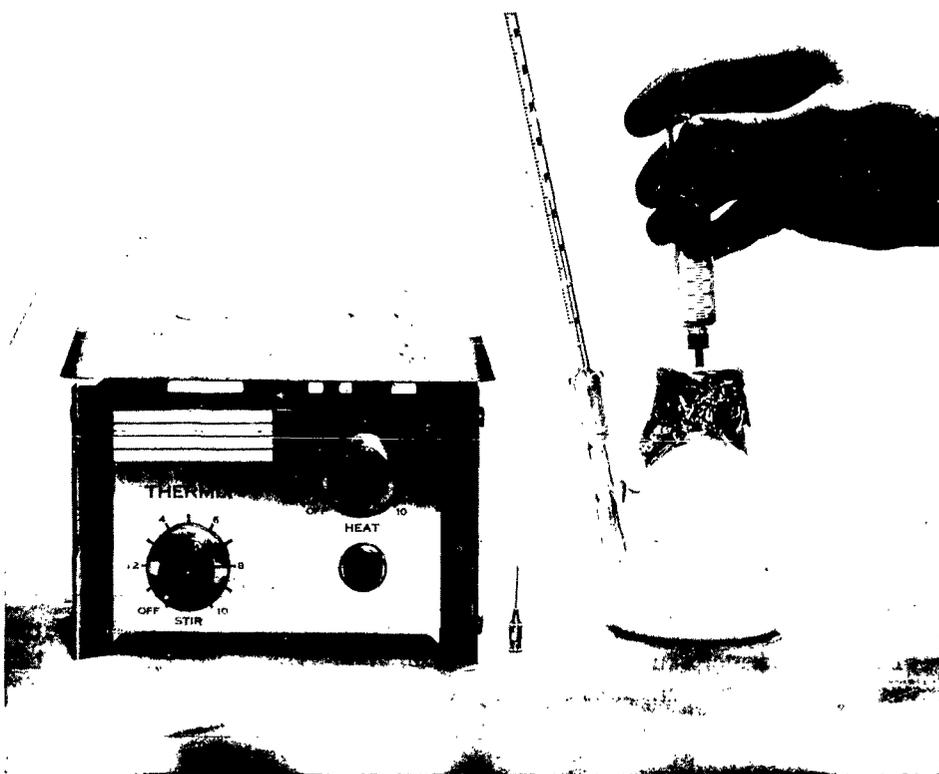


Fig. 1.1. Vapor sampling flask

indicators of rancidification, investigations have been undertaken to identify some of the other carbonyl peaks. Several of them, presumably arising from the autoxidation of linoleic acid in the bulgur, have been tentatively identified. The following procedure was used. A slurry of rancid white wheat bulgur was steam-distilled under vacuum (water aspirator), and the steam distillate condensed in ice-cooled containers. 2,4-Dinitrophenylhydrazine reagent (in 2N hydrochloric acid) was added, and the precipitated 2,4-dinitrophenylhydrazones (2,4-DNPH's) of carbonyl compounds present in the steam distillate were filtered off. The carbonyl compounds were then liberated from their 2,4-DNPH's by two modifications of the Ralls' flash exchange technique (Anal. Chem. 32, 332 (1960)).

The two modifications of Ralls' technique are as follows:

(1) A mixture of 2,4-DNPH's and α -ketoglutaric acid was heated to about 140° for 3 or 4 minutes in a 3-in. aluminum-foil-capped test tube; a vapor sample was withdrawn immediately and injected into the GLC equipment. Both types of columns, packed and capillary, were used in this work.

(2) Ralls' technique was modified by substituting a GLC capillary column for a packed column. A 350-ft by 0.02-in. stainless steel capillary column coated with "Tween 20" was used. The open end of an L-shaped glass tube containing the sample and α -ketoglutaric acid was forced through the silicone rubber septum of the GLC apparatus, and the carbonyls were liberated when the closed end of the L-shaped tube containing the reactants was heated with a small, hot silicone oil bath. The diameter of the L-shaped tube is critical (5-mm diameter tubes work well).

Hexanal, acetaldehyde, isobutyraldehyde, isovaleraldehyde, 2-hexenal, nonanal, pentanal, and octanal were identified by Ralls' technique, by comparing their retention times with those of known carbonyls. Identification of pentanal and octanal is clouded by some lack of agreement between knowns and unknowns. Hexanal and the compound tentatively identified as pentanal are the principal carbonyls. Other carbonyls were present which had retention times not corresponding to any of the knowns.

2,4-DNPH's from the steam distillate were later partially purified and separated into 6 zones on a silicic acid chromatographic column. Material from each zone was chromatographed on paper. Zones 1,2,3, and 4 each gave a faint spot; all moved at the same rate, which was somewhat slower than that of acetaldehyde 2,4-DNPH. The identity of the faint spot is still unknown. Zones 5 and 6 each gave a streak on paper chromatograms. The streaks moved faster than heptanal 2,4-DNPH on the same chromatogram, indicating that

carbonyls with molecular weights higher than that of heptanal may be present. Larger samples of 2,4-DNPH's are being prepared from rancid bulgur for more rigorous identification studies which have not been possible with the small amounts used in the above studies.

Of particular interest was the detection of some low-molecular-weight compounds possessing retention times corresponding to those of saturated hydrocarbons. (The presence of saturated hydrocarbons in rancid bulgur was suspected when vapors from rancid bulgur were shaken with concentrated sulfuric acid, which should remove all oxygenated compounds and unsaturated hydrocarbons and leave the saturated hydrocarbons in the vapors, but peaks still appeared in the aromagram of the remaining vapors.)

One or more of these compounds (from the vapors of rancid bulgur) possessing retention times corresponding to saturated hydrocarbons (up to pentane) might be good indicators of rancidity. Since our packed columns failed to separate the lower molecular weight compounds from vapors of autoxidized bulgur and related products, we tried other types of columns. Nylon capillary columns, 500 ft long, coated with General Electric SF-96-50 silicone oil possessed excellent separating power (with 400,000 theoretical plates based on pentane) for synthetic hydrocarbon mixtures, but they were not practical for autoxidized bulgur and related products. The thermal instability of nylon above 80° C. and its permeability proved to be serious disadvantages. Attempts to use 350- and 250-foot, 0.02-in. stainless steel capillary columns coated with "Tween 20" and SF-96-50 silicone oil for vapor sampling of our products failed because the detector in our commercial GLC unit was not sufficiently sensitive. Attempts to increase its sensitivity by saturating the carrier gas with water and decreasing the sample split ratio (two methods which workers occasionally have found to be effective) did not make any sizeable difference.

A model system -- methyl linoleate

A simplified system for studying rancidification in bulgur and related products has been found in methyl linoleate, which is appropriate for the purpose because linoleic acid is the principal unsaturated acid moiety in wheat germ oil. We applied the same analytical procedures to the identification of individual compounds in the carbonyl fraction from autoxidized methyl linoleate as we used for carbonyls from rancid bulgur.

Samples (0.5 to 1.0 g) of methyl linoleate (95% purity) were allowed to autoxidize on purified glass wool in aluminum-foil-capped flasks containing air. (This is our "Oxidative Technique I.") Aromagrams were prepared by withdrawing known volumes of

vapor at room temperature and injecting them into a GLC apparatus. Equal volumes of laboratory air were injected into the GLC apparatus to detect artifacts.

Autoxidation of 10- to 15-g samples of methyl linoleate was effected by passing approximately 10 ml of oxygen gas per minute through a flask containing purified cotton impregnated with methyl linoleate (95% purity). (This is our "Oxidation Technique II.") The carbonyl fraction was collected by passing the effluent gases from the reaction through a solution of 2,4-dinitrophenylhydrazine in 2N hydrochloric acid. The 2,4-DNPH's collected over a 2- to 3-week period were filtered from the solution, separated partially from unreacted reagent, and partially fractionated on silicic acid columns. Each fraction from the silicic acid column was further analyzed with paper chromatography. Known 2,4-DNPH's were chromatographed with the unknowns.

By the use of two types of silicic acid chromatographic columns, a crystalline 2,4-DNPH of hexanal was obtained from the 2,4-DNPH's. Its infrared spectrum was superimposable on a spectrum from an authentic sample of hexanal 2,4-DNPH. A mixture of the authentic sample and the crystalline material gave no melting point depression.

By the use of several chromatographic columns (both adsorption and partition types), enough crystalline 2,4-DNPH of pentanal was isolated to determine that the melting point of authentic pentanal 2,4-DNPH mixed with pentanal 2,4-DNPH from autoxidizing methyl linoleate was not depressed. Paper chromatography with an authentic sample of pentanal 2,4-DNPH supported the identity.

The two modifications of Ralls' technique were used to identify tentatively the major carbonyl compounds in the unfractionated 2,4-DNPH's and in each 2,4-DNPH fraction from the autoxidized methyl linoleate. The retention times obtained from the unknown mixture of 2,4-DNPH's were compared with those obtained from known 2,4-DNPH's.

Some of the individual carbonyl compounds were also tentatively identified by observation of their retention times on aromagrams made with packed GLC columns. The major peaks were identified by comparing retention times with those of known aldehydes, most of which had been purified by preparative GLC.

Tentative identification of the principal carbonyl compounds isolated appears in Table 1.5.

Table 1.5
 Carbonyl compounds identified in vapors of
 autoxidized methyl linoleate

	Paper chroma- tography	Vapor samp- ling	Flash exchange Modifica- tion I	Flash exchange, Modifica- tion II ^{1/}	Infra- red	Mixed melting point
Acetaldehyde		+	+			
Propanal		+	+	+		
Pentanal	+	+	+	+		+
Hexanal	+	+	+	+	+	+
Octanal		+	+			
Nonanal		+	+			

^{1/} 2,4-DNPH fraction partially purified by column chromatography.

The presence of a saturated hydrocarbon fraction in the vapors from autoxidizing methyl linoleate was established by shaking a known volume of vapor (using "Oxidation Technique I") with concentrated sulfuric acid, withdrawing a known volume of this vapor, and injecting it into a GL chromatograph. Comparison of the chromatogram obtained from this sample with that from the vapors of autoxidized methyl linoleate showed that several peaks had disappeared. Several other peaks, however, persisted after the sulfuric acid treatment, although they were reduced in size.

A sample of the low-boiling fractions was obtained by oxidizing 10 to 15 g of methyl linoleate on purified cotton with oxygen gas, and condensing the volatile products in a U-tube in a "dry-ice"-acetone bath. Extraction of the sample with chromatographically pure decane yielded an extract containing the saturated hydrocarbon fraction. This extract was analyzed using a 200-ft by 0.01-in. stainless steel capillary column coated with "SF-96-50." The aromagrams showed several peaks corresponding to low-boiling hydrocarbons.

Low-molecular-weight compounds with retention times corresponding to those of saturated hydrocarbons up to C5 began to form in the vapors of autoxidizing methyl linoleate before pentanal and the higher molecular weight aldehydes formed and before the rancid aroma appeared. If we can establish the time elapsing between the appearance of similar low molecular weight compounds and the development of the rancid aroma in bulgur we may be able to detect incipient rancidification in bulgur and related products containing esters of linoleic acid long before it can be organoleptically observed.

These studies with autoxidized methyl linoleate indicate that the saturated hydrocarbons and the two aldehydes, hexanal and pentanal, could be produced from wheat oil in bulgur, and they also support the assumption that linoleic acid in the natural wheat lipids plays a major role in governing the shelf-life of bulgur and related products.

Acceleration of rancidity

The oxygen bomb has been tried as a device to accelerate rancidity in ground puffed bulgur. In preliminary tests, the use of oxygen at 80 to 100 pounds per square inch and 100° C. showed some promise; the area of hexanal and pentanal peaks in the aromagrams increased with increasing time (Bulgur Wafer and Adjuncts for Fallout Shelter Rations, OCD-OS-62-54, Feb.-June 1962, p. 17). The previous work also showed that the rate of the Strecker reaction (reaction of amino acids and active carbonyl compounds

to produce aldehydes) becomes appreciable around 60° C. For the current oxygen bomb experiments, therefore, we chose 45° C. as the upper limit, because the formation of aldehydes would only complicate evaluation of this test.

Bulgur, ground bulgur, and ground puffed bulgur were the test materials because they are more easily oxidized at room temperature in air than is the shelter wafer mix. Ground (20 mesh) bulgur and whole bulgur from white wheat were mixed in pressure vessels at 45° C. with oxygen at 80 pounds per square inch. After two weeks the increase in the hexanal peak was negligible. Ground (20 mesh) puffed white wheat bulgur mixed at ambient temperature with oxygen at 30 psi showed a 3- to 4-fold increase in the area of the hexanal peak after two weeks. These findings are consistent with our observations of the relative stabilities of these materials at ambient temperature in air. The oxygen bomb method of producing accelerated rancidification for shelter wafers doesn't appear to be useful, since the time required to effect a change is too great, and the shelter wafer mix is even more stable than ground or puffed bulgur.

UV light or a mixture of fluorescent light and sunlight have been tested to determine their effect in speeding deterioration of bulgur. Ground (20 mesh) puffed white wheat bulgur was spread in a layer about 1/4 in. thick in crystallizing dishes, and a UV source (320-370 mμ, power rating 18.7 watts) placed about 3 in. above its surface. No effort was made to maintain the bulgur at a constant moisture level. After 10 days, the area of the hexanal peak had increased 75-fold. A similar sample exposed to laboratory light (a mixture of sunlight and fluorescent light) for 10 days also showed a 75-fold increase in the hexanal peak. The samples were definitely rancid.

To further examine the oxidation rate of bulgur under UV irradiation, ground (20-mesh) puffed bulgur was placed in 250-ml pyrex Erlenmeyer flasks with glass stoppers, and irradiated with UV lamps placed about 6 in. above the surface of the bulgur. Controls in similar flasks were stored in the dark. Samples were analyzed over a 24-day period by the aromagram technique.

Table 1.6 shows the development of the hexanal peak in samples irradiated by two different UV sources. The rate of hexanal development was, of course, much less than in the test with bulgur in crystallizing dishes because the distance of the sample from the UV source was greater, the light passed through Pyrex, and the surface-to-volume ratio of the bulgur was less.

Table 1.6

Effect of UV on hexanal in vapor above bulgur

Days	Control (dark)	UV lamp I ¹	UV lamp II ²
	Area of hexanal peak, cm.		
0	7.7	7.7	7.7
6	8.2	8.4	11.8
18	---	13.2	---
24	11.2	32.0	51.7

¹ UV lamp I was a Black Raymaster (320-370 m μ) rated at 18.2 watts. Manufactured by George W. Gates and Co., Franklin Sq., Long Island, New York.

² UV lamp II was a Blak-Ray Ultraviolet Lamp (320-370 m μ) rated at 18.2 watts. Manufactured by Ultra-violet Products, Inc., San Gabriel, Calif.

The two UV lamps had equivalent sources and envelopes and the same power rating, but differences in their age or manufacturing characteristics could have affected the rates of autoxidation of the samples.

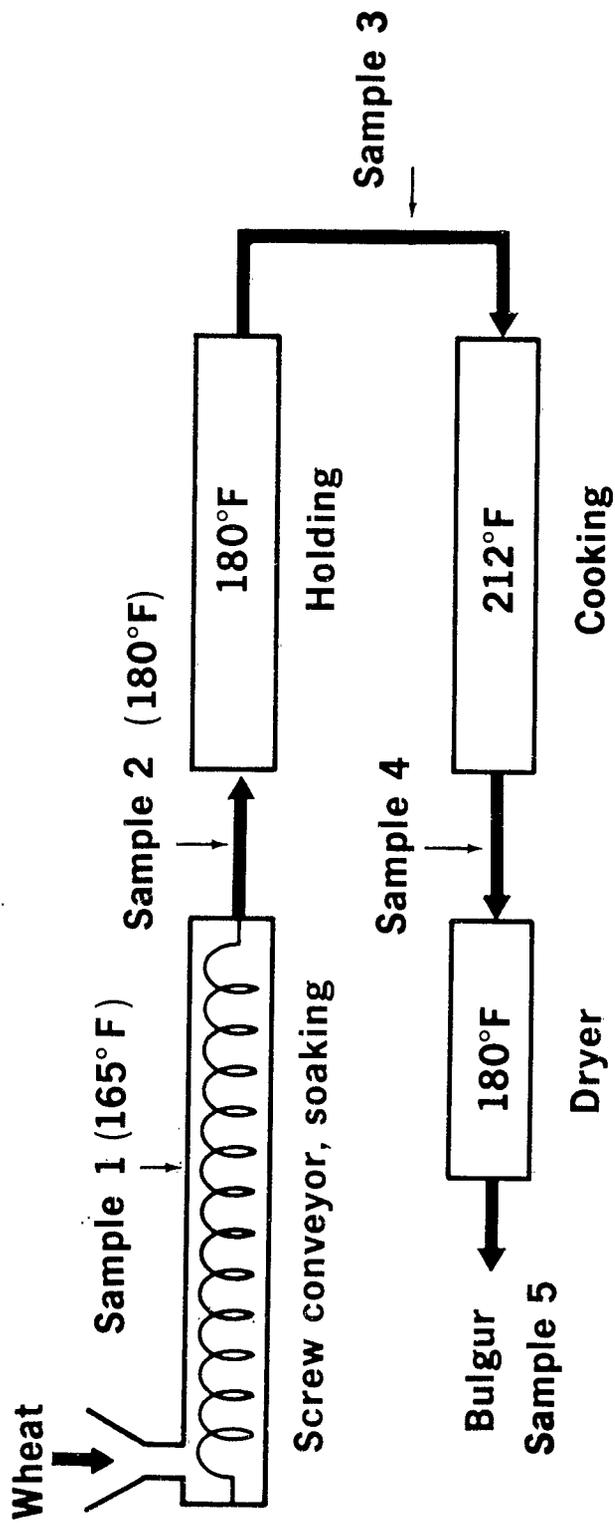
Of the techniques investigated for an accelerated storage test for bulgur shelter wafers, UV light appears to hold the most promise since large increases in hexanal develop in relatively short periods of time. Further work will be done to determine optimum conditions for this test.

Loss of Natural Antioxidants during Processing of Wheat to Bulgur

Oil in the intact wheat kernel is protected from rancidification by natural antioxidants, but this protection is lost somewhere in processing wheat to bulgur. Some research workers maintain that antioxidants cannot protect the oxidizable oils after autoxidation has once begun; therefore it would be desirable to add antioxidants at the appropriate point in the process.

To determine the point where the natural antioxidants become ineffective, we obtained samples from various stages in the bulgur process (Fig. 1.2), air-dried them 24 hr at 110° F., then sprayed them with water in a Hobart mixer, and equilibrated them overnight in closed containers. The moisture content then was approximately that of bulgur (8.5 to 9.5%). The samples were stored at

Fig. 1.2
Flow diagram for preparing bulgur from wheat



100° F. to accelerate rancidification. A sample of the white wheat used for making the bulgur was stored for the same length of time under the same conditions.

All samples were analyzed periodically for hexanal by GLC and the vapor sampling technique previously described, and evaluated for rancidity by a panel of judges. After 3 months of storage, Sample I and white wheat were not rancid, but all other samples were. No significant amounts of hexanal were present in the vapors of wheat or Sample I. However, the hexanal in the other samples increased 50- to 60-fold. The natural antioxidants apparently become ineffective at a very early stage in the processing, after the wheat has gone only half-way through the soaking step. This finding suggests that the antioxidant should be added to the process during the soaking step, but such a procedure seems impractical because excessively large amounts would be required as a result of dilution and loss by steam distillation.

SECTION 2

ALTERATIONS IN CEREAL INGREDIENT PROCESSING

Since bulgur constitutes nearly 80% by weight of the wafer, changes in this grain ingredient should have the greatest effect on texture, strength, chewability, and hydration characteristics of the wafer. In addition, approximately 90% of any cost reduction in the grain portion would be reflected in the cost of the wafer. (See report "Bulgur Wafers and Adjuncts for Fallout Shelter Wafers," Oct. 1962.) Effort has been placed, therefore, on developing more economical processing techniques that would yield a wheat ingredient comparable to or better in quality than the one presently used. Expansion of bulgur (puffing) in a stream of hot air results in a product that is fully cooked and of a texture suitable for preparation of wafers. The manner of puffing affects the textural quality of bulgur, hence studies have been directed to developing objective measurements and improving the texture of puffed bulgur.

Bulgur Puffing and Texture

Bulgur puffed in the commercial equipment used by Van Brode Milling Company in the production test run was more uniformly puffed and toasted and was crisper, with fewer hard particles than samples from the same bulgur puffed in our laboratory's continuous puffer, even though puff indices (bulk density unpuffed/bulk density puffed) were the same. Microscopic examination of the laboratory-puffed sample revealed irregular size voids and some small vitreous areas, whereas the commercially puffed sample showed small uniform voids throughout with no evidence of unpuffed areas.

The commercial equipment apparently differed from our laboratory unit in two regards: air velocity and uniformity of conveying during heating. Our unit was limited in these regards. We could approximate the product produced commercially only by operating at the upper limits of our equipment, and only on the same batch of bulgur used commercially. With different bulgur, however, products with less uniform textures were still produced. In order to expand the range of process variables and to determine probable interdependence of variables, new puffing equipment has been specified and procured, and is currently being placed in operation.

Indications (see report "Bulgur Wafers and Adjuncts for Fallout Shelter Wafers," Oct. 1962) that pressure-cooked bulgur expands to a greater degree than atmospheric-cooked bulgur have been confirmed (Table 2.1). Five batches of bulgur were prepared in which only the steam-cooking step was different. One was pressure-cooked and one atmospheric-cooked from a single lot of hard red winter wheat; one was pressure- and two were atmospheric-cooked from a single lot of white club wheat. These samples were debranned, as nearly as possible, to the same degree, adjusted to 9% moisture, and puffed 30 secs in air at 500° F. and 525 fpm linear velocity.

Table 2.1
Effect of cooking procedure on
subsequent expansion of bulgur
(laboratory samples)

Sample description	Bulk density, grams/cc		Puff index
	Before puffing	Reduction due to puffing	
Red wheat bulgur			
Pressure cooked	.760	.348	1.85
Atmospheric cooked	.750	.223	1.42
White wheat bulgur			
Pressure cooked	.706	.375	2.13
Atmospheric cooked*	.713	.224	1.46

* Average of 2 lots, not significantly different.

When samples of commercially prepared bulgurs were puffed under standard conditions, no variations in puff index or change in bulk density could be attributed to cooking processes (pressure vs atmospheric) or raw material (red or white wheat) (Table 2.2). Factors other than cooking process and wheat type apparently exert an influence on expansion characteristics.

These experiments again point up the inadequacy of puff index as a single criterion for acceptability of the puffed product. The puff index tends to exaggerate differences between samples when differences in reduction in bulk density due to puffing are relatively small (Tables 2.1 and 2.2), and it does not reflect textural characteristics.

Table 2.2
Comparison of cooking procedure and wheat type on
subsequent expansion of bulgur
(commercial samples)

Wheat type	Cooking process	Bulk density, grams/cc		Puff index
		Before puffing	Reduction due to puffing	
Red	Pressure	.774	.297	1.61
White	Pressure	.800	.312	1.64
Red	Probable pressure	.830	.467	2.29
White	Atmospheric	.791	.350	1.80
White	Atmospheric	.790	.316	1.66
White	Atmospheric	.785	.386	1.97
Red	Probable atmospheric	.765	.238	1.45
Red	Probable atmospheric	.861	.258	1.43

Texture of puffed bulgur appears to be influenced by the degree of puff and the uniformity of puff, both within individual kernels, and from kernel to kernel. Air elutriation and air classification were tried in an attempt to reveal differences in uniformity of puff within samples. Differences were so small that these approaches did not appear promising.

A hardness tester designed to measure certain milling characteristics of wheat gives objective measurement of gross textural differences in puffed bulgur, according to manufacturers tests. The instrument has been obtained. Sample texture is expressed graphically as meter-grams (m-gm) of torque required to grind a sample; higher values indicate harder samples.

The possible effects of sample size, temperature, and moisture at time of testing have been checked, and a standard technique developed. Sample temperatures in the range of 34° to 175° F. have no measureable effect. Sample size has an appreciable effect (Table 2.3) as measured on 3 different samples, but values are relatively constant for samples of 80-g to 120-g size. In our testing program 100-g samples will be used routinely, and at least duplicate determinations will be made. Hardness tester readings are extremely sensitive to sample moisture content (Table 2.4). The drier the sample the lower the reading. Hence, for consistent and comparable results, it is necessary to equilibrate all samples to a standard moisture before testing. Since the current specification calls for a moisture content of 2.5% to 3.5% in the puffed bulgur ingredient in the wafer, $3.0 \pm 0.2\%$ will be used as standard sample moisture.

Table 2.3

Effect of sample size on hardness tester results

Sample size grams	Torque, meter - grams		
	Sample 1	Sample 2	Sample 3
50	410	404	425
60	414	411	429
70	428	416	439
80	437	418	438
90	440	420	443
100	440	423	440
120	439	426	448
140	439	429	453

Table 2.4

Effect of sample moisture on hardness tester results

Sample 1		Sample 2	
% Moisture	Torque, m-gm	% Moisture	Torque, m-gm
8.0	664	7.8	514
6.8	580	7.2	491
4.8	473	6.3	470
3.5	452	5.4	425
		4.0	399
		3.0	366
		2.1	355

Precision of the instrument (at constant moisture and sample size) in the range of 300-700 m-gm appears to be ± 3 m-gm, as indicated by several replicate measurements on different samples. Insufficient data have been collected to permit conclusions concerning the effects of processing conditions on textural properties.

Variations in Puffing Technique

The wheat ingredient, as now specified for bulgur-type wafers, requires the following processing steps: (1) soaking to raise the moisture content of the wheat to about 40%, (2) steam cooking to gelatinize the starch, (3) drying to about 10% moisture, (4) partial debranning, (5) puffing the resultant bulgur in a hot air stream, (6) cooling, and (7) grinding to desired particle

size. Many of these steps require large amounts of thermal energy. If one or more steps could be eliminated or combined, appreciable savings could be realized in the cost of the wafer's raw materials.

Hot-air puff-drying

Raw wheat can be expanded in hot air, but the product has a raw-flour taste, and the interior of the kernel is soft and powdery. When wet bulgur is dried rapidly at high temperatures the kernels become fixed in a partially expanded or swollen form, and the structure is somewhat friable with some large internal voids. These two observations suggest that a suitable wheat ingredient for the wafer might be obtained with less stringent cooking conditions by combining the drying and puffing steps.

Accordingly, two series of experiments were set up to determine minimum cooking requirements: in one, partially debranned wheat at 25% moisture was steamed for various lengths of time from 0 to 60 min; in the second, partially debranned wheat was steamed for 15 minutes at moistures ranging from 15% to 45%. Undried samples from each treatment were then given various time exposures in the hot-air puffer at 600 fpm air velocity and 200°, 260°, and 320° C. to see if puffing and drying could be combined. (Hot-air treatment schedule is given in Table 2.5.) Solubilization of starch, as a measure of cooking, was determined by an empirical Iodine Blue Value (IBV) determination (IBV = % transmittance as measured at 590 μ on the Coleman Colorimeter; decreasing transmittance indicates increasing starch solubilization). Bulk density of treated materials was also determined as a measure of the degree of expansion achieved.

Table 2.5

Hot-air treatment schedule

200 g aliquot at each indicated temperature and time

<u>200°C.</u>	<u>260°C.</u>	<u>320°C.</u>
10 secs	10 secs	5 secs
20 "	15 "	10 "
30 "	20 "	15 "
45 "	30 "	20 "
60 "	40 "	30 "
75 "	50 "	40 "
90 "	60 "	50 "
120 "	75 "	60 "

A fully cooked flavor (disappearance of raw starch taste) and maximum expansion were achieved by steaming 10 min at 25% moisture or by steaming 15 min at 20% moisture followed by a 30-sec treatment in hot air at 260° C. Grain expansion increased as IBV decreased until maximum expansion of 1.4 was reached at an IBV value of 40. Treatments of greater severity modified the flavor and further reduced the IBV values, but did not increase maximum expansion.

The maximum expansion achieved did not meet current specifications, but the ultimate value of the method will depend upon evaluation of the products by hardness testing and by organoleptic evaluation of wafers formed from these materials. The reduced soaking time and steaming requirements and the elimination of the drying step could effect important savings in the cost of the wheat ingredient for the wafer.

Hot-oil puffing

Parboiled rice can be expanded several fold in hot oil (deep fat) as can a partially germinated raw wheat. Since 10% fat is included in the bulgur wafer formulation, oil puffing of either bulgur or moisture-conditioned raw wheat appeared to be a distinct possibility as an alternate method of producing the wheat ingredient.

Samples of both wheat and bulgur were preconditioned to 5 moisture levels (11%, 15%, 20%, 25%, and 30%) and treated in hot oil at 375° F. and 450° F. for the time required to expand the kernels. A maximum expansion of 1.6 was obtained on wheat at 20% and 25% moisture at both temperatures, while maximum expansion of 1.4 was obtained with bulgur at the lowest moisture. Both products had poor texture and excessive oil sorption; therefore, this approach was discontinued.

Bumping

The opinion has frequently been expressed by people in the cereal industry that bumping (compression of kernels while in a plastic state) might lead to better puffing. We moistened bulgur to 32% to make it plastic, held one portion as a control, and compressed other portions with cold rolls and with hot and cold platens in a hydraulic press to 1/16-in. and 3/32-in. All samples were dried to 10% moisture and puffed at standard conditions in the hot-air puffer. No differences were apparent in either puff index or texture of the samples. Under the conditions tried, bumping does not appear to be of any value in this type of puffing.

Gun-puffing

Raw wheat is gun-puffed in the breakfast cereal industry by creating sudden changes in internal grain pressure. Expansions of 12- to 16-fold are obtained. Test wafers prepared from these materials have shown that such high degrees of expansion are undesirable. Preliminary experiments with rather crude equipment indicated that such a technique might be used to bring about expansion of only 2- to 4-fold. Accordingly, a small commercial puffing gun of the general type used in the breakfast food industry has been obtained. It is a rotating, gas-fired, hollow cylinder with a quick-opening gate at one end. A charge of grain is loaded into the gun, the gate closed, and the gas burners lit while the gun is rotated. Moisture in the grain vaporizes and builds up pressure. When pressure reaches a predetermined super-atmospheric point, the gun is fired by opening the gate. The sudden release of pressure in the grains expands the kernel.

Preliminary tests have been made to define the limits of operating variables. Wheat has been expanded to puff indices between 1.1 and 6.6 at pressures ranging from 75 to 190 psig. The principal variable controlling expansion appears to be pressure. Grain moisture content exerts a smaller influence on expansion, but it has a major influence on cooking and toasting (flavor and color development and disappearance of raw starch taste). Moisture content also affects the time required to develop the required pressure (come-up time) when the gun is charged cold, but not when the gun is hot. Come-up time, which is considerably greater when the gun is cold than when hot, has an influence on color and flavor of the finished product.

Experimental wafers have been made from both wheat and bulgur expanded in this gun to a puff index of 2.1. Both pressed well, and the texture of the resultant wafers was softer and had fewer hard particles than in wafers prepared from conventional hot-air puffed bulgur. The wheat wafers had a slight raw-starch flavor, but the bulgur wafers were over-toasted. These minor difficulties can probably be overcome.

A systematic study of the effects of the process variable on expanded volume, cooking (soluble starch measurements), color, and texture of wheat and bulgur puffed in the gun has been undertaken. Insufficient data have been obtained to draw conclusions concerning their effects.

Additional research is needed to determine the nature of the changes that occur in wheat during processing, and to assess the effects of differences in wheat composition (e.g., kind and quantity of protein, amylose-amylopectin ratios, gluten strength) on the characteristics of puffed bulgur.

SECTION 3

WAFER FORMULATIONS

It has been suggested that wafers might be prepared to include substances reported to alleviate or moderate the effects of radiation on the body. We have investigated the effect of many of these materials on flavor and texture of the wafer, in the event such additions were advised. Wafers were made according to the basic formula with the addition of the following quantities of materials: up to 5% calcium carbonate, 5% tribasic calcium phosphate, up to 0.04% ascorbic acid, 0.04% L-cysteine hydrochloride, 0.09% potassium iodide, 10% yeast, 0.06% folic acid, 0.03% methionine, and 7% calcium citrate. In no case was the flavor, texture or general appearance of the wafer judged to be adversely affected. The influence of such additives on wafer stability is unknown.

It has also been suggested that wafers could be given increased palatability, caloric content, and nutritional balance, and that variety could be added to the shelter diet by incorporating adjuncts (flavoring materials) directly into the wafer instead of supplying these materials separately. If this were done, a simplification of procurement and space savings might result. In a preliminary test, wafers were prepared containing dehydrated fruits, fruit extracts, cheeses, honey, peanut butter, chocolate, and yeast. Satisfactory pressing conditions could be found for most of these mixtures, and the wafers generally possessed a pleasant taste characteristic of the additive. An unexpected side light to this program was the interest expressed by North American Aviation Incorporated in the possible use of flavored wafers in the NASA Apollo program as a 3-man, 3-day survival kit to be used, if necessary, by the astronauts upon their return to earth. The suitability of such high bulk-density, space-saving material is obvious.

SECTION 4

ADJUNCTS FOR USE WITH THE BULGUR WAFER

The bulgur wheat wafer could be used as the only food in fallout shelters, but the diet might be too austere to provide the morale-building aspect desired. To relieve the monotony of a single-item ration, foods (adjuncts) are being developed to go with or add to the wafer. (Bulgur Wafer and Adjuncts for Fallout Shelter Rations, OCD-OS-62-54, October 1962.)

Factors of prime importance in development and selection of adjuncts include: long-shelf life (stability), compatibility with basic shelter ration (bulgur wheat wafer), low protein content, high caloric value, high bulk density, low cost, and ease of preparation and serving.

Shelf-life of Adjuncts

To prolong-shelf life of adjuncts, we are trying to "build" stability into the product by selecting stable ingredients, eliminating incompatible mixtures, using low moisture materials, and packaging the products to prolong their stability. Our success in these efforts is difficult to assess because, at present, we have no accurate way to predict stability. The only method of determining stability is by actual storage tests and organoleptic evaluation, which are time-consuming and costly.

Preliminary tests

In order to obtain a preliminary evaluation of the adjuncts developed and reported in OCD-OS-62-54 (October 1962), these adjuncts, packed in air, were stored at room temperature for 8 to 10 months. They were then evaluated as to odor, flavor, color, and ease of rehydration of the dehydrated fruits and vegetables.

Pea soup and potato soup were rancid, and all apricot-flavored adjuncts were off-flavored. These items (nos. 5, 15, 26, 27, and 42) have been eliminated from the adjunct list.

Beef-mushroom gravy had a soapy taste, which we think is due to deterioration of the dry Worcestershire sauce seasoning in the mixture. Deterioration of the dehydrated vegetables was indicated by a slight hay-like odor in the sauces (oriental, chicken-vegetable, beef-vegetable, and creole), and by the slow rehydration rate of the vegetables. The leeks, spinach, celery and parsley had deteriorated to the greatest extent. Onions and

peppers were in the best condition. Oriental sauce contained starch and the deterioration was greatest in this sauce. Several other adjuncts containing starch had a slight off-flavor and a slight hay-like odor. We found that the starch had a high moisture content, which increased the total moisture above the level desired for good storage stability. We also found that the starch had a strong flavor. These faults may be corrected by use of a suitable starch.

Although adjuncts containing dehydrated vegetables packed in air deteriorated slightly during 8 to 10 months at room temperature, we do not recommend that they be excluded from the adjunct list at this time. Increasing the sulfur dioxide content of the vegetables, packing them in an atmosphere of nitrogen, and using in-package desiccants may increase the stability of these adjuncts sufficiently to make them suitable shelter rations. This will be determined by long-term storage tests.

Storage contract with Oregon State University

Oregon State University will conduct (under contract) a five-year storage study of 12 adjuncts that represent a cross-section with respect to type (spreads, soups, sauces, etc.) and to kinds of ingredients. The 12 are raspberry jelly, strawberry spread, cream of chicken soup, beef soup, oriental sauce, curry sauce, paprika gravy, chili sauce, apple topping, butterscotch topping, chocolate pudding, and wild cherry icing.

Five adjuncts have a moisture content below 1.5%, the others range from 1.5 to 4%. The adjuncts with moisture levels above 1.5% will be packed with and without in-package desiccant. The amount of desiccant used will be calculated to bring all moisture contents to 1.5%.

All adjuncts will be packed in tin cans with nitrogen atmosphere in half the samples and air in the other half.

Storage will be at temperatures of 40°, 70°, and 100° F. Controls stored at -18° F. will be nitrogen-packed with in-package desiccants in the higher moisture materials, above 1.5%.

Every six months samples will be evaluated by a taste panel of approximately fifty students using a nine-point hedonic scale. Each sample will also be evaluated by an experienced taste panel of four persons who will judge color, flavor, odor, ease of preparation and rehydration, and evidence of deterioration.

Oxygen content of head-space will be measured in all nitrogen-pack samples, and any sample with an unusually high oxygen content will be discarded. Moisture content will be determined by the Karl Fischer method.

Modification of Adjuncts

Commercial pregelatinized starches of low moisture content (one each of wheat, potato, and yellow waxy maize starch, three corn, and three tapioca) were evaluated for gel characteristics and flavor. A tapioca starch was selected as having the most desirable characteristics. When this bland low-moisture starch was substituted in the adjunct formulas, the flavors of the adjuncts were too strong or too sweet. With the starch originally used, a high flavor concentration had been necessary to mask the flavor of the starch. In order to use the bland starch, all formulas containing starch (cream of chicken soup, chili sauce, oriental sauce, paprika gravy, beef-mushroom gravy, curry sauce, chicken gravy, puddings, toppings, and icings) had to be modified.

Protein produces a diuretic effect, which increases water demand, hence, a low protein level is desirable in fallout shelter rations. Since specifications have been modified to allow higher protein content of the bulgur wafer, we have reconsidered all formulas with high protein content. Whenever possible, protein has been decreased.

To decrease the total moisture content of adjuncts and to give better storage stability, high moisture content ingredients have been decreased or eliminated. To give better storage stability, dehydrated green pepper has been substituted for dehydrated celery or parsley in cream of chicken soup, chicken soup, and curry sauce, and Worcestershire sauce seasoning has been eliminated from beef-mushroom gravy.

The carboxymethyl cellulose used in the original formulas for spreads is no longer manufactured. Use of another type has enabled us to devise a spread prepared with cold water instead of boiling water (Appendix A, Nos. 11 through 20).

The low-methoxyl pectin used in the original jelly formulas does not have the same characteristics as the pectin commercially available now. We have developed new jelly formulas to fit the characteristics of the new pectin (Appendix A, Nos. 1 through 10).

Development of New Adjuncts

Several new adjuncts have been prepared and screened for acceptability. Products passing this preliminary screening are nutmeg topping, chocolate mint pudding, imitation maple syrup, and mashed potato salad (Appendix A, Nos. 55 through 58). Eight fruit flavors and colors have been selected for icings #54.

In cases where the liquid form of a flavor is superior to the powdered form, we have added anhydrous dextrose to the liquid to produce a dry product. All other ingredients included in these new adjuncts are dry, relatively low in moisture, and of good stability. Protein content has been kept at a low level.

High-stability margarine-type fat spread

Margarine is an emulsion of fats, milk solids and water, with color, flavor and stabilizers. When subjected to prolonged storage, the milk solids in the water phase deteriorate. Water in the mixture provides conditions conducive to accelerated rancidification of the fats and separation of liquid and solid portions. Margarine would be a desirable adjunct, but obviously, it cannot be used because it lacks storage stability.

Work is in progress to develop a spread that has good storage stability, and the appearance and taste of margarine. Since a wide range of temperatures are anticipated in a fallout shelter, the product should be spreadable at perhaps 40° F., and should not separate at 90° F. The basic formula consists of coloring and flavoring agents, antioxidants if needed, liquid fat, medium hard fat, and hard fat. Increasing the proportion of liquid fat increases the spreadability at 40° F., but lowers the separation point. Increasing the hard fat raises the separation or "bleeding point," but it also produces an objectionable waxiness which coats the mouth, giving a very unpleasant "taste-feel" sensation.

Two types of fat spreads are being considered: The first has a medium stability, comparable to that of the shortening in the bulgur wafer. Ingredients for this spread are readily available and should be low in cost. The second type has high stability (twice as long a shelf-life as the medium-stability spread), but it may cost approximately 25% more than the first type. Although ingredients are more expensive in the more stable type, the longer shelf-life obtainable may offset the higher cost.

The spreads are prepared in the laboratory by mixing the ingredients, melting the mixture, cooling it to 105° to 110° F., and then solidifying it very rapidly in a thin sheet at -10° F. The frozen flakes are brought slowly to 70° to 80° F., and thoroughly beaten by hand. This treatment is necessary to obtain the smooth creamy texture that results from formation of the small, least stable (alpha) crystals which transform into the relatively stable (beta-prime) crystals instead of the large, stable curdy (beta) crystals that form at room temperature. Near the melting point or separation point of a margarine spread, the beta-prime crystal slowly transforms into the beta crystal, and the waxy taste is intensified.

Therefore a spread which is already waxy will become progressively more waxy when held near its melting point. Products having the desired plasticity range invariably have had an objectionable waxiness. Therefore the upper limit of the plasticity range may have to be lowered 5° to 10° F. to produce high stability without waxiness. A high-stability spread with good flavor and appearance and very little waxiness has been prepared, but it separates at about 84° F. The following formula was used:

High-stability liquid fat (500 hour A.O.M. Test)	59.31%
Medium-stability medium-hard fat (200 hour A.O.M. Test)	39.54%
Synthetic color, 22% beta carotene	0.01%
"Starter distillate" butter flavor	0.14%
Powdered salt	1.0%

Addition of 3% powdered hard fat to the above formula produced a spread that separated slightly at 90° F., but it was waxy and became progressively more so when held at 90° F. Addition of 6% powdered hard fat produced a spread that did not separate at 90° F., but it was extremely waxy.

Although a completely satisfactory spread has not yet been obtained, results are encouraging. None of the medium-stability spreads have been satisfactory. However, other materials available may enable us to make a satisfactory product of both types. Monoglycerides, acetoglycerides, and a cellulose gum will be investigated in an attempt to decrease waxiness, and increase the upper limit of the plasticity range.

Antioxidant 0.01% BHA plus 0.01% BHT, with 0.01% citric acid have been added to the formulations, and no off-flavors could be detected.

Cold-water pectin jelly

Two different gel systems have been used to make cold-water pectin jellies, one using low-methoxyl pectin, and the other, high-methoxyl pectin.

In making a cold-water pectin jelly, it is necessary to obtain rapid and complete pectin dispersion and solution and to delay gel set until pectin dispersion and solution is complete. The method for obtaining rapid pectin dispersion and solution is based upon patent No. U. S. 2,673,157 by Shepherd, McCreedy and Owens, "Low Methoxyl Pectin Gels and Method of Making the Same." A concentrated solution of sugar and pectin (12.5:1 by weight) is made and drum dried. In the dried mix, the pectin is thoroughly dispersed in the sugar at the micro level so that when the mix is added to cold water, the sugar and pectin dissolve simultaneously, rapidly, and completely.

The drum dried mix is amorphous, very hygroscopic and, therefore, difficult to handle. Crystallizing the drum dried material produced a non-hygroscopic, stable product, low in moisture content and easy to handle. Studies are now in progress to develop a rapid method for crystallization. Work is also progressing on reduction of the cost of a drum dried mix and on improving its solution rate.

The gel structure of a low-methoxy pectin is formed by ionic cross-bonding of the carboxyl groups by di-valent calcium ions. Gel-structure formation can be delayed by using a slowly soluble, relatively insoluble calcium salt and maintaining continuous dissolution of this salt by controlled pH, but preventing and delaying the reaction of the calcium with the pectin by use of a calcium sequestering agent and the sodium salt of a weak acid until the pectin is completely dissolved. The temporary time delay of gel formation can be controlled by varying the proportion of the ingredients. A good gel set can be obtained in one to two hours, which is no longer than the time required to cool jelly prepared by the hot method.

The cold-water low-methoxyl pectin jelly, which sets in one to two hours, was made with the following formula:

Low-methoxyl pectin-sugar mixture, drum-dried	45.51 g
Granulated sugar	49.33 g
Citric acid	2.24 g
Tribasic calcium phosphate	1.12 g
Sodium hexametaphosphate	.90 g
Sodium citrate	.90 g
Cold water	224 cc

Gel structure formation of a high-methoxyl pectin results from dehydration of the pectin molecule by a high sugar concentration and hydrogen bonding at a pH below 3.5. If lowering of the pH can be delayed until the pectin is completely dissolved, a good cold water jelly can be made. An acid anhydride (delta gluconolactone) and a sodium citrate buffer were used to control the pH.

The cold-water high-methoxyl pectin jelly was made with the following formula:

High-methoxyl pectin mixture, drum dried	22.04 g
Granulated sugar	75.92 g
Sodium citrate	.08 g
Delta glucono-lactone	1.96 g
Cold water	67 cc

Immediately after the pectin had dissolved, the pH was 4.9, and the final pH was 3.1 to 3.0. Gel-set started in two hours, and a jelly with excellent characteristics was formed in 10 to 12 hours.

These cold-water jellies are not included in the formulas listed in the appendix, as work on them is not complete. The low-methoxyl pectin jelly should be improved in flavor, and its stability should be investigated. Further work should be done to reduce set time of the high-methoxyl pectin jelly. The sugar-pectin mix should be stabilized and preparation methods developed to reduce cost.

New Packaging Concept

We are developing a new packaging-preparation concept. A specially designed unsealed polyethylene bag (Exhibit in Appendix B) is packed in the tin can with the dry ingredients and is used to prepare the adjunct for serving. A designated amount of cold water is added to the dry ingredients in the bag, the top of the bag is quickly twisted and locked with a paper-covered wire clip (tie), and the bag is shaken and manipulated to mix the ingredients. Mixing is more rapid and complete than in the conventional container. The adjunct is served directly from the bag by cutting off the end of a preformed dispensing tip and squeezing the food directly onto the bulgur wheat wafer. No additional equipment, containers, spoons or ladles are necessary.

In the closed community of a fallout shelter the use of this packaging-dispensing system would have several advantages. Bacterial contamination from improperly cleaned food preparation equipment and the subsequent food spoilage is a health problem wherever large-volume servings are involved. In a fallout shelter, where the water supply may be limited, the problem could become acute. Use of the plastic bag would remove this hazard, because the bag is disposable. In addition, water could be conserved because none would be needed to wash preparation and serving equipment. If the bags are properly designed, they should reduce spillage and waste. The bag can be mass produced at a cost of less than 1.5 cents per bag.

Cold-water jelly, fruit spreads, puddings, toppings, icings, and syrup have been prepared and dispensed successfully from this bag. The margarine spread also dispenses well from this package.

Description of Adjuncts

Formulas for all adjuncts are given in the Appendix A, with information on equipment, portions and manner of use.

The approximate grams of protein per serving, calories per serving, grams of protein per 100 calories for each adjunct are shown in Table 4.1. Some adjuncts described in our 1962 report have been modified to decrease protein; they now have less calories per serving because the high-protein ingredients supplied a large portion of the calories. Servings listed are the minimum amounts needed to complement the wafers, larger servings may be desirable.

Estimated Costs

Bulk densities and preliminary cost estimates have been made for the adjuncts (Table 4.2). These estimates are based on production of one-ton lots of finished product. Prices of ingredients are for ton or drum lots, depending on quantities required. All prices are f.o.b. San Francisco, California, as of August 1963.

Cans are standard sizes, commercially available. For some of the adjuncts of lower bulk density, can sizes were selected on the basis of slightly compressing the material into the can. Compressing these materials to increase the bulk density is desirable, and commercial equipment is available to do the job.

The cost of the adjuncts containing sugar could be decreased by substituting dextrose sugar for part of the sucrose. Although it has not been tested, it is possible that one third to as much as one half of the sucrose could be replaced by dextrose without appreciably changing the formulas or significantly decreasing stability. Using the jelly formulas as an example, the cost would be decreased \$ 0.33 per 100 lbs of dry mix by substituting dextrose for one third of the sucrose. Substituting dextrose for one half of the sucrose would decrease the cost \$ 0.49 per 100 lbs of dry mix.

Manufacture of Adjuncts

Preparation of most adjuncts is simply a matter of mixing the ingredients and canning them. However, formulas containing starch, pectin, or carboxy-methyl cellulose should have special attention.

In formulas containing starch, the starch should be thoroughly mixed with other powdered ingredients, then ingredients of larger particle size should be added and thoroughly mixed.

In formulas for spreads, the carboxy-methyl cellulose should be mixed thoroughly with part of the sugar and all of the other ingredients except citric acid. The material should be placed in the can in three layers as follows; the mixed material in the

Table 4.1

Protein content and caloric value of adjuncts

Adjunct number	Adjunct	Protein, g/serving	Calories/ serving	Protein, g/100 calories
1-10	Jelly	0	39	0
11-20	Fruit spread	0	17	0
21	Soup, onion	1.0	20	5.0
22	Soup, cream of chicken	2.1	51	4.1
23	Soup, chicken	2.0	29	7.0
24	Soup, chili-beef	1.1	17	6.5
25	Soup, beef	1.0	15	6.7
	N.F. dry milk	2.3	23	10.0
28	Raisins	0.4	40	1.0
	Sugar	0	25	0
29	Pudding, Kansas Indian	3.0	94	3.2
30	Applesauce	0.3	84	0.4
31	Sauce, chili	1.1	42	2.7
32	Sauce, oriental	1.8	44	4.1
33	Gravy, paprika	2.0	47	4.4
34	Gravy, beef-mushroom	1.2	39	3.1
35	Sauce, curry	1.9	47	4.0
36	Gravy, chicken	1.9	43	4.3
37	Sauce, chicken-vegetable	2.5	43	5.8
38	Sauce, beef-vegetable	3.3	48	6.9
39	Sauce, creole	3.2	44	7.3
40	Pudding, chocolate	2.5	84	3.0
41	Topping, apple	1.4	129	1.1
43	Topping, wild cherry	1.3	112	1.2
44	Topping, orange	1.3	112	1.2
45	Topping, grape	1.3	112	1.2
46	Topping, peach	1.3	112	1.2
47	Topping, raspberry	1.3	112	1.2
48	Topping, pineapple	1.3	112	1.2
49	Topping, strawberry	1.3	112	1.2
50	Topping, lemon	1.3	112	1.2
51	Topping, vanilla	1.3	113	1.2
52	Topping, butterscotch	1.3	112	1.2
53	Icing, chocolate	0.2	79	0.3
54	Icing, other than chocolate	0	35	0
55	Topping, nutmeg	1.3	112	1.2
56	Pudding, chocolate mint	2.5	84	3.0
57	Syrup, imitation maple	0	60	0
58	Salad, mashed potato	1.1	54	2.0

Note: #5, #15, #26, #27, and #42 are omitted because of their instability.

Table 4.2
 Cost estimates and bulk densities of adjuncts

Adjunct	Persons served	Can size	Can weight	Cost		Bulk densities oz./cu.in.
				per can	per 100 calories	
1. Cherry	50	(#2) 307 x 409	1 lb 2 oz	\$0.230	\$0.005	0.454
2. Strawberry						
3. Grape						
4. Pineapple						
6. Orange						
7. Lemon						
8. Raspberry						
9. Apple	50	(#2) 307 x 409	1 lb 2 oz	0.225	0.005	0.454
10. Peach						
11. Cherry						
12. Strawberry						
13. Grape						
14. Pineapple						
16. Orange						
17. Lemon						
18. Raspberry	50	(#1) 211 x 400	0 lb 8 oz	0.110	0.002	0.444
19. Apple						
20. Peach						
21. Onion soup						
22. Cream of chicken soup						
23. Chicken soup						
24. Chili-beef soup						

Table 4.2 (Con't.)

Adjunct	Persons served	Can size	weight	Cost		Bulk densities oz./cu.in.
				per can	per 100 calories	
25. Beef soup	50	(300) 300 x 407	0 lb 12 oz	\$0.441	\$0.009	0.481
28. Breakfast cereal	50	N.F. dry milk	(#2-1/2) 401 x 411	0 lb 10 oz	0.004	0.213
			Raisins	1 lb 9 oz	0.007	0.435
			Sugar	1 lb 5 oz	0.002	0.463
29. Kansas Indian pudding	25	(#3) 404 x 414	1 lb 10 oz	0.389	0.016	0.426
30. Applesauce	50	(#10) 603 x 700	3 lb 5 oz	1.485	0.030	0.259
31. Chili sauce	50	(#3) 404 x 414	1 lb 7 oz	0.700	0.014	0.398
32. Oriental sauce	25	(#2-1/2) 401 x 411	0 lb 13 oz	0.570	0.023	0.250
33. Paprika gravy	50	(#3) 404 x 414	1 lb 9 oz	0.740	0.015	0.380
34. Beef-mushroom gravy	50	(#2-1/2) 401 x 411	1 lb 7 oz	0.694	0.014	0.417
35. Curry sauce	50	(#3) 404 x 414	1 lb 9 oz	0.855	0.017	0.389
36. Chicken gravy	50	(#3) 404 x 414	1 lb 7 oz	0.653	0.013	0.398
37. Chicken-vegetable sauce	10	(#2-1/2) 401 x 411	0 lb 7 oz	0.354	0.035	0.130
38. Beef-vegetable sauce	10	(#2-1/2) 401 x 411	0 lb 8 oz	0.453	0.045	0.167
39. Creole sauce	10	(#300) 300 x 407	0 lb 9 oz	0.406	0.041	0.296
40. Chocolate pudding	25	(#2-1/2) 401 x 411	1 lb 5 oz	0.293	0.012	0.444
41. Apple topping	10	(#300) 300 x 407	0 lb 12 oz	0.180	0.018	0.426
43. Cherry	25	(Toppings)	1 lb 10 oz	0.315	0.013	0.444
44. Orange						
45. Grape						
46. Peach						
47. Raspberry						
48. Pineapple	0.012					
49. Strawberry						
50. Lemon						

Table 4.2 (Con't.)

Adjunct	Persons served	Can		weight	per can	Cost per serving	per 100 calories	Bulk densities oz./cu.in.
		size	Can					
51. Vanilla topping	25	(#3) 404 x 414	1 lb 10 oz	0.308	0.012	0.011	0.444	
52. Butterscotch topping	25	(#3) 404 x 414	1 lb 10 oz	0.333	0.013	0.012	0.444	
53. Chocolate icing	50	(Jumbo) 307 x 510	1 lb 1 oz	0.205	0.004	0.011	0.407	
54. Icing other than chocolate	50	(#2-1/2) 401 x 411	1 lb 0 oz	0.183	0.004	0.011	0.306	
55. Nutmeg topping	25	(#3) 404 x 414	1 lb 10 oz	0.320	0.013	0.012	0.444	
56. Chocolate mint pudding	25	(#2-1/2) 401 x 411	1 lb 5 oz	0.294	0.012	0.014	0.444	
57. Imitation maple syrup	50	(#3) 404 x 414	1 lb 12 oz	0.283	0.006	0.010	0.472	
58. Mashed potato salad	50	(#3) 404 x 414	1 lb 12 oz	0.570	0.011	0.020	0.491	

* #5, #15, #26, #27 and #42 are omitted because of their instability.

bottom, a center layer of sugar only, and the citric acid mixed with a small portion of the sugar in the top layer. This layering isolates the carboxy-methyl cellulose from the citric acid and prevents a possible reaction of citric acid with the carboxy-methyl cellulose during storage, which would degrade the cellulose.

In jelly formulas, the pectin should be thoroughly mixed with part of the sugar and all of the other ingredients except, citric acid. The material should be layered in the can to separate the pectin from the citric acid as described above for the spreads, as citric acid if stored in contact with pectin will degrade it.

APPENDIX A

Formulas for Adjuncts

All formulas make 50 servings.

Jellies, Nos. 1-7*

<u>Ingredients</u>	<u>% by weight</u>
Low-methoxyl pectin #3466 (8)**	2.510
Citric acid monohydrate (16)	0.737
Sodium citrate (16)	0.369
Anhydrous dibasic calcium phosphate (16)	0.124
Sugar, granulated (10)	95.867
Flavor (1)	0.364
Color (1)	0.029

Flavor	Color
1. Wild cherry #25862	New dark red
2. Strawberry #28994	Strawberry red
3. Grape #28990	Fast purple
4. Pineapple #28992	FD & C Yellow #5
6. Orange #35286	FD & C Yellow #6
7. Lemon #29227	FD & C Yellow #5

Note: Separate citric acid from pectin in package (see page 43).

Directions for mixing: Add contents of 1 can of dry mix (1 lb. 2 oz.) to 3-1/4 cups of water in a 2-quart container. Bring to a full boil, stirring constantly. Let stand until set (2-3 hours).

Serving: 1 tablespoon, as a spread for 1 wafer.

* #5, #15, #26, #27, and #42 are omitted because of their instability.

** Numbers in parentheses indicate sources listed on page 67.

Jellies (Nos. 8-10)

<u>Ingredients</u>	<u>% by weight</u>
Low-methoxyl pectin #3466 (8)	2.510
Citric acid monohydrate (16)	0.739
Sodium citrate (16)	0.369
Anhydrous dibasic calcium phosphate (16)	0.124
Sugar, granulated (10)	96.037
Flavor (1)	0.192
Color (1)	0.029

Flavor	Color
8. Raspberry #29461	Raspberry red
9. Apple #33025	0.191% Yellow egg shade and 0.001% chocolate brown "N" shade
10. Peach #26185	Yellow egg shade

Note: Separate citric acid from pectin in package (see page 43).

Directions for mixing: Add contents of 1 can of dry mix (1 lb. 2 oz.) to 3-1/4 cups of water in a 2-quart container. Bring to a full boil, stirring constantly. Let stand until set (2-3 hours).

Serving: 1 tablespoon, as a spread for 1 wafer.

Fruit Spreads (Nos. 11-17)

<u>Ingredients</u>	<u>% by weight</u>
Carboxy methyl cellulose 7HOP (15)	1.020
Carboxy methyl cellulose 7MSXP (15)	1.930
Sugar, granulated (10)	94.428
Citric acid (16)	1.500
Flavor (1)	0.300
Color (1)	0.022

Flavor	Color
11. Wild cherry #25862	New dark red
12. Strawberry #28994	Strawberry red
13. Grape #28990	Fast purple
14. Pineapple #28992	FD & C Yellow #5
16. Orange #35286	FD & C Yellow #6
17. Lemon #29227	FD & C Yellow #5

Directions for mixing: Add 1 can of dry mix (8 oz.) to 1 cup of cold water in a 1-pint container. Stir until the sugar dissolves. Let stand 15 minutes before using.

Serving: 1 teaspoon, as a spread for one wafer.

Fruit Spreads (Nos. 18-20)

<u>Ingredients</u>	<u>% by weight</u>
Carboxy methyl cellulose 7HOP (15)	1.8300
Carboxy methyl cellulose 7MSXP (15)	1.9300
Sugar, granulated (10)	94.5785
Citric acid (16)	1.5000
Flavor (1)	0.1400
Color (1)	0.0215

Flavor	Color
18. Raspberry #29461	Raspberry red
19. Apple #33025	0.0204% Yellow egg shade and 0.0011% chocolate brown "N" shade
20. Peach #26185	Yellow egg shade

Directions for mixing: Add 1 can of dry mix (8 oz.) to 1 cup of cold water in a 1-pint container. Stir until the sugar dissolves. Let stand 15 minutes before using.

Serving: 1 teaspoon, as a spread for one wafer.

Onion Soup (No. 21)

<u>Ingredients</u>	<u>% by weight</u>
Beef soup seasoning #2 (2)	56.25
Dehydrated chopped mellow-toasted onion flakes (3)	43.75

Directions for mixing: Add 1 can of dry mix (14 oz.) to 10 quarts plus 3 cups of water in 3-gallon container. Bring to a boil, stirring.

Serving: 7/8 cup, served with 2 wafers.

Note: Wafers may be crumbled and added to mix before heating.

Cream of Chicken Soup (No. 22)

<u>Ingredients</u>	<u>% by weight</u>
Chicken soup seasoning #71985 (2)	43.79
Dehydrated green pepper granules (4)	4.51
Powdered milk (5)	9.03
Poultry seasoning (11)	0.23
Pregelatinized tapioca starch (12)	36.12
Sugar, granulated (10)	6.32

Directions for mixing: Gradually add 11 quarts of water to the contents of 1 can of dry mix (1 lb. 13 oz.) in a 3-gallon container; first make a thick paste and then add the remaining water, stirring constantly. Bring the soup to a boil. Let stand 10 minutes before serving.

Serving: 7/8 cup, served with 2 wafers.

Note: Wafers may be crumbled and added to the mix before heating.

Chicken Soup (No. 23)

<u>Ingredients</u>	<u>% by weight</u>
Chicken soup seasoning #71985 (2)	83.22
Poultry seasoning (11)	0.14
Dehydrated green pepper granules (4)	2.77
Sugar, granulated (10)	13.87

Directions for mixing: Add 1 can of dry mix (1 lb. 5 oz.) to 12 quarts of water in a 4-gallon container. Bring to a boil, stirring.

Serving: 1 cup, served with 2 wafers.

Note: Wafers may be crumbled and added to the mix before heating.

Chili-Beef Soup (No. 24)

<u>Ingredients</u>	<u>% by weight</u>
Beef soup seasoning #2 (2)	66.42
Dehydrated chopped mellow-toasted onion flakes (3)	14.76
Dehydrated green pepper (4)	7.38
Chili powder (13)	8.86
Cumin (9)	2.33
Garlic powder (3)	0.25

Directions for mixing: Add 1 can of dry mix (14 oz.) to 12 quarts of water in a 4-gallon container. Bring to a boil, stirring.

Serving: 1 cup, served with 2 wafers.

Note: Wafers may be crumbled and added to mix before heating.

Beef Soup (No. 25)

<u>Ingredients</u>	<u>% by weight</u>
Beef soup seasoning #2 (2)	81.52
Dehydrated chopped mellow-toasted onion flakes (3)	18.12
Cumin (9)	0.36

Directions for mixing: Add 1 can of dry mix (12 oz.) to 12 quarts of water in a 4-gallon container. Bring to a boil, stirring.

Serving: 1 cup, served with 2 wafers.

Note: Wafers may be crumbled and added to the mix before heating.

Breakfast Cereal (No. 28)

1 serving: 2 wafers
1/2 tablespoon sugar (10)
1-1/2 tablespoons raisins
1 tablespoon non-fat dry milk (5)

The wafers can be prepared as a cereal in three ways:

1. Crumble the wafers and add raisins, powdered milk, sugar, and water. This gives a hard, crunchy type of cereal.
2. Crumble the wafers, add raisins and 1/4 cup cold water. Let stand 45-60 minutes, sprinkle with powdered milk and sugar. This gives a soft, easily chewed, cold cereal.
3. Crumble the wafers, add raisins and 1/4 cup boiling water. Let stand 5 minutes, sprinkle with powdered milk and sugar. This gives a mush-like hot cereal.

Kansas Indian Pudding (No. 29)

<u>Ingredients</u>	<u>% by weight</u>
Salt (17)	0.33
Cinnamon (11)	0.33
Ginger (11)	0.07
Cloves (11)	0.03
Sugar, granulated (10)	16.43
Powdered milk (5)	23.66
Raisins	59.15

Directions for mixing: Add 1-1/2 cups molasses and 2 quarts plus 3-1/2 cups of water to 2 cans of dry mix (1 lb. 10 oz. each) in a 2-gallon container. Mix thoroughly. Heat until mixture thickens (about 10 minutes). Eat either hot or cold.

Serving: 1/4 cup, served as a pudding with 2 crumbled wafers.

Note: Wafers should be added to the mix during preparation.

Applesauce (No. 30)

<u>Ingredients</u>	<u>% by weight</u>
Dried apples	43.05
Cinnamon (11)	0.66
Raisins	39.74
Sugar, granulated (10)	16.55

Directions for mixing: Add contents of 1 can dry mix (3 lb. 5 oz.) to 2 quarts of water in a 1-gallon container. Bring to a boil, stirring. Let stand 3 minutes.

Serving: 1/4 cup, served as a topping for 2 crumbled wafers.

Note: Wafers may be added to the mix before heating.

Chili Sauce (No. 31)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated chopped mellow-toasted onion flakes (3)	13.72
Pregelatinized tapioca starch (12)	46.80
Beef soup seasoning #2 (2)	25.19
Monosodium glutamate (15)	3.65
Cumin (9)	0.37
Oregano (11)	0.37
Chili powder (13)	9.90

Directions for mixing: Gradually add 5 quarts plus 3 cups of hot water to the contents of 1 can dry mix (1 lb. 7 oz.) in a 2-gallon container; first make a thick paste and then add the remaining water, stirring constantly. Let stand 15 minutes before serving.

Serving: 1/2 cup, as a sauce for 3 crumbled wafers.

Oriental Sauce (No. 32)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated leek - 3/8 in. dice (4)	4.34
Dehydrated green pepper - 1/4 in. dice (4)	4.64
Dehydrated mellow-toasted chopped onion flakes (3)	10.85
Chicken soup seasoning #71985 (2)	16.22
Salt (17)	3.46
Monosodium glutamate (15)	2.88
Mushroom powder (2)	5.79
Pregelatinized tapioca starch (12)	37.35
Dehydrated celery stalk - 3/8 in. dice (4)	14.47

Directions for mixing: Gradually add 7 quarts of hot water to the contents of 2 cans dry mix (12.5 oz. each) in a 3-gallon container; first make a thick paste and then add the remaining water, stirring constantly. Let stand 15 minutes before serving.

Serving: 2/3 cup, as a sauce with 3 crumbled wafers.

Paprika Gravy (No. 33)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.79
Dehydrated mellow-toasted chopped onion flakes (3)	11.51
Monosodium glutamate (15)	2.30
Pepper cream (2)	0.69
Chicken soup seasoning #71985 (2)	27.95
Pregelatinized tapioca starch (12)	30.69
Paprika (11)	6.39
Sugar, granulated (10)	7.68

Directions for mixing: Gradually add 5 quarts plus 3 cups of hot water to the contents of 1 can dry mix (1 lb. 9 oz.) in a 2-gallon container; first make a thick paste and then add the remaining water, stirring constantly. Let stand 15 minutes before serving.

Serving: 1/2 cup, as a sauce with 3 crumbled wafers.

Beef Mushroom Gravy (No. 34)

<u>Ingredients</u>	<u>% by weight</u>
Mushroom powder (2)	6.12
Dehydrated mellow-toasted chopped onion flakes (3)	10.21
Salt (17)	2.04
Beef soup seasoning #2 (2)	28.57
Pregelatinized tapioca starch (12)	48.98
Monosodium glutamate (15)	4.08

Directions for mixing: Gradually add 6 quarts plus 1 cup of hot water to the contents of 1 can dry mix (1 lb. 7 oz.) in a 2-gallon container; first make a thick paste and then add the remaining water, stirring constantly. Let stand 15 minutes before serving.

Serving: 1/2 cup, as a sauce for 3 crumbled wafers.

Curry Sauce (No. 35)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated mellow-toasted chopped onion flakes (3)	14.52
Dehydrated green pepper granules (4)	5.63
Powdered milk (5)	9.07
Pregelatinized tapioca starch (12)	41.74
Chicken soup seasoning #71985 (2)	19.97
Curry powder (13)	5.44
Monosodium glutamate (15)	3.63

Directions for mixing: Gradually add 6 quarts of hot water to the contents of 1 can dry mix (1 lb. 9 oz.) in a 2-gallon container; first make a thick paste and then add the remaining water, stirring constantly.

Serving: 1/2 cup, as a sauce for 3 crumbled wafers.

Chicken Gravy (No. 36)

<u>Ingredients</u>	<u>% by weight</u>
Chicken soup seasoning #71985 (2)	30.19
Dehydrated green pepper granules (4)	1.51
Powdered milk (5)	12.08
Poultry seasoning (11)	0.36
Pregelatinized tapioca starch (12)	45.29
Sugar, granulated (10)	6.04
Monosodium glutamate (15)	4.53

Directions for mixing: Gradually add 6 quarts of hot water to the contents of 1 can dry mix (1 lb. 7 oz.) in a 2-gallon container; first make a thick paste and then add the remaining water, stirring constantly.

Serving: 1/2 cup, as a sauce with 3 crumbled wafers.

Chicken Vegetable Sauce (No. 37)

<u>Ingredients</u>	<u>% by weight</u>
Chicken soup seasoning #71985 (2)	32.43
Salt (17)	5.41
Dehydrated mellow-toasted onion flakes (3)	16.22
Dehydrated celery flakes (4)	16.22
Dehydrated leek flakes (4)	10.81
Dehydrated parsley flakes (4)	3.78
Dehydrated spinach flakes (4)	8.10
Poultry seasoning mix*	1.62
Monosodium glutamate (15)	5.41

Directions for mixing: Add 5 cans of dry mix (7 oz. each) to 10 quarts of hot water in a 4-gallon container.

Serving: 7/8 cup, as a topping for 3 crumbled wafers.

Note: A better product results if the wafers are added to the mix and heated.

* Poultry seasoning mix

<u>Ingredients</u>	<u>% by weight</u>
Thyme (2)	11.76
Sage (2)	23.53
Savory (11)	23.53
Salt (17)	11.77
Coriander (2)	5.88
Pepper cream (2)	5.88
Marjoram (2)	5.88
Cumin (2)	11.77

Beef-Vegetable Sauce (No. 38)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated mellow-toasted onion flakes (3)	17.02
Dehydrated green pepper flakes (4)	12.77
Dehydrated parsley flakes (4)	2.13
Dehydrated spinach flakes (4)	6.38
Monosodium glutamate (15)	4.25
Worcestershire sauce seasoning #5254 (2)	10.64
Beef soup seasoning #2 (2)	34.04
Dehydrated celery flakes (4)	12.77

Directions for mixing: Add contents of 5 cans of dry mix (8 oz. each) to 10 quarts of hot water in a 4-gallon container.

Serving: 7/8 cup, as a topping for 3 crumbled wafers.

Note: A better product results if the wafers are added to the mix and heated. Dried beef chunks may also be added.

Creole Sauce (No. 39)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated mellow-toasted onion flakes (3)	13.81
Dehydrated green pepper flakes (4)	7.89
Dehydrated celery flakes (4)	13.81
Dehydrated parsley flakes (4)	1.18
Beef soup seasoning #2 (2)	39.45
Chili pepper (4)	2.76
Oregano (2)	0.79
Cumin (2)	1.18
Cloves (2)	0.20
Thyme (2)	0.39
Pepper cream (2)	0.79
Salt (17)	5.92
Monosodium glutamate (15)	3.94
Worcestershire sauce seasoning #5254 (2)	7.89

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 6 oz. each) to 12 quarts of water in a 4-gallon container. Bring to boil.

Serving: 1 cup, as a sauce with 3 crumbled wafers.

Note: A better product results if the wafers are added to the mix and heated.

Chocolate Pudding (No. 40)

<u>Ingredients</u>	<u>% by weight</u>
Cocoa - Dutch Process - Van Kre #11 (6)	12.880
Salt (17)	1.030
Sugar, granulated (10)	56.437
Powdered milk (5)	19.330
Pregelatinized tapioca starch (12)	10.310
Vanillin (14)	0.013

Directions for serving: Add contents of 2 cans of dry mix (1 lb. 5 oz. each) to 9 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes before serving.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Apple Topping (No. 41)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	11.5400
Pregelatinized tapioca starch (12)	11.5400
Sugar, granulated (10)	68.7233
Nutmeg (11)	0.0650
Salt (17)	0.4700
Cinnamon (11)	0.3150
Dehydrated apple granules (7)	7.3400
Color-yellow egg shade (1)	0.0064
and chocolate brown "N" shade (1)	0.0003

Directions for mixing: Add contents of 5 cans of dry mix (12 oz. each) to 3 quarts plus 2-1/2 cups of cold water in a 2-gallon container. Stir vigorously for 2 minutes. Let stand 30 minutes before serving.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Wild Cherry Topping (No. 43)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.136
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - wild cherry #25862 (1)	0.176
Color - new dark red (1)	0.008

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Orange Topping (No. 44)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.158
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - orange #35286 (1)	0.154
Color - deep orange shade (1)	0.008

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Grape Topping (No. 45)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.123
Salt (17)	0.410
Vanillin (14)	0.010
Color - fast purple shade (1)	0.006
Flavor - grape #28990 (1)	0.191

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Peach Topping (No. 46)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.151
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - peach #26185 (1)	0.154
Color - yellow egg shade (1)	0.015

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Raspberry Topping (No. 47)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.780
Pregelatinized tapioca starch (12)	10.460
Sugar, granulated (10)	76.130
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - raspberry #29461 (1)	0.204
Color - raspberry red (1)	0.006

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Pineapple Topping (No. 48)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.780
Pregelatinized tapioca starch (12)	10.460
Sugar, granulated (10)	76.134
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - pineapple #28992 (1)	0.199
Color - FD & C yellow #5 (1)	0.007

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Strawberry Topping (No. 49)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.182
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - strawberry #28994 (1)	0.133
Color - strawberry red (1)	0.005

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Lemon Topping (No. 50)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.790
Pregelatinized tapioca starch (12)	10.470
Sugar, granulated (10)	76.158
Salt (17)	0.410
Vanillin (14)	0.010
Flavor - lemon #29227 (1)	0.157
Color - FD & C yellow #5 (1)	0.005

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Vanilla Topping (No. 51)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.8300
Pregelatinized tapioca starch (12)	10.5000
Sugar, granulated (10)	75.6135
Salt (17)	0.2100
Vanillin (14)	0.0200
Imitation coumarin #1662-D (14)	0.016
Color - FD & C yellow #5 (1)	0.0005
Anhydrous dextrose (21)	0.8100

Thoroughly mix the imitation coumarin (liquid) with anhydrous dextrose, and then combine with the other ingredients.

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Butterscotch Topping (No. 52)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.730
Pregelatinized tapioca starch (12)	10.420
Sugar, granulated (10)	75.800
Salt (17)	0.410
Caramel color - a caramelized sugar powder (2)	0.231
Flavor - butterscotch "c" #2876-D (14)	0.410

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Chocolate Icing (No. 53)

<u>Ingredients</u>	<u>% by weight</u>
Powdered sugar (10)	81.63
Pregelatinized tapioca starch (12)	3.06
Cocoa (19)	14.29
Salt (17)	1.02

Directions for mixing: Add contents of 1 can of dry mix (1 lb. 2 oz.) to 3/4 cup of cold water in a 1-pint container, and mix vigorously.

Serving: 1 teaspoon, as an icing for 1 wafer.

Icings (No. 54A)

<u>Ingredients</u>	<u>% by weight</u>
Powdered sugar (10)	97.392
Pregelatinized tapioca starch (12)	2.480
Flavor (1)	0.119
Color (1)	0.009

Flavor	Color
Wild cherry #25862	New dark red
Strawberry #28994	Strawberry red
Grape #28990	Fast purple
Pineapple #28992	FD & C yellow #5
Orange #35286	FD & C yellow #6
Lemon #29227	FD & C yellow #5

Directions for mixing: Add contents of 1 can of dry mix (1 lb.) to 1/2 cup of cold water in a 1-pint container, and mix vigorously.

Serving: 1 teaspoon, as an icing for 1 wafer.

Icings (No. 54B)

<u>Ingredients</u>	<u>% by weight</u>
Powdered sugar (10)	97.455
Pregelatinized tapioca starch (12)	2.480
Flavor (1)	0.056
Color (1)	0.009

Flavor	Color
Raspberry #29461	Raspberry red
Peach #26185	Yellow egg shade
Apple #33025	0.0086% Yellow egg shade and 0.0004% chocolate brown "N" shade

Directions for mixing: Add contents of 1 can of dry mix (1 lb.) to 1/2 cup of cold water in a 1-pint container, and mix vigorously.

Serving: 1 teaspoon, as an icing for 1 wafer.

Nutmeg Topping (No. 55)

<u>Ingredients</u>	<u>% by weight</u>
Powdered milk (5)	12.74
Pregelatinized tapioca starch (12)	10.43
Sugar, granulated (10)	75.85
Salt (17)	0.41
Vanillin (14)	0.01
Nutmeg (11)	0.51
Caramel color - caramelized sugar powder (2)	0.05

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 10 oz. each) to 9-1/3 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes before serving.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Chocolate Mint Pudding (No. 56)

<u>Ingredients</u>	<u>% by weight</u>
Cocoa - Dutch Process - Van Kre #11 (6)	12.880
Salt (17)	1.030
Sugar, granulated (10)	56.405
Powdered milk (5)	19.320
Pregelatinized tapioca starch (12)	10.300
Vanillin (14)	0.013
Aromalok peppermint rect. #25999 (1)	0.052

Directions for mixing: Add contents of 2 cans of dry mix (1 lb. 5 oz. each) to 9 cups of cold water in a 1-gallon container. Stir vigorously for 2 minutes. Let stand 5 minutes before serving.

Serving: 1/4 cup, as a topping for 1 crumbled wafer.

Imitation Maple Syrup (No. 57)

<u>Ingredients</u>	<u>% by weight</u>
Carboxy methyl cellulose 7HSXP (15)	0.860
Sugar, granulated (10)	95.085
Salt (17)	0.740
Flavor - conc. ess. imit. maple (14)	0.061
Caramel color - a caramelized sugar powder (2)	0.184
Anhydrous dextrose (21)	3.070

Note: Thoroughly mix the flavor (liquid) with anhydrous dextrose, and then combine with the other ingredients.

Directions for mixing: Add contents of 1 can of dry mix (1 lb. 12 oz.) to 4 cups of cold water in a 2-quart container. Stir vigorously, and let stand 10 minutes before serving.

Serving: 2 tablespoons, as a topping for 1 crumbled wafer.

Mashed Potato Salad (No. 58)

<u>Ingredients</u>	<u>% by weight</u>
Dehydrated instant mashed-potato granules (18)	84.96
Dehydrated finely chopped onion flakes (untoasted) (3)	5.10
Dry mustard (20)	0.51
Salt (17)	5.10
Paprika (11)	0.09
Sugar, granulated (10)	2.55
Curry powder (13)	0.42
Citric acid (16)	0.42
Dehydrated green pepper granules (4)	0.85

Directions for mixing: Add contents of 1 can of dry mix (1 lb. 12.5 oz.) to 2 quarts plus 3-1/2 cups of cold water in a 1-gallon container. Stir until a good mashed potato consistency is reached.

Serving: 1/4 cup with one wafer.

Sources of Products Used

1. Fritzsche Brothers, Inc.
2. Wm. J. Stange Company
3. Basic Vegetable Products, Inc.
4. California Vegetable Concentrates, Inc.
5. Sana Dairies
6. Bakers Chocolate Div. of Gen. Foods Corp.
7. Vacu-Dry Corporation
8. Sunkist Growers, Inc.
9. Spice Islands Company
10. C. & H. Sugar Refining Corporation
11. Schilling Brand, McCormick & Company, Inc.
12. Morningstar Paisley (Morningstar tapioca pregelatinized
starch - Redisol #4)
13. Durkee Famous Foods
14. George Lueders & Company
15. Hercules Powder Company
16. Van Waters & Rogers, B K H Division
17. Leslie Salt Company
18. R. T. French Company
19. Hershey Chocolate Corporation
20. Colman's Mustard
21. Corn Products Corporation

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