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BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

A report of research conducted July 1963 - June 1964.

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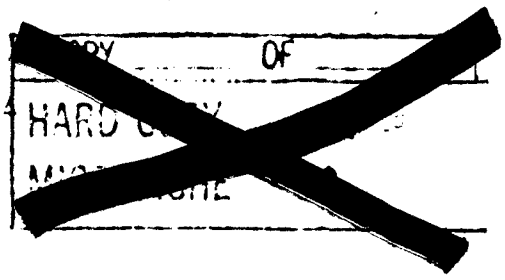

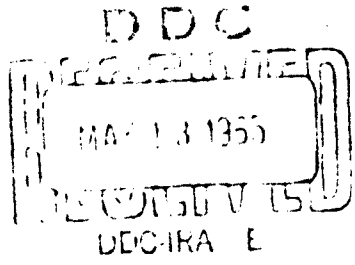

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BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

A report of research conducted July 1963 - June 1964

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Albany, California

BULGUR WAFERS AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

ABSTRACT

Long-term (five-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. Taste panel results after 16 months of storage indicate that the shelf-life of bulgur wafers may be increased by nitrogen-gas packing and by use of malt sirup rather than corn sirup in the formulation. Chemical-physical analyses are being made on duplicate samples of wafers in a search for a test that correlates with organoleptic evaluation. Trends are not yet well enough developed to permit meaningful correlation. Identity of components of the vapors from rancidifying bulgur and from a model compound, methyl linoleate (linoleic acid comprises more than half of the fatty acids in wheat), is being sought by means of a new technique which combines gas-liquid chromatography and rapid-scan mass spectrometry. Wheat products prepared by hot-air puff-drying and by gun puffing have been evaluated as wafer ingredients potentially cheaper than regular puffed bulgur. Material obtained by hot-air puff-drying shows some promise as a suitable alternate wheat ingredient for wafers. Several new adjuncts have been proposed, including a pectin jelly prepared with cold water to replace the originally developed jellies requiring hot water for preparation. A micropenetrometer was fabricated to evaluate consistency of margarine-type fat spreads.

Acknowledgments

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The authors also acknowledge with thanks the assistance of John Blum of Durkee Famous Foods in the studies on the margarine-type spread.

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SUMMARY

Previous development work on the bulgur wheat wafer (the basic fallout shelter ration) and adjuncts (foods to be served with the wafer) has been reported in "Food Supply for Fallout Shelters," CDM-SR-60-62, Nov. 1960 and in two succeeding annual reports, "Bulgur Wafer and Adjuncts for Fallout Shelter Rations" for fiscal years 1962 and 1963. The work reported herein represents continuation of work covered in those reports, as well as research in new areas.

Long shelf-life (stability), low cost, and palatability are of prime importance for a shelter ration; as a consequence, much of the work during F.Y. 1964 has been in these areas. The evaluation of storage stability continues under a five-year contract. Bulgur wafers prepared in different ways (two types of wheat, two cooking processes, two kinds of binder ingredient, and two package atmospheres) are stored at three temperatures: 40°, 70°, and 100° F. for purposes of these evaluations. After 16 months of storage, taste panel results indicate a substantial protective effect from nitrogen packing. Consequently, it has been recommended that the cost of nitrogen packing the bulgur wafers be estimated. Nitrogen packing appears to offer a cost advantage, because of the increased shelf-life it provides. Taste panel results also indicate an improved stability for wafers made with the malt sirup binder, in place of the corn sirup. A preferred use of malt sirup may thus be justifiable. Analytical information on changes in certain chemical-physical properties of the same storage samples continues to be accumulated for future correlation with taste panel results. Changes to date have not been sufficient to justify attempts to find meaningful correlations.

The products of and to a degree the mechanisms of rancidification of fats in the wafers have been further elucidated, principally through the use of gas-liquid chromatography in combination with rapid scan-mass spectrometry (GLC-MS). In many cases similar results are obtained using either bulgur or the model system, methyl linoleate. In the combination technique, GLC-MS, the gas-liquid chromatograms show 59 peaks, each peak representing a different compound resulting from the oxidative breakdown. Of these, 39 peaks are probably large enough to allow identification by mass spectrometry. When more facts are known, an increase in concentration of one or more of these compounds may be found superior to hexanal, suggested previously, as an index to a degree of rancidification of a bulgur product.

The saturated hydrocarbons in the normal series, methane through pentane, have been positively identified in the autoxidation products from bulgur, as well as methyl linoleate. Pentane appears in detectable amounts in the headspace above methyl linoleate in air and at room temperature conditions in 24 hours--long before hexanal or other carbonyl reach detectable levels. Under similar conditions a week or more is required for the easily detectable appearance of hexanal.

Storage of samples under an oxygen atmosphere at somewhat elevated temperatures offers the prospect of a means for an accelerated storage test of wafers or wafer ingredients.

In studies on alterations in the processing of the cereal ingredient for wafers, work was continued on two methods. In one the drying step for bulgur processing is combined with hot-air puffing. Maximum degree of expansion obtainable was 1.4, somewhat below the minimum currently required in wafer procurement specifications. However, evaluation by the Brabender Hardness Tester showed that the hardness continues to decrease with increased hot-air treatment beyond the point where maximum expansion was achieved. The lowest hardness values obtainable in this way were not very much higher than those obtained for some lots of ordinary puffed bulgur. The method thus offers definite possibilities on an alternative way to produce the principal wafer ingredient.

Gun-puffing of partially debranned wheat was investigated as the second alternative method for processing the cereal ingredient. The process variables, moisture content and firing pressure, were investigated for their influence on puff index, texture as measured in a Brabender Hardness Tester, color as measured on the Gardner-Hunter Color difference meter, and extent of cooking as estimated by solubilized starch. Optimum moisture content of wheat for gun puffing lies between 16 and 19%. Puff index appears to be controlled principally by firing pressure. The products obtained are, however, of lesser interest than the puff-dried wheat as an alternate wheat ingredient for wafers.

Twelve selected adjuncts have been placed in a 5-year storage test to study the influence on storage stability, of in-package-desiccant (on seven of the adjuncts with moisture levels over 2%), nitrogen atmosphere, and temperature. Initial taste panel scores and moisture contents are reported.

Several new adjuncts were developed and screened for acceptability. These include dehydrated fruit sauces and butters and cold-water pectin jellies which can replace the hot-water jellies previously developed. For these latter products, use is made of a drum-dried

sugar-high methoxyl pectin mix which disperses easily in cold water. The setting of the jelly comes about through an increase in acidity caused by a slow reaction between water and delta-glucono-lactone. As produced, the drum-dried sugar-pectin mix contains amorphous sugar which makes for a hygroscopic product. The sugar in the mixture may, however, be converted to a crystalline form under proper conditions to provide a non-hygroscopic ingredient. The crystalline product has another asset--it is higher in bulk density.

Improvements have been made in decreasing waxiness while maintaining spreadability in a margarine-type fat spread. A micropenetrometer was built to measure product consistency. It should be useful in guiding further development by providing a means of showing changes in crystal structure of the fat.

Formulas for several revised and new adjuncts are provided.

BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

SECTION 1

STORAGE STABILITY OF BULGUR WAFERS

Storage stability is one of the dominant factors 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 consequence 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.

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:

Red Wheat:		White Wheat
1	Pressure cooked, malt binder, nitrogen pack (REFERENCE).	9
2	Pressure cooked, malt binder, air pack.	10
3	Pressure cooked, corn sirup binder, nitrogen pack.	11
4	Pressure cooked, corn sirup 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 sirup binder, nitrogen pack.	15
8	Cooked in atmosphere, corn sirup binder, air pack.	16

Taste-panel evaluation

One red wheat and one white wheat formulation, arbitrarily chosen, serve as reference samples and also serve as controls held at -18° F. The flavor of control samples is scored at each sampling period by means of a 9-point hedonic scale ranging from a value of 1 for the lowest to a value of 9 for the highest rating. Results of these judgements through 16 months are shown in Table 1.1. At any given sampling time, no significant difference was found between red wheat and white wheat wafers. No statement is possible for the zero-time samples because they were not judged at the same tasting session. The variation in flavor scores as the test progresses appears to be only a variation in taste panel performance.

Throughout the 5-year study, the reference formulations (#1 and #9) stored at 40° F., 70° F., and 100° F. are compared with their appropriate controls (-18° F. storage) by means of a reference-preference test, and each of the other formulations is compared with its appropriate reference sample by means of the reference-preference test. Results of samplings made at 10 and 16 months are presented in Tables 1.2 and 1.3.

The protective effect on flavor stability of packaging wafers in a nitrogen atmosphere is striking. Our recommendation that an estimate be made of the cost of such packaging was based upon this evidence. Nitrogen packing could result in important cost savings. A rough estimate follows: If wafers cost 20 cents per pound packed in an air atmosphere and have a shelf-life expectancy of 5 years, then each year of shelf-life costs 4 cents per pound. If nitrogen packing extends the shelf-life one year and can be

Table 1.1

Flavor scores (9-point Hedonic[a/]) of bulgur wheat wafers (Formulations #1 and #9) stored at -18° F.

	Storage time (months)			
	0[b/]	4	10	16
Red wheat	6.40	6.03	5.68	6.53
White wheat	5.72	6.41	5.82	6.42

a/ A score of 1 is lowest, 9 highest.

b/ At "0" time, red wheat and white wheat samples were judged by different panels and, therefore, cannot be compared.

Table 1.2

Flavor scores of bulgur wafers after 10 months storage at 40, 70 and 100° F.

(Reference-preference test, mean scores)

Cooking	Packaging	Red wheat						White wheat					
		Storage temperature						Storage temperature					
		40° F.		70° F.		100° F.		40° F.		70° F.		100° F.	
		Malt[a]	Corn[a]	Malt	Corn	Malt	Corn	Malt	Corn	Malt	Corn	Malt	Corn
Pressure	In Nitrogen[b]	5.42		5.27		5.12		5.22		5.21		4.89	
Pressure	In Nitrogen	5.25	5.46	5.50	5.07	5.27	5.37	5.25	4.73	5.37	5.01	5.04	5.15
Pressure	In Air	5.25	5.35	5.27	4.98	4.54	3.43	5.00	4.83	5.02	4.55	4.23	3.55
Atmospheric	In Nitrogen	5.55	5.90	5.71	5.14	5.64	5.52	5.34	5.36	5.32	5.17	5.51	5.35
Atmospheric	In Air	5.60	5.11	5.48	5.04	5.25	3.50	5.65	5.06	5.36	4.74	4.51	3.70

a/ Wafer formulated with malt sirup or corn sirup.

b/ Reference samples.

Table 1.3

Flavor scores of bulgur wafers after 16 months storage at 40, 70 and 100° F.

(Reference-preference test, mean scores)

Cooking	Packaging	Red wheat						White wheat					
		Storage temperature						Storage temperature					
		40° F.		70° F.		100° F.		40° F.		70° F.		100° F.	
		Malt[a]	Corn[a]	Malt	Corn	Malt	Corn	Malt	Corn	Malt	Corn	Malt	Corn
Pressure	In Nitrogen[b]	5.28		5.20		5.23		5.59		5.31		5.35	
Pressure	In Nitrogen	5.52	5.12	5.67	5.29	5.55	5.31	5.33	5.26	5.21	4.67	5.45	4.74
	In Air	5.52	5.14	5.40	4.95	4.38	3.67	5.33	4.81	5.26	4.55	4.21	3.67
Atmospheric	In Nitrogen	5.81	5.33	5.33	5.86	5.71	5.43	5.28	5.36	5.31	5.43	5.33	5.17
	In Air	5.64	5.74	5.21	5.10	4.45	3.98	5.33	5.12	5.05	4.86	4.26	3.98

[a] Wafer formulated with malt sirup or corn sirup.

[b] Reference samples.

accomplished for less than 4 cents per pound, there is a cost advantage. If shelf-life were extended 2 years, any cost less than 8 cents per pound would be advantageous. The extension of shelf-life cannot be estimated at this time, but it appears to be substantial, hence nitrogen packaging would have to be quite expensive in order not to show a cost advantage.

Wafers made with corn sirup deteriorate in flavor faster than do those made with malt sirup. The increased stability of the wafers containing malt sirup is difficult to understand, since the shortening used contains substantial quantities of anti-oxidants. Perhaps malt sirup contains a very effective anti-oxidant, or the flavor of the malt may mask the rancid flavors. The cost advantage of using corn sirup over malt sirup is about one-third cent per pound of wafers. The improved stability of wafers containing malt sirup might well be sufficient to warrant this small additional cost.

Chemical-physical determinations

At each sampling period each lot of wafers is analyzed to determine percent fat, peroxide number, thiobarbituric acid number, carbonyls (alkanals, alk-2-enals, alk-2,4 dienals), and diene value. Gas chromatograms (aromagrams) are also prepared.

Chemical-physical analyses through 10 months of storage show changes to be occurring in many of the factors being studied. These are influenced to varying degrees by the several variables of interest, such as temperature, package atmosphere, and corn versus malt sirup. The analytical information is being steadily accumulated, and when a sufficient period has elapsed, correlations between the several chemical-physical values and taste panel results will be possible. It is on the basis of these correlations that the value of each analysis for predicting storage stability can be determined.

Development of New Evaluation Methods

The component in bulgur shelter wafers most likely to limit their shelf-life is the naturally occurring oil in the wheat. For this reason the autoxidation of puffed bulgur is being studied intensively, with emphasis on identity of compounds responsible for rancid or stale odors and flavor and on rate of appearance of the compounds. A model system, methyl linoleate is being used because about half of the oil in wheat is linoleic acid. The ultimate objective is to develop improved methods for surveillance of shelter food stocks.

Components of bulgur vapors

Gas-liquid chromatography (GLC) has been used to provide important information on the tentative identity of volatile compounds recovered from autoxidizing bulgur (Bulgur Wafers and Adjuncts for Fallout Shelters, July 1962 to July 1963). Use of the method continues, with the addition of supplementary and more nearly positive methods for identification.

Identification of carbonyls

Hexanal and pentanal, the two principal carbonyls recovered from the vapor from rancidifying white wheat bulgur, were positively identified by essentially the same chromatographic procedures used for the identification of these compounds in our model system, methyl linoleate (Bulgur Wafer and Adjuncts For Fallout Shelter Rations, July 1962 to July 1963, p. 11). Last year, we obtained carbonyl samples by steam distillation of rancid bulgur (Bulgur Wafer and Adjuncts For Fallout Shelter Rations, July 1962 to July 1963, p. 11); now the procedure has been modified to eliminate any effect that heat may have on the carbonyl compounds formed during rancidification. In our present work, bulgur was swept continuously for two months with purified air, and the exit gases were passed through traps containing 2,4-dinitrophenylhydrazine, which causes the carbonyls to precipitate as 2,4-dinitrophenylhydrazones (2,4-DNPH's).

Other carbonyls in bulgur vapors cannot be identified conveniently by classical analytical techniques because they occur in very low concentrations, and excessive time is required to prepare and separate them. Capillary-column gas chromatography combined with a rapid-scan mass spectrometer provides a much better technique. Only a minute sample (1 to 2 microliters) is required, and the samples can be fractionated on a GLC capillary column better than by other physical separation procedures. From the capillary column, each peak is fed directly into the rapid-scan mass spectrometer, which gives a mass spectrum for every peak. The mass spectrum and retention time on the capillary column are often sufficient for the positive identification of a compound. We have started preliminary work to develop this technique (capillary column -- rapid-scan mass spectrometry) for analyzing the condensate from autoxidizing bulgur using the trapped condensate from our model compound, methyl linoleate (Bulgur Wafer and Adjuncts for Fallout Shelter Rations, July 1962 to July 1963, p. 13). A 200-ft by 0.01-in. stainless-steel capillary column coated with General Electric SF-96-50 (1% carbowax) and temperature-programmed from 65° to 200° C. at a rate of 5°/min., separated the condensate from methyl linoleate into 59 peaks. This column

was coupled with the mass spectrometer and preliminary work was begun to interpret the mass spectra obtained. Because the condensate from autoxidizing bulgur has a composition similar to our model compound, methyl linoleate, the same column will be employed to analyze the former material.

Identification of hydrocarbons

Pentane, butane, propane, ethane and methane have been tentatively identified by GLC in the headspace gas of ground puffed white-wheat bulgur stored in oxygen. Peaks corresponding to these compounds were not observed in aromagrams (Bulgur Wafer and Adjuncts For Fallout Shelter Rations, July 1962 to June 1963, p. 9) made periodically over a five-month period from this canned material, which was being used in connection with an oxygen storage test. It appears that the low-molecular-weight saturated hydrocarbons were boiled off during the heating step used in our aromagram technique. Hence we decided to attempt to obtain headspace gases by direct sampling of the cans for analysis by GLC. Samples of headspace gas were successfully obtained by use of a device that punctures the can and simultaneously seals it with a silicone rubber septum. Using a gas-tight syringe, we withdrew vapor samples (1 to 3 ml) through the silicone rubber septum and injected the vapor into a gas chromatograph equipped with a dual hydrogen flame detector and a 7-ft column containing Apiezon M on firebrick.

Sharp new peaks possessing much lower retention times than any authentic aldehydes, ketones, or alcohols appeared. These oxygenated compounds produce wide peaks accompanied by some tailing. The sharpness of the new unidentified peaks suggested that they were saturated hydrocarbons. Confirmation of the saturated nature of these compounds was obtained by shaking 10 ml of headspace vapors from the canned samples with 1 ml of concentrated sulfuric acid, which should absorb any olefins or oxygen-containing compounds. Only three peaks appeared in the chromatograms after the sulfuric acid treatment. Two of the three were tentatively identified as butane and pentane by retention times. The Apiezon column, which had been chosen for its ability to separate carbonyls, failed to separate authentic methane, ethane, and propane.

In order to determine whether the third peak consisted of methane, ethane, and propane, headspace vapors were further analyzed on a molecular-sieve column. Five peaks possessing retention times corresponding to methane, ethane, propane, butane, and pentane were present in the resulting chromatograms. Pentane was the major component, representing over 90% of the hydrocarbon fraction.

It is interesting to note that these same five hydrocarbons can be identified from our model compound, methyl linoleate, after autoxidation has proceeded for only one day. If the early occurrence of these hydrocarbons can be related to incipient organoleptic manifestations of lipid breakdown, a rapid and perhaps very sensitive, objective appraisal method can be developed for evaluating stored food products (see following paragraphs).

A model system -- methyl linoleate

Wheat oil is composed of a number of lipids containing several fatty acids. Of these, as mentioned above, linoleic acid represents more than half, so that methyl linoleate is a logical choice as a model system. Results obtained with methyl linoleate are more easily interpretable than those from bulgur because of the simplicity of the model system. In every case tested, findings have been parallel between bulgur and methyl linoleate. This provides confidence for continued use of the model system.

Identification of carbonyls

Work is in progress on the rigorous identification of the minor carbonyls and other constituents in the vapors of autoxidizing methyl linoleate by a combination gas chromatograph-mass spectrometer technique (this report, Identification of carbonyls in bulgur).

Condensate from the model system was collected by passing oxygen at the rate of 10 ml/min through methyl linoleate on purified glass wool and trapping the exit gases in a U-tube at -78° C. Condensate was then extracted with 2,2,4-trimethyl pentane and analyzed on a 200-ft x 0.01-inch capillary column coated with General Electric Silicone Oil SF-96(50). The chromatograms from this extract showed 39 peaks.

Two experimental runs were performed using this technique, and preliminary work has begun to interpret the mass spectra obtained. The identification and olfactory evaluation of compounds detected might enable us to determine which ones are responsible for the off-flavor in rancidifying bulgur products. Furthermore, the increase in concentration of some of these compounds might be superior to hexanal as an index of degree of rancidification of a bulgur product.

Identification of hydrocarbons

Pentane, butane, propane, ethane, and methane were also identified in the vapors of rancidifying methyl linoleate by their GLC retention times.

To obtain vapor samples, one-gram samples of methyl linoleate (97%) were placed on purified glass wool in 50 ml Erlenmeyer flasks, the flasks were capped with aluminum foil, and the samples exposed to laboratory light. By means of a gas-tight syringe, vapor samples were withdrawn through the foil; they were then analysed on an Apiezon M column and on a Linde type 5A molecular-sieve column.

The five hydrocarbons began to appear after the ester had been exposed to air less than 24 hours, long before hexanal, pentanal or higher molecular weight carbonyls were observed. This oxygenated type of compound has been regarded as the principal source of rancid flavors and odors, but the preceding appearance of saturated hydrocarbons may provide an early clue that fatty materials have begun to change and will soon become rancid.

Acceleration of rancidity

An accelerated storage test to be used on bulgur-containing products, one that is based upon the increase of hexanal in samples stored in oxygen at elevated temperature, was investigated. Samples of ground puffed white-wheat bulgur, ground bulgur mixed with corn syrup, ground puffed bulgur mixed with malt syrup, and wafer mix without antioxidants in the shortening were canned with an oxygen atmosphere and stored at room temperature, at 90° F., and at 100° F. Controls consisted of each material stored in air at room temperature. The samples were analyzed periodically using the Aromagram technique (Bulgur Wafer and Adjuncts For Fallout Shelter Rations, July 1962 to June 1963, p. 8). The increase in the areas of the hexanal peaks is used as an index of degree of rancidification. The results of GLC analysis for hexanal covering periods up to eight months are summarized in Table 1.4.

By examining Table 1.4, one can see that vapors over plain bulgur or bulgur mixed with corn or malt sirup and stored under oxygen at either 90° F. or 100° F. reach a maximum hexanal concentration between the fifth and sixth month. Increases in the hexanal peak in the aromagrams up to the fifth month tend to reflect the expected stabilities, that is, increases with storage temperature, increases with storage time, and decreases with samples in the following order: ground puffed bulgur, ground puffed bulgur with corn sirup, ground puffed bulgur with malt sirup, and wafer mix without antioxidants. Relationships to storage temperature are reversed for the two higher temperatures, however. Samples stored at 90° F. had higher values than samples stored at 100° F., almost without exception. Similarly, ground puffed bulgur stored at

Hexanal peak areas for samples under accelerated storage
(Peak area in cm^2 of n-hexanal in gas chromatograms[1/])

	Days Stored Prior to Sampling							
	30	60	90	120	150	180	210	240
Ground puffed white wheat bulgur								
Stored under air at 100° F.	50	50	27	26	40	80	120	210
Stored under oxygen at 72° F.	15	60	120	185	250	305	350	385
Stored under oxygen at 90° F.	45	50	175	75	210	395	315	205
Stored under oxygen at 100° F.	85	425	205	75	125	225	180	115
Ground puffed white wheat bulgur mixed with corn sirup (10%)								
Stored under air at 72° F.	3	10	7	20	70	115	145	
Stored under oxygen at 72° F.	35	25	15	60	240	330	375	
Stored under oxygen at 90° F.	10	30	60	210	395	360	310	
Stored under oxygen at 100° F.	45	80	70	125	255	225	170	
Ground puffed white wheat bulgur mixed with malt sirup (10%)								
Stored under air at 72° F.	2	2	5	10	25	45	70	
Stored under oxygen at 72° F.	5	10	5	35	135	225	290	
Stored under oxygen at 90° F.	2	40	60	155	490	470	425	
Stored under oxygen at 100° F.	25	70	60	105	320	300	255	
Ground puffed white bulgur with wafer mix								
Stored under air at 72° F.	2	2	2	2	2	5	10	
Stored under oxygen at 72° F.	2	2	2	2	2	11	30	
Stored under oxygen at 90° F.	2	2	5	30	70	110	135	
Stored under oxygen at 100° F.	2	2	5	45	90	115	115	

1/ Peak areas for zero storage times were less than 1 cm^2 for all samples.

72° F. had higher values for most storage times than were found in the samples stored at 90° and 100° F. No explanation can be offered for these irregularities. The greater stability of the ground puffed bulgur, in the form of the complete wafer mix, confirms results obtained previously and consistently by organoleptic evaluation methods.

SECTION 2

ALTERATIONS IN CEREAL INGREDIENT PROCESSING

Efforts have been continued to develop puffed forms of bulgur that will have improved properties for use in wafers or that will be lower in cost. Principal emphasis was devoted to the latter factor because of the dominance of the wheat ingredient in the cost of total wafer ingredients. The wheat ingredient comprises approximately 80% of the wafer. Hence, some sacrifice of texture or other properties might be considered justifiable, if costs of production could be lowered sufficiently. Although variations in preparation of the grain materials to be puffed were included in the experimental work reported, these were made with specific reference to two alternative methods of puffing. The results are therefore reported under headings reflecting the puffing techniques.

Hot-Air Puff-Drying

Initial attempts to modify the currently used method of producing the wheat ingredient for wafers (making dry bulgur and then hot-air puffing) by reducing the moisture content and/or steaming time normally used in the cooking steps for bulgur production and by combining drying and hot-air puffing into one operation were reported previously (see report "Bulgur wafers and adjuncts for fallout shelter rations" 1963). The combined drying and puffing step is referred to as puff-drying.

We have now found that an expanded product with a fully cooked flavor can be obtained by atmospheric steaming for 10 min at 25% moisture or 15 min at 20% moisture, followed by a 30 sec puff-drying treatment in hot-air at about 500° F. Maximum expansion obtained under these or more severe treatment conditions, however, is only 1.4, somewhat below the minimum currently required in wafer procurement specifications.

The complete series of samples prepared in this study has now been evaluated in the Brabender Hardness Tester for textural differences and for their possible suitability for wafer production. Tests were made at room temperature on 100 g samples having 2.5 $\pm$ 0.2% moisture. Results show that no textural advantage is gained from an increase in grain moisture content or from a steaming time beyond that required for adequate cooking. Increasing the time of the hot-air puffing treatment beyond the point of maximum expansion, however, improves texture significantly, as is demonstrated in Figures 2.1 and 2.2. Final hardness values throughout the series were near 450 m-gm, as measured on the hardness tester. This compares favorably to the 400 to 450 m-gm obtained on several lots

Figure 2.1
Effect of temperature and treatment time on
texture of wheat puff-dried in hot air

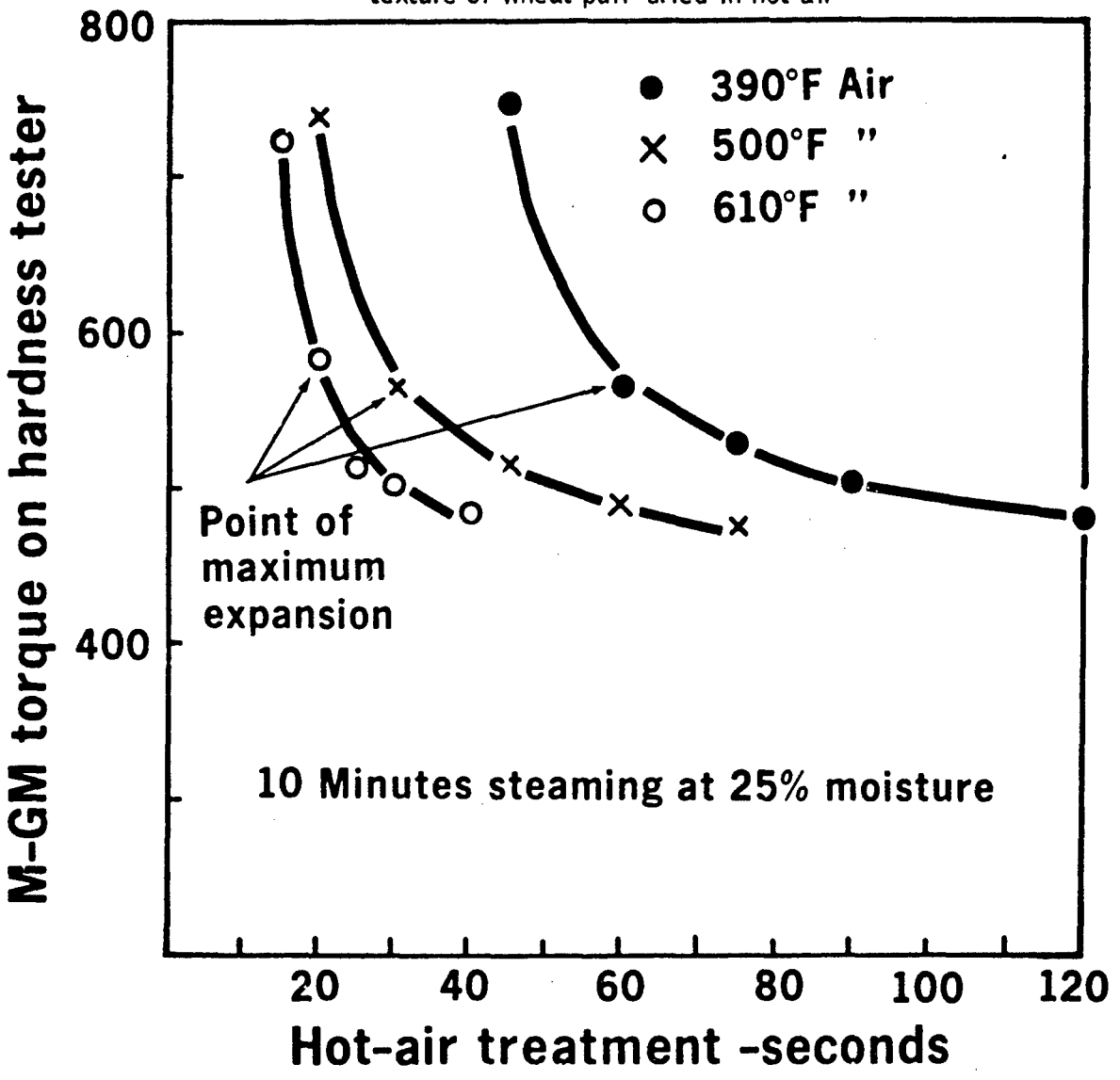
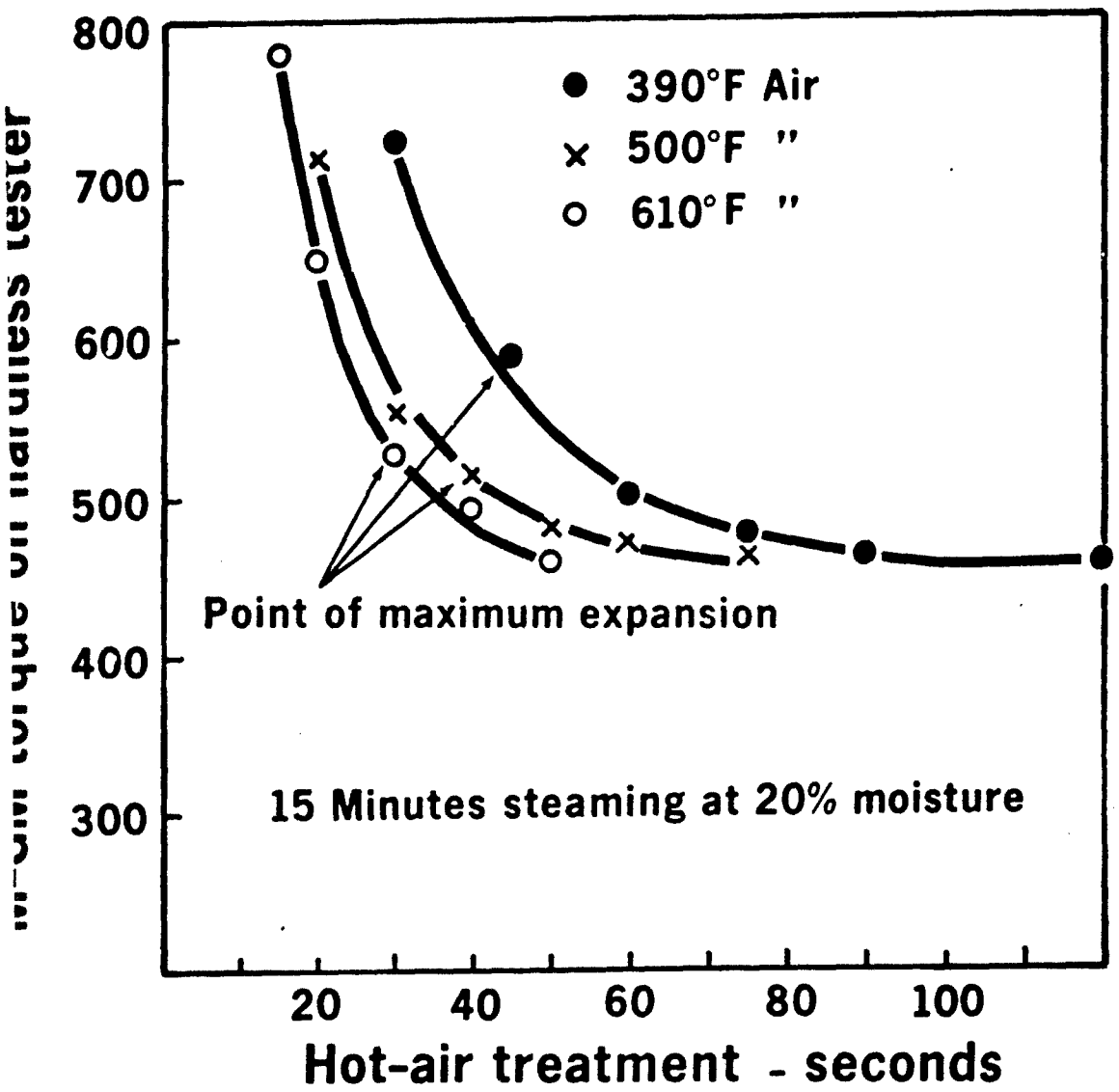


Figure 2.2
Effect of temperature and treatment time on
texture of wheat puff-dried in hot air



of regular puffed bulgur and is not too much above the optimum textural value of 360 m-gm obtained on a single sample of puffed white wheat bulgur obtained from the Van Brode Company. Textural measurements on the hardness tester seem clearly to be much more sensitive than puff index for indicating suitability of puffed materials as a wafer ingredient.

The air temperature used in the puff-drying treatment appears to have no significant effect on final texture. Low temperatures (390° F.) give optimum control of toasting and textural changes, but the longer treatment times also required might be impractical from the standpoint of equipment requirements or production rates. At high temperatures (610° F.) degree of toasting is difficult to control. Optimum temperature for best overall control of product quality is probably in the range of 390°-500° F.

A modification of this alternative possibility for preparing the wheat ingredient involves a prolonged soaking of raw wheat prior to the puff-drying. Wheat soaked for 48 to 72 hours in water at ambient temperature and drained was subjected to hot-air puff-drying, and a product with apparently good texture for wafers was obtained. This experimentation is very preliminary in nature, but the results are promising enough to indicate that additional trials should be continued into the next report period.

Gun Puffing

A second promising alternate approach to preparing the wheat ingredient for the wafer is explosive puffing using a puffing gun similar to those used in the breakfast cereal industry (see report "Bulgur wafer and adjuncts for fallout shelter rations" 1963). A study of the effect of grain moisture and firing pressure on the expanded grain was carried out.

A single well blended lot of partially debranned hard red winter wheat was used. Portions were adjusted to 10, 13, 16, 19, 22, 25 and 28% moisture. Samples at each moisture level were fired from the gun at pressures of 100, 120, 135, 150, 165, and 180 psig. The 28% moisture level proved to be too high. It gave very erratic and non-reproducible results and was eliminated from consideration in evaluations or results. Samples of the puffed materials were evaluated for (a) puff index (bulk density); (b) texture, as measured on the Brabender Hardness tester; (c) color or amount of toasting, as measured on the Gardner-Hunter Color difference meter; and (d) for extent of cooking by an estimate of starch solubilized by the treatment.

Puff index appears to be controlled principally by the firing pressure over the ranges studied. Puff indices ranged from 1.4 to

6.0. A moisture effect is present, however, with maximum expansion being obtained in the range of 16 to 19% (Figure 2.3) for all firing pressures investigated.

Darkness and redness of ground puffed samples increased with firing pressure, according to comparisons made with the color difference meter. When puffed whole kernel samples were compared, no appreciable darkening effect was apparent, but a marked decrease in redness accompanied increased firing pressures. The greater expansion and resultant exposure of the lighter colored endosperm apparently offsets the toasting more readily observed with the ground samples. Contrary to preliminary indications, no relationship between moisture content and color development became evident.

Textural values were, as expected, a function of degree of expansion. Values for the gun puffed wheat samples are slightly lower (i.e., tenderer texture) than for hot-air puffed bulgur samples of similar puff index. A rather unexpected moisture relationship appeared, in that textural measurements fell into two distinct curves, one for the 10 to 16% samples and one for the 19 to 25% samples. The curves converge as expansion increases and finally merge at puff index of about 5 (Figure 2.4). The lower moisture samples have tenderer textures than those prepared from high moisture wheat. Soluble starch measurements show a similar relationship to moisture for expansions in the lower ranges, with essentially no difference in starch gelation or granule rupture occurring over the range of 10 to 16% moisture. Above 16% moisture starch solubilization or "cooking" is increased, at comparable puff index, as moisture content of the grain increases (Figure 2.5). This substantiates organoleptic observations on both gun puffed and hot-air puff-dried samples which indicate that wheat processed at low moisture retains a raw starch flavor. These observations also correlate with the finding that optimum moisture for gun puffing of wheat lies between 16 and 19%.

Both of the methods investigated as less expensive alternatives for preparing the wheat ingredient for wafers appear promising. Samples of materials prepared by both techniques will next be evaluated in the preparation of wafers.

Figure 2.3
Effect of moisture content and firing pressure
on expansion of gun-puffed wheat

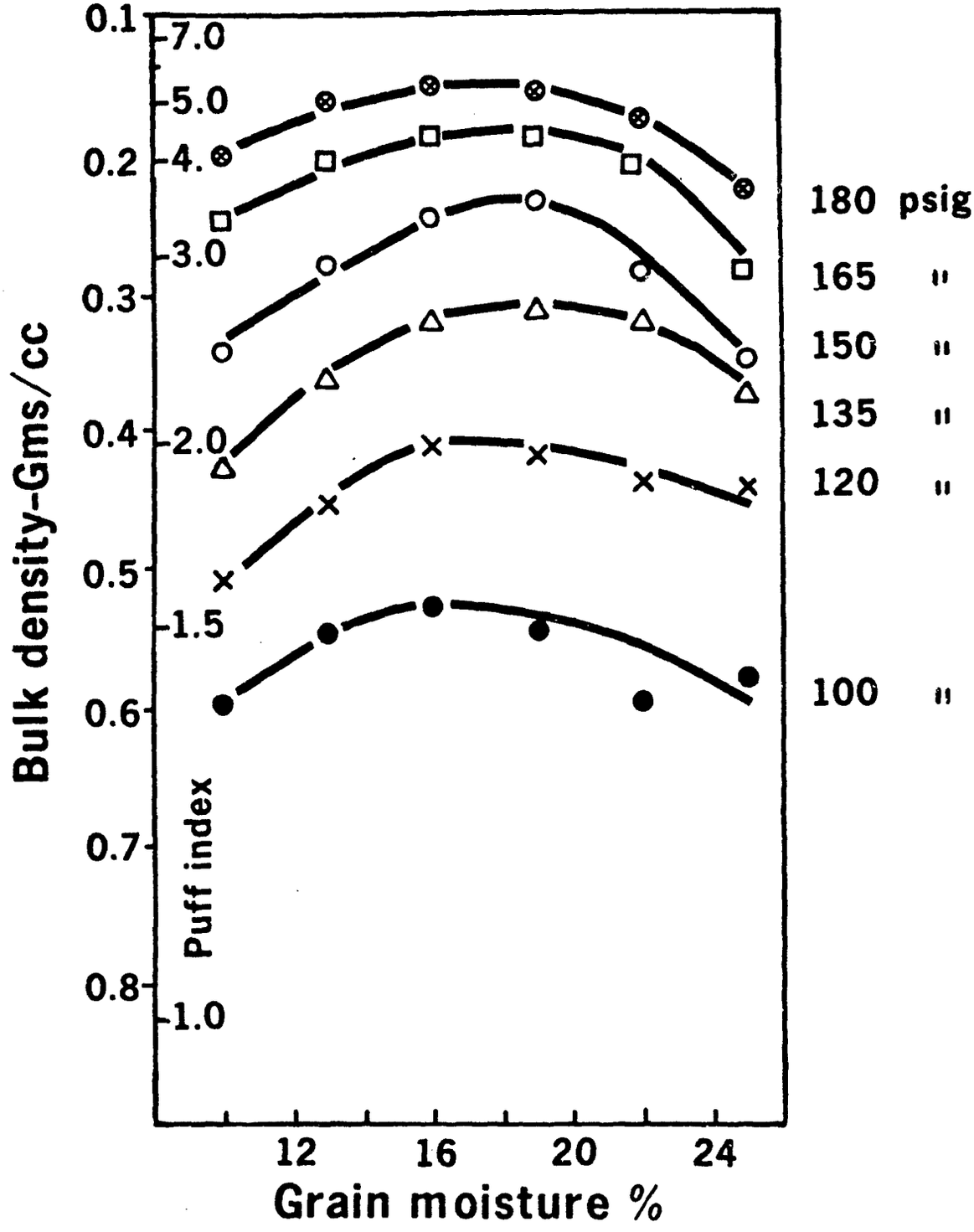


Figure 2.4
Relationship between hardness and expansion
as influenced by moisture content

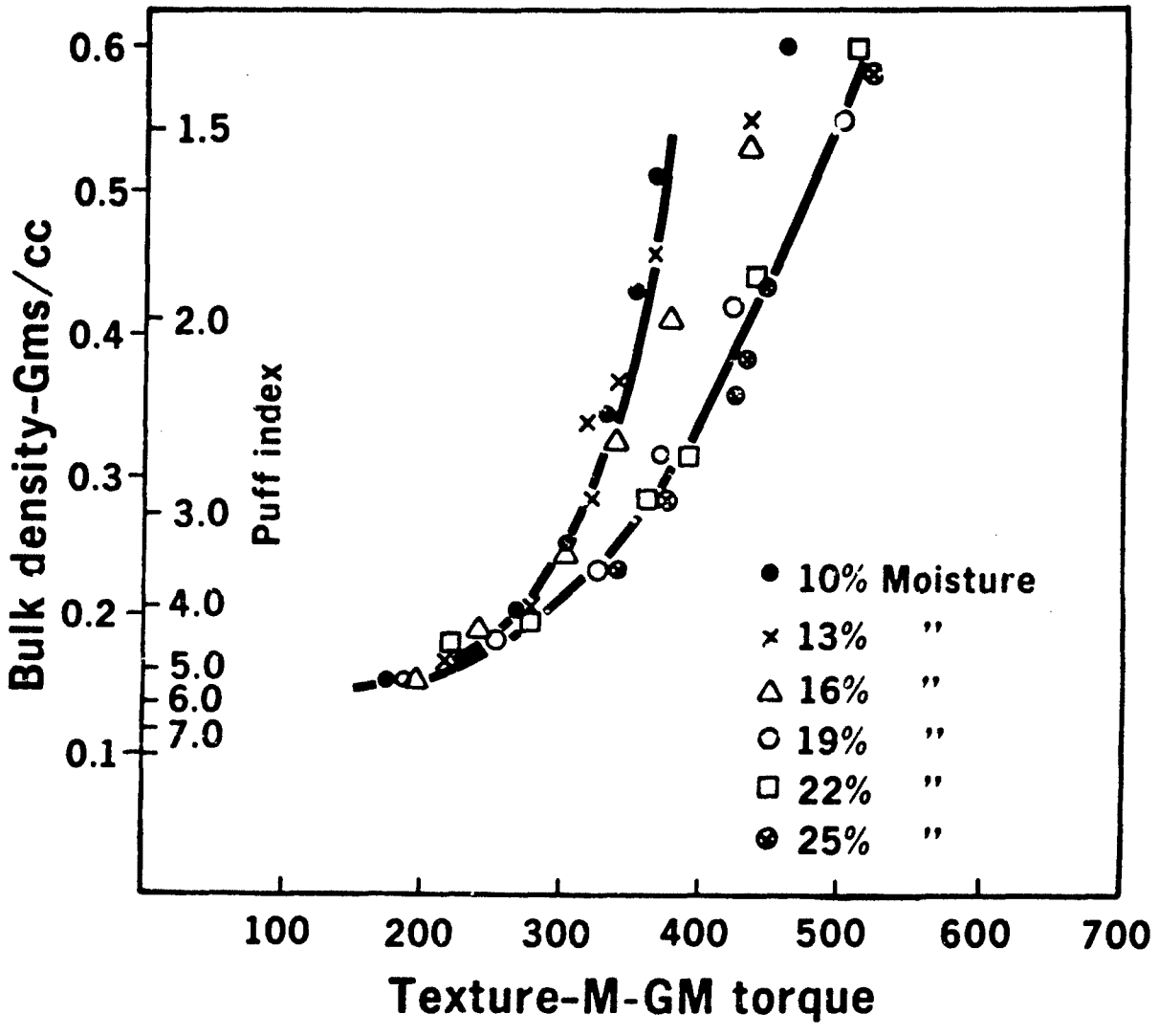
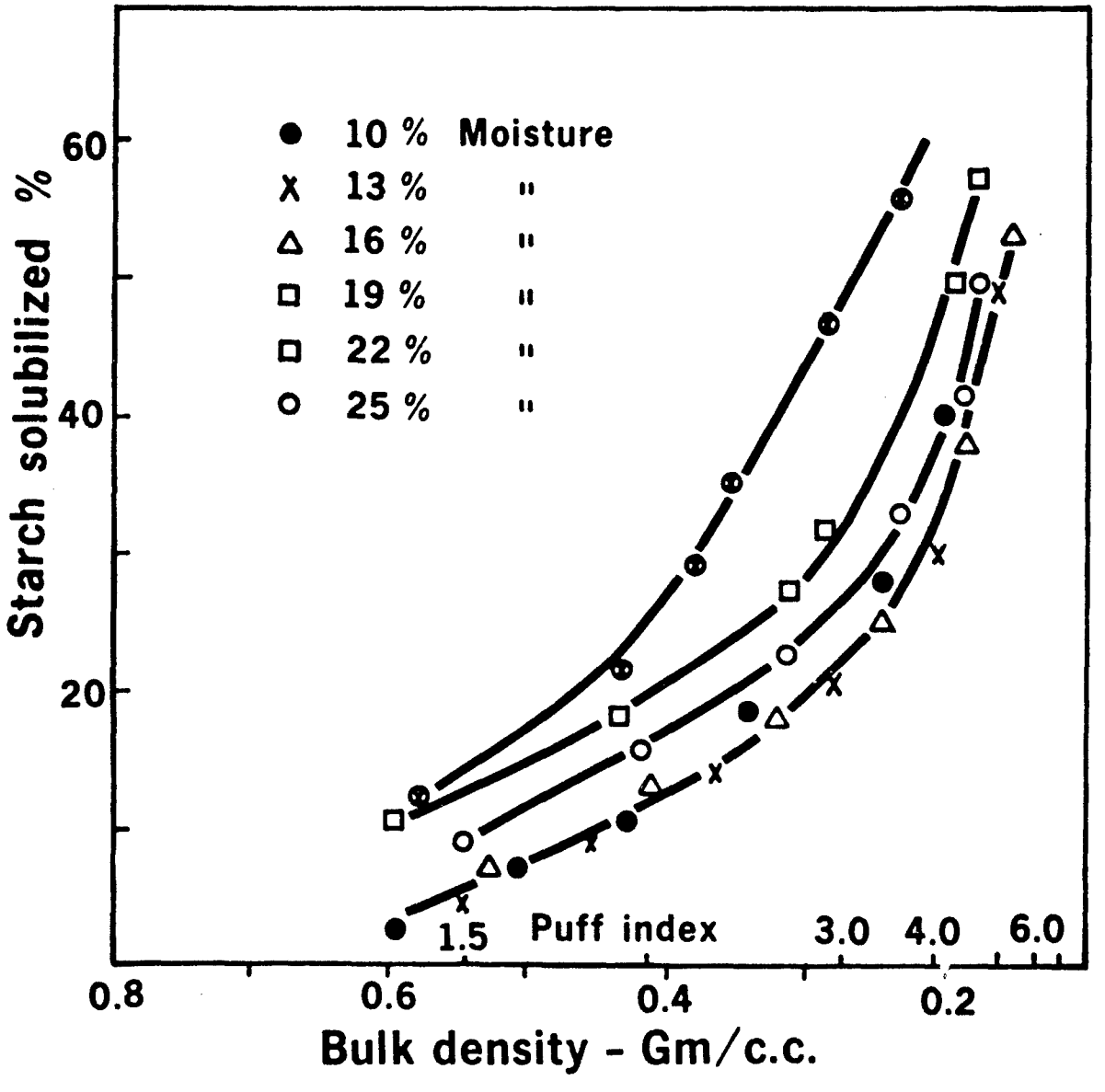


Figure 2.5
Relationship between solubilized starch and expansion
as influenced by moisture content



SECTION 3

ADJUNCTS FOR USE WITH THE BULGUR WAFER

The bulgur wheat wafer can be used as the only food in fallout shelters, but such a diet may be too austere to provide the morale-building aspect desired. To relieve the monotony of a single-item ration a series of foods (adjuncts) were developed to go with or add to the wafer. This work has been reported previously. It is being continued at a reduced scale.

Shelf-life of Adjuncts

In order to determine the stability of adjuncts in normal storage, a contract was let with Oregon State University on June 25, 1964. The contract provides for a taste panel evaluation, over a 5-year period, of twelve selected adjuncts, representative of the type of adjuncts formulated and the kinds of ingredients used. Samples stored at 40°, 70° and 100° F. are to be compared to nitrogen-packed controls at -18° F. All sample adjuncts are packed in tin cans, with nitrogen atmosphere in half the samples and air in the other half. Five adjuncts with low moisture content are packed without desiccants; the other seven higher moisture products are packed with and without in-package desiccant.

Apple granules and the dehydrated vegetables used were analyzed for moisture (Karl Fischer method) and sulfur dioxide contents (Monier-Williams method) before they were mixed with the other ingredients (Table 3.1).

Before beginning differential temperature storage, a sample from one can of each adjunct was analyzed for moisture (Table 3.2), and the contents of each can was evaluated by four expert judges before, during, and after preparation for odor, color, texture, and for ease of preparation (Table 3.3). To establish the initial flavor score the adjuncts were evaluated by a large taste panel, using a nine point hedonic scale (Table 3.4). As noted in the tables, difficulty was experienced in the preparation of butterscotch topping, curry sauce, and strawberry spread. These adjuncts also received the lowest taste panel ratings. In cooperation with Oregon State University, the problem of preparation was studied, and methods of preparation were altered to give good preparation results.

Modification of Adjuncts

The original Kansas Indian Pudding (Adjunct No. 29) was reformulated to provide a one-package low-moisture product which is more convenient and probably much more stable. The new formula utilizes low-moisture dehydrated raisin granules and imitation molasses flavor. The revised formulation is given in the appendix.

Table 3.1

Sulfur dioxide and moisture contents of dehydrated products before mixing

Product	p.p.m. SO_2	% Moisture
Apple granules	1005	3.15
Green pepper dices	2342	3.88
Green pepper granules	941	4.68
Leek	560	4.40
Celery stalk	992	4.28
Onion flakes	none	1.70

Table 3.2

Initial moisture contents of adjuncts

Adjunct	% Moisture dry mix
1. Apple topping	1.85
2. Beef soup	3.46
3. Butterscotch topping	1.61
4. Chili sauce	4.85
5. Chocolate pudding	2.54
6. Cream of chicken soup	4.68
7. Curry sauce	4.77
8. Oriental sauce	4.42
9. Paprika gravy	4.45
10. Raspberry jelly	0.37
11. Strawberry spread	0.45
12. Wild cherry icing	0.52

Table 3.3

Mean scores for preparation evaluation (0-normal, no criticism to 5, extreme off-color, odor, etc. See table 3.2 for number and name of adjuncts)

	1-AT	2-BfS	3-BT	4-ChS	5-ChP	6-CCS	7-CuS	8-OS	9-PG	10-BJ	11-SS	12-WC
Container	0	0	0	0	0	0	0	0	0	0	0	0
Dry Mix												
Odor	0	0	0	0	0	0	0	0	0	0	0	0
Color	0	0	0	0	0	0	0	0	0	0	0	0
Texture	0	0	1	0	1	0	0	0	0	0	0	0
During Preparation												
Odor	0	0	0	0	0	0	0	0	0	0	0	0
Color	0	0	0	0	0	0	0	0	0	0	0	0
Texture	0	0	2	1	1.3	0	0	0	0	0	1	0
Ease of	1	0	2	1.6	1.6	1	3	1.6	1	0	2.6	1
After Rehydration												
Odor	0	0	0	0	0	0	0	0	0	0	0	0
Color	0	0	0	0	0	0	0	0	0	0	0	0
Texture	0	0	0	0	1.3	0	0	0	0	0	1	0.6

Table 3.4

Frequency scores for flavor preference tests on adjuncts

(See table 3.2 for number and name of adjuncts)

		1-AT	2-BfS	3-BT	4-ChS	5-ChP	6-CCS	7-CuS	8-OS	9-PG	10-RJ	11-SS	12-WC
(9)	Like extremely	15	16	0	9	3	13	8	15	5	6	4	17
(8)	Like very much	42	56	12	30	25	34	14	47	31	37	16	35
(7)	Like moderately	53	51	26	44	49	62	38	49	39	38	41	28
(6)	Like slightly	26	21	27	37	24	26	21	28	34	39	38	20
(5)	Neither like nor dislike	14	7	15	12	10	8	9	11	14	18	19	5
(4)	Dislike slightly	13	11	32	18	12	15	31	13	23	11	23	7
(3)	Dislike moderately	9	7	27	13	1	3	25	5	9	10	15	5
(2)	Dislike very much	2	4	22	4	1	1	12	2	2	1	9	4
(1)	Dislike extremely	1	0	7	3	1	0	11	4	1	1	1	0
	Total Judgments	175	173	168	170	126	162	169	174	158	161	166	121
	Mean Scores	6.58	6.84	4.61	6.08	6.49	6.73	5.06	6.62	6.10	6.32	5.62	6.82

Development of New Adjuncts

Several new adjuncts were developed and screened for acceptability. These include four dehydrated fruit sauces (appendix Nos. 59 through 62), three dehydrated fruit butters (appendix Nos. 63 through 65), and a cold water type of pectin jelly (appendix Nos. 66 through 74) which can replace the previously developed hot water jellies Nos. 1 through 10 (OCD report OCD-05-62-54 July 1962 to June 1963).

Cold-water pectin jellies

Two gel systems were studied in the development of the cold-water pectin jellies, one using low methoxyl pectin and the other, high-methoxyl pectin. Considerable success was reported last year for the low-methoxyl pectin and, indeed, an entirely satisfactory product was formulated with the low-methoxyl pectin we were using. When a new supply of the same low-methoxyl pectin was obtained, however, it would no longer perform in the devised formulation. Substantial changes in formulation were required even to form jellies. If the original solids content of 30 to 40% was maintained, the shortest set time that could be achieved for a jelly of good consistency and textural characteristics was about six hours. This was considered to be too long. The set time could be reduced to two to three hours, if the solids content were lowered to about 20%. At this solids content, however, the flavor is very poor. Obviously, while the low-methoxyl pectin was designated as the same product as previously available, it was no longer satisfactory for our purpose.

With the failure of the commercially available low-methoxyl pectin to provide a satisfactory jelly by our process, subsequent effort was directed toward use of the high-methoxyl pectin system. Rapid dispersibility of the pectin was achieved by use of a drum dried sugar-pectin mixture.

A very good cold-water high-methoxyl pectin jelly was developed using drum dried sugar-pectin (12.5-1 by weight) (see appendix Nos. 66 through 74).

The initial developmental work was carried out with an extra rapid-set high-methoxyl pectin. However, a rapid-set and a slow-set high-methoxyl pectin were also drum dried (sugar-pectin ratio 12.5-1) and made into jellies to determine whether either of these types of pectin would be better to use. Both the rapid-set and the slow-set pectins made good jellies, but the set time was considerably longer than the extra rapid-set pectin used. In developing a jelly for the fallout shelter program, speed of gel set is considered of prime importance. Further work was therefore restricted to the extra rapid-set pectin. To further shorten the time of gel-set,

sufficient delta-glucono lactone was used to give a final pH of 2.6 to 2.7, three hours after adding water to the jelly mix. Normally, syneresis (weeping) occurs in jellies with this low a pH when they stand for prolonged periods of time. However, no syneresis has occurred when this jelly has stood at room temperature for a period of two days. When the delta-glucono lactone was increased to 2.2%, syneresis occurred after three to four hours; decreasing the delta-glucono lactone to 1.4 or 1.6% produced a weak jelly which took several hours to set. Increasing the amount of pectin-sugar mix did not increase the speed of gel-set, but merely increased the firmness.

Control of pH in the jelly during mixing is extremely important, because the pectin must thoroughly dissolve during mixing and before the pH lowers sufficiently to start pregelation. The pH in the recommended mixes after three minutes of mixing is approximately 3.8, which is considered to be above the gelling range. However, localized areas of low pH can occur, as evidenced by curdy jelly particles which float to the top of the jelly on the air bubbles formed during mixing. This results in a granular foam area on the exposed surface of the jelly. It was found that when the pH was raised to between 4.2 and 4.4 during mixing, a better, less granular jelly resulted. Much better results were also obtained by adjusting the pH of the sugar-pectin mix to 5.6 before drum drying. Such material, when used in a jelly, gave a pH of about 4.5 after three minutes of mixing and produced a clear, smooth jelly free of granules and with a very small foam layer. The pH of 5.5-5.6 was an entirely arbitrary selection. More work should be carried out to determine the optimum pH to be used for the drum dried material. Preliminary work with an 11.5 to 1 sugar-pectin mix indicates that this ratio probably can be used with proper pH adjustment. This will decrease the cost of the jelly. Drum dried sugar-pectin mixes of 5 to 1, 7.5 to 1, and 10 to 1 ratios were prepared and evaluated. All produced granular, weak gels with some evidence of syneresis. Preliminary evidence indicates, however, that these lower ratios (possibly 10 to 1) may be satisfactory, if drum dried after adjusting to an optimum pH.

To determine the stability of delta-glucono lactone, weighed samples were stored at room temperature and humidity and then checked periodically for deterioration, as shown by a lower than normal pH one minute after solution. After five months, the pH of the stored material was identical to that of control samples and there was no other evidence of deterioration. This indicates satisfactory stability.

Drum-dried sugar-pectin mix

A 12.5 to 1 sugar to pectin mix was made by dispersing 600 gm of pectin in 2.5 kg sugar, and slowly adding this mixture to ten

liters of water while agitating with a mechanical mixer. The material was mixed for one hour, five kg more sugar were added, the pH was adjusted to between 5.5 to 5.6 with sodium hydroxide solution, and mixing was continued for another hour. The final solution was drum dried on a double drum drier, using a drum spacing of .002 in., a drum temperature of 280° F., and a drum speed of one rpm. The dried material coming off the drums was brittle and flaky, very hydroscopic, and had about 3% moisture. The material was next rubbed through a screen with 16 meshes to the inch and used in the jelly formula. This dry mix becomes gummy, cakes, and is difficult to handle unless protected from atmospheric moisture. It should probably be handled commercially in a low humidity room. Material handled in such a room would probably be satisfactory, because a pilot plant batch of the material packed in our dry room did cake, and was still satisfactory after one year. Estimated cost of producing this material is $0.26 per pound.

Crystalline drum-dried sugar-pectin mix

If the sugar in a jelly mix crystallizes, the mix is no longer hygroscopic, but rapidly loses water and becomes stable. Also, bulk density increases (see Table No. 3.6). This is another important asset of the stabilized material.

In order to obtain more stable mixes, therefore, crystallization studies were conducted, and a laboratory unit was devised to study methods of achieving rapid crystallization. A method was developed whereby heated (150° to 160° F.) forced-draft air is passed over heated (170° F.) tumbling drum-dried sugar-pectin (12.5 to 1) mix that had been seeded previously with 3% of a commercial powdered sugar. A controlled amount of water is injected into the hot air stream to increase the humidity and to moisten the tumbling mix to about 6% moisture. Aeration is then continued to dry the material. Crystallization is generally complete in about 15 min, and final moisture content may drop to below 2%. The crystals formed by this method are very small, and jelly made from this material is very good.

In an attempt to simplify the procedure, material was removed from the drum dryer while still somewhat wet (approx. 4 to 6% moisture) and immediately crystallized by tumbling in a closed heated container rotating at 12 rpm. Seeding with 3% commercial powdered sugar and tumbling 15 min at 170° F. produced complete crystallization. Drying the crystallized 6% moisture material for 10 min at 170° in a forced draft dehydrator decreased the moisture content to 2.5%. Drum-dried material, which had not been pH adjusted, formed large irregular shaped crystals when crystallized. The solubility rate

was slow, and the resultant jelly was very granular on top. Also, the gel was weak, and syneresis was quite pronounced. Decreasing the total solids content and varying the level of delta-glucono lactone did not appreciably improve this situation.

Drum-dried material which had been adjusted to pH 5.5 to 5.6 crystallized more readily and formed small crystals. The solubility rate was more rapid, and a very good jelly was produced. All crystallized material was ground through a 16 mesh screen. Degree of crystallinity was determined by use of a polarizing microscope.

At the present time, it is not possible to estimate the cost of crystallization. It is probable that crystallization costs might be $0.02 to $0.03 per pound, which would increase the total cost of drum dried crystallized material to $0.28 to $0.29 per pound. In making cost estimates for the jelly mixes, crystallization costs were not included, as they were considered impossible to estimate.

High-stability margarine-type fat spread

A laboratory mixer was built to simulate the mixing procedure commonly used in commercial margarine manufacture. The mixer consisted of a stainless steel beaker which could be lowered into either an ice bath or into an alcohol and dry ice bath to give any desired cooling temperature. The melted margarine mix was placed in this beaker and beaten with a variable speed mechanical mixer. Wiper blades scraped the chilled fat off the sides and bottom of the beaker and gave a thorough mixing action, producing rapid solidification. Chilling temperature, solidification speed, and mixing speed were readily controlled. Acetoglycerides and monoglycerides were used with limited success in various formulations to decrease waxiness. The following formula gave the best results:

	%
High-stability liquid fat (500 hr A.O.M. test) (Durkees Kex 500)	59.321
Medium-stability medium-hard fat (200 hr A.O.M. test) (Durkees C.C.C.)	35.58
Monoglyceride (Myverol 1800)	3.95
Starter distillate butter flavor (Hansens)	.15
Annatto Color (Paul Servis Laboratory)	.009
Powdered salt	.99

A spreadability range of 40° to 90° F. could be attained, but the material had a waxy taste when stored at the higher part of the temperature range. The waxiness was less with this formula than with those used previously, but was still noticeable.

A needle micropenetrometer was built (Figure 3.1) to evaluate consistency and to study polymorphic changes of the fat crystals. To follow these changes, a margarine sample was partially melted, cooled to a temperature slightly above the solidification point, and poured into brass blocks held at a temperature of 0° C. The fat was thus very rapidly cooled and solidified in the form of the alpha crystal. The solidified fat was then warmed a few degrees at a time, and penetrometer readings were taken after the sample had become equilibrated to each new temperature. As the temperature is raised in such a procedure, the fat softens and the penetrometer needle penetrates deeper. A plot of penetration against temperature produces a consistency curve. When a polymorphic change occurs, a definite change in consistency also occurs and is indicated by a change in the plotted curve. To date one such polymorphic change has been observed in several margarine samples, but a second change has not been obtained. At the present time, we do not know whether the single change observed is from the alpha to the beta prime or from the beta prime to the beta crystal form. Waxiness is generally more pronounced when fat crystals are in the beta form. If a margarine spread could be produced in which the fat existed chiefly in the alpha or the beta prime crystal forms, the resultant material would have a minimum of waxiness in the temperature range of 40° to 90° F. Such material would eventually revert to the alpha form, but the delay would be long enough to be worthwhile seeking. Acetoglycerides, monoglycerides, and phospholipids could also be used to reduce waxiness, so that a satisfactorily stable spread could be made.

Description of Adjuncts

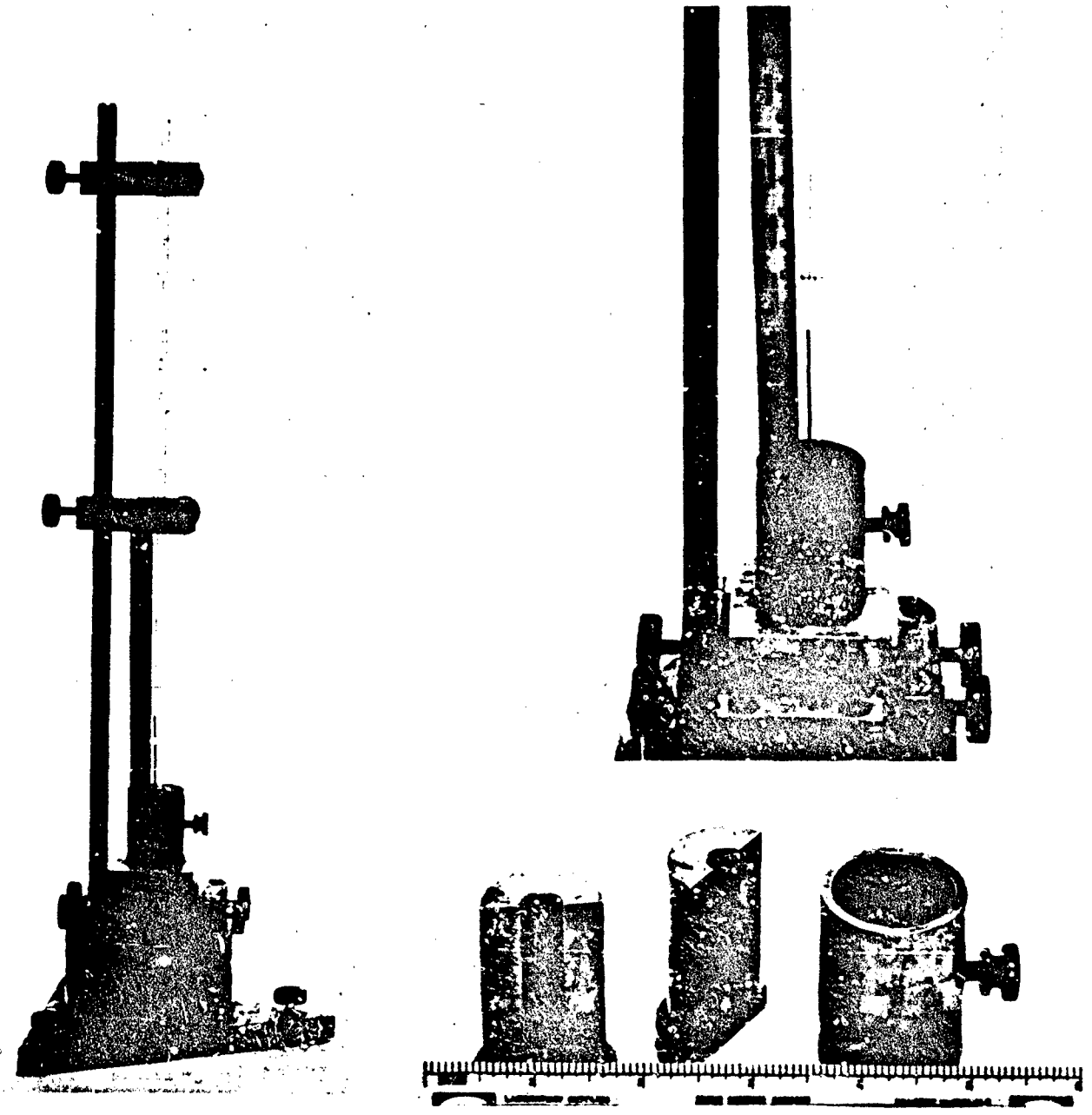
Formulas for all modified and new adjuncts are given in the appendix, with information on equipment, portions, and manner of use. The approximate grams of protein per serving, calories per serving, and grams of protein per 100 calories for each adjunct are shown in Table 3.5. Servings listed are minimum amounts needed to complement the wafers; larger servings may be desired.

Estimated Costs

Bulk densities and preliminary cost estimates have also been made for the modified and new adjuncts (Table 3.6). The estimates are based on production of one-ton lots of finished products. Prices of ingredients are for ton or drum lots, depending on quantities required. All prices are f.o.b., San Francisco, as of June 1963. The estimated cost of drum dried sugar-pectin mix (used in jellies, appendix Nos. 66 through 74) is based upon known costs per pound of water removal by drum drying methods. Bulk density of jellies is greater (see Table 3.5), when made with the more dense crystalline sugar-pectin mix.

Figure 3.1

MICROPENETROMETER



Detail of Sample Holder

Table 3.5

Protein content and caloric value of adjuncts*

Adjunct number	Adjunct	Protein, g/serving	Calories/ serving	Protein, g/100 calories
29	Kansas Indian pudding	1.4	118	1.3
59	Prune sauce	trace	71	trace
60	Apricot sauce	trace	68	trace
61	Prune-peach sauce	trace	71	trace
62	Prune-raisin sauce	trace	71	trace
63	Date butter	trace	27	trace
64	Black fig butter	.2	28	.7
65	Apricot-peach butter	.1	29	.5
66-74	Jellies	0	62	0

* Source of information for components: Watt, B. K., and Merrill, A. L. Composition of Foods, Agric. Handbook No. 8. U.S. Dept. of Agric., Agric. Res. Serv., Washington, D. C. 1963.

Table 3.6

Cost estimates and bulk densities of adjuncts

Adjunct	Persons served	Can size	Can weight	Cost per can	Cost per serving	Cost per 100 calories	Bulk densities oz./cu.in.
29. Kansas Indian pudding	25	(#3) 404 x 414	1 lb 13 oz	$0.525	$0.021	$0.018	0.444
59. Prune sauce	25	(#2) 307 x 409	1 lb 0.5 oz	0.225	0.009	0.012	0.441
60. Apricot sauce	25	(#2) 307 x 409	1 lb 0 oz	0.261	0.010	0.014	0.448
61. Prune-peach sauce	25	(#2) 307 x 409	1 lb 0.5 oz	0.240	0.010	0.014	0.446
62. Prune-raisin sauce	25	(#2) 307 x 409	1 lb 0.5 oz	0.218	0.009	0.012	0.448
63. Date butter	50	(#2) 307 x 409	0 lb 13 oz	0.309	0.006	0.022	0.349
64. Black fig butter	50	(Jumbo) 307 x 510	0 lb 14 oz	0.334	0.007	0.025	0.345
65. Apricot-peach butter	50	(Jumbo) 307 x 510	0 lb 14 oz	0.488	0.010	0.034	0.333
66. Raspberry							
67. Pineapple							
68. Orange							
69. Apple	*50	(#3) 404 x 414	1 lb 12 oz	0.310	0.006	0.009	0.455
70. Wild cherry (Jellies)							
71. Strawberry	**25	(#2) 307 x 409	0 lb 14 oz	0.167	0.007	0.011	0.435
72. Grape							
73. Peach							
74. Lemon							

* Crystallized sugar-pectin.

** Amorphous sugar-pectin.

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.

Manufacture of Adjuncts

Preparation of adjuncts is simply a matter of thoroughly mixing the ingredients and canning them. However, formulas containing powdered sugar should be screened to break up lumps before final mixing of the ingredients.

APPENDIX

Formulas for Adjuncts

All formulas make 50 servings

Kansas Indian Pudding (No. 29)

Ingredients	% by weight
Salt (13)*	0.920
Cinnamon (9)	0.260
Cloves (9)	0.073
Ginger (10)	0.153
Sugar, granulated (8)	56.584
Powdered milk (5)	10.700
Raisin granules #4 mesh (6)	30.590
Caramel color - a carmelized sugar powder (4)	0.460
Imitation molasses #51.660/AP (2)	0.260

Directions for mixing: Empty 2 cans of dry mix (1 lb. 13 oz. each) into a 2-gallon container. Crumble 50 wafers into the dry mix, and add 3 quarts plus 3/4 cup of water to the dry ingredients. Bring to a boil, stirring constantly. Let stand for 15 minutes before serving.

Serving: 1/3 cup.

Note: 1/3 cup is equivalent to 1 wafer crumbled into the pudding before heating.

* Numbers in parentheses indicate sources listed on page 42.

Prune Sauce (No. 59)

Ingredients	% by weight
Carboxy methyl cellulose 7HOP (12)	0.750
Citric acid (15)	1.260
Sugar, granulated (8)	87.890
Prune powder (6)	10.050
Vanillin (3)	0.025
Cinnamon (9)	0.025

Directions for mixing: Add 5 cups of water to 2 cans of dry mix (1 lb. 0.5 oz. each) in a 1-gallon container. Let stand 30 minutes, stirring occasionally.

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

Apricot Sauce (No. 60)

Ingredients	% by weight
Carboxy methyl cellulose 7HOP (12)	0.780
Cinnamon (9)	0.194
Cloves (9)	0.065
Sugar, granulated (8)	90.521
Citric acid (15)	0.650
Apricot powder (6)	7.760
Vanillin (3)	0.030

Directions for mixing: Add 5 cups of water to 2 cans of dry mix (1 lb. each) in a 1-gallon container. Let stand 30 minutes, stirring occasionally.

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

Prune-Peach Sauce (No. 61)

Ingredients	% by weight
Carboxy methyl cellulose 7HOP (12)	0.750
Citric acid (15)	1.260
Sugar, granulated (8)	87.925
Prune powder (6)	5.020
Peach powder (6)	5.020
Vanillin (3)	0.025

Directions for mixing: Add 5 cups of water to 2 cans of dry mix (1 lb. 0.5 oz. each) in a 1-gallon container. Let stand 30 minutes, stirring occasionally.

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

Prune-Raisin Sauce (No. 62)

Ingredients	% by weight
Carboxy methyl cellulose 7HOP (12)	0.750
Citric acid (15)	1.260
Sugar, granulated (8)	87.915
Vanillin (3)	0.025
Prune powder (6)	6.280
Raisin granules #4 mesh (6)	3.770

Directions for mixing: Add 5 cups of water to 2 cans of dry mix (1 lb. 0.5 oz. each) in a 1-gallon container. Let stand 30 minutes, stirring occasionally.

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

Date Butter (No. 63)

Ingredients	% by weight
Date granules #4 mesh (6)	49.300
Sugar, powdered (8)	49.300
Salt (13)	0.672
Pregelantinized tapioca starch (11)	0.672
Imitation brown sugar 59.267/AP (2)	0.056

Directions for mixing: Add 1/2 cup plus 2 tablespoons of water to 1 can of dry mix (13 oz.) in a 1-quart container, and mix well. Let stand for 30 minutes until of spreading consistency.

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

Black Fig Butter (No. 64)

Ingredients	% by weight
Black fig powder (6)	49.640
Sugar, powdered (8)	49.638
Salt (13)	0.451
Citric acid (15)	0.271

Directions for mixing: Add 1/2 cup plus 2 tablespoons of water to 1 can of dry mix (14 oz.) in a 1-quart container, and mix well.

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

Apricot-Peach Butter (No. 65)

Ingredients	% by weight
Peach powder (6)	24.030
Apricot powder (6)	13.730
Sugar, powdered (8)	61.785
Vanillin (3)	0.069
Cloves (9)	0.129
Citric acid (15)	0.257

Directions for mixing: Add 1/2 cup plus 2 tablespoons of water to 1 can of dry mix (14 oz.) in a 1-quart container, and mix well.

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

Raspberry Jelly (No. 66)

Ingredients	% by weight
Drum-dried sugar-pectin (7) mix*	8.900
Sugar, granulated (8)	89.022
Delta glucono lactone (14)	1.942
Flavor - imit. raspberry #29461 (1)	0.118
Color - raspberry red (1)	0.018

Directions for mixing: Add 2-1/4 cups of cold water to: (a) 1 can of dry mix containing crystallized sugar-pectin (1 lb. 12 oz.), or (b) 2 cans of dry mix containing amorphous sugar-pectin (14 oz. each), in a 2-quart container. Stir for 3 minutes. Let stand until set (3 hours).

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

Pineapple Jelly (No. 67)

Ingredients	% by weight
Drum-dried sugar-pectin (7) mix	8.900
Sugar, granulated (8)	89.077
Delta glucono lactone (14)	1.943
Flavor - imit. pineapple #28992 (1)	.074
Color - FD & C yellow #5 (1)	.006

Directions for mixing: Add 2-1/4 cups of cold water to: (a) 1 can of dry mix containing crystallized sugar-pectin (1 lb. 12 oz.), or (b) 2 cans of dry mix containing amorphous sugar-pectin (14 oz. each), in a 2-quart container. Stir for 3 minutes. Let stand until set (3 hours).

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

* 12.5 parts by weight of granulated sugar to 1 part by weight of high-methoxyl pectin #3430 (7).

Orange Jelly (No. 68)

Ingredients	% by weight
Drum-dried sugar-pectin (7) mix	8.900
Sugar, granulated (8)	88.973
Delta glucono lactone (14)	1.941
Flavor - orange powder #2287D (3)	0.168
Color - FD & C yellow #6 (1)	0.018

Directions for mixing: Add 2-1/4 cups of cold water to: (a) 1 can of dry mix containing crystallized sugar-pectin (1 lb. 12 oz.) or (b) 2 cans of dry mix containing amorphous sugar-pectin (14 oz. each), in a 2-quart container. Stir for 3 minutes. Let stand until set (3 hours).

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

Apple Jelly (No. 69)

Ingredients	% by weight
Drum-dried sugar-pectin (7) mix	8.900
Sugar, granulated (8)	89.0218
Delta glucono lactone (14)	1.9423
Flavor - apple #33025 (1)	0.1182
Color - chocolate brown "N" shade (1)	0.0008
yellow egg shade (1)	0.0169

Directions for mixing: Add 2-1/4 cups of cold water to: (a) 1 can of dry mix containing crystallized sugar-pectin (1 lb. 12 oz.), or (b) 2 cans of dry mix containing amorphous sugar-pectin (14 oz. each), in a 2-quart container. Stir for 3 minutes. Let stand until set (3 hours).

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

Jellies (Nos. 70-74)

Ingredients	% by weight
Drum-dried sugar-pectin (7) mix	8.90
Sugar, granulated (8)	88.919
Delta glucono lactone (14)	1.940
Flavor (1)	0.223
Color (1)	0.018

	Flavor	Color
70.	Wild cherry #25862	New dark red
71.	Strawberry #28994	Strawberry red
72.	Grape #28990	Fast purple
73.	Peach #26185	Yellow egg shade
74.	Lemon #29227	FD & C yellow #5

Directions for mixing: Add 2-1/4 cups of cold water to: (a) 1 can of dry mix containing crystallized sugar-pectin (1 lb. 12 oz.), or (b) 2 cans of dry mix containing amorphous sugar-pectin (14 oz. each), in a 2-quart container. Stir for 3 minutes. Let stand until set (3 hours).

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

Sources of Products Used

1. Fritzsche Brothers, Inc.
2. Firmenich & Company
3. George Leuders & Company
4. Wm. J. Stange Company
5. Sana Dairies
6. Vacu-Dry Corporation
7. Sunkist Growers, Inc.
8. C. & H. Sugar Refining Corporation
9. Schilling Brand, McCormick & Company, Inc.
10. Durkee Famous Foods
11. Morningstar Paisley (Morningstar tapioca pregelantinized starch - Redisol #4)
12. Hercules Powder Company
13. Leslie Salt Company
14. Charles Pfizer & Company
15. Van Waters & Rogers, B K H Division

The designation of any manufacturer or brand-name does not imply a specific recommendation by the U.S. Department of Agriculture. Such mention means only that these particular items would be satisfactory for the purpose indicated: other sources and items may prove equally satisfactory.