A COMPARISON OF THE FLAVOR PREFERENCE OF FREEZE-DRIED WHOLE EGG SOLIDS WITH OTHER PROCESSED EGGS AND FRESH EGGS

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ABSTRACT

This study was a comparison of the flavor preference of freeze-dried whole egg solids with other processed eggs and fresh eggs.

Custards were prepared from a standard recipe. The ingredients were eggs, milk, and sugar. Spices and flavoring were purposely omitted to avoid masking the flavor of the eggs. Frozen, freeze-dried, and dried eggs were substituted for fresh eggs on a weight basis. All custards were baked to the end internal temperature of 190°F. (87.8°C.) A consumer preference panel was utilized to determine which type of baked custard was preferred.

The data was statistically analyzed by the Chi Square (χ^2) Method.

Statistical evidence showed that the panel preferred custards prepared with the dried eggs over those using fresh, frozen, and freeze-dried eggs. The study also concluded that although freeze-dried egg custards were preferred over frozen egg custards, the panel was unable to detect any significant difference between custards prepared from freeze-dried and those prepared from fresh eggs. The panel was unable to distinguish any difference between custards made from fresh eggs and those made from frozen eggs.

ACKNOWLEDGEMENT

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Grateful acknowledgement is also due Dr. L. E. Dawson, Associate Professor of Food Science, Michigan State University. To Dr. R. W. Kline and the Research Division, Armour and Company, Chicago, Illinois, I wish to express my gratitude for providing the processed eggs used in this study. I also wish to thank Dr. J. W. Thompson, Head of the School of Hotel, Restaurant, and Institutional Management, and the National Restaurant Association for making this project possible. The guidance of Dr. R. D. Wilson is very much appreciated. The assistance of Frank Borsenik, Instructor, Michigan State University, in the statistical analysis of the data represents an important contribution.

William Stafford, Instructor, Michigan State University, and those individuals who served on the consumer preference panel were most generous with their time and interest. The writer is most grateful for their assistance.

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INTRODUCTION

In recent years the demand has increased for an acceptable type of processed egg for use in quantity cooking and commercial food products. Studies of dried eggs have indicated that certain characteristics of these products were objectionable. The drying process has been considered the main deficiency, but storage has also been a factor. As was pointed out in the review of literature, claims have been made that freeze-dried products overcome these shortcomings.

An undesirable change in flavor has been one of the main objections to dried eggs. Studies of the freeze-drying of other food products indicated that flavor changes did not occur.

The purpose of this study, therefore, was to compare the flavor preference of freeze-dried whole egg solids with other processed eggs and fresh eggs.

CHAPTER I

REVIEW OF LITERATURE

History

The principle of "low-temperature evaporation of water under vacuum to produce freezing, followed by sublimation is very old."[1] William Hyde Wollaston demonstrated this principle before the Royal Society of London in 1813. But only in the past few years have food products been dried by sublimation. "Sublimation is the vaporisation of a solid without the intermediate formation of a liquid."[2]

Flosdorf[3] reports that Shackell employed sublimation for preserving biological materials in 1909. Shackell's procedure consisted of using a salt-ice mixture to freeze the product. The product was then dried in *vacuo*. Sulphuric

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[1]Earl W. Flosdorf, *Freeze-Drying (Drying by Sublimation)*. (New York: Reinhold Publishing Corp., 1949), p. 2.

[2]*Chambers's Technical Dictionary*. Edited by C. F. T. Tweney and L. E. C. Hughes. (New York: The MacMillan Co., 1956).

[3]Flosdorf, *op. cit.*, p. 5.

acid acted as the desiccant. Preservation of antisera, rabies virus, meat, and blood was accomplished by this method.

The advantages of freeze-drying for industry were very early recognized. Sharp and Dohme, Inc., early pioneers in this area, presented the first market-container units in 1935, at which time the firm began processing serum for clinical distribution. Freeze-dried blood plasma appeared in 1940. Sharp and Dohme's interest, experience and efforts made it possible for the accumulation of supplies of freeze-dried human blood plasma in 1941.[4]

In 1938-39, Dr. R. E. N. Greaves experimented with freeze-drying. These experiments were of great interest and the possibilities of using the method for drying food-stuffs were considered.[5]

General Method of Processing

"The freeze-drying process is simple in principle. The material to be dried is frozen, and water vapor is removed by sublimation. The temperature must, of course, be

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[4] Ibid., pp. 5-9.

[5] "Freezing and Drying." Report of a Symposium held in June, 1951, (New York: Hafner Publishing Co., Inc, 1952), p. 31.

kept sufficiently low to avoid melting the ice phase present. The rate of sublimation is greatly increased if the material is held under a vacuum, preferably with the total pressure well below the vapor pressure of the ice."[6]

Stages of Drying

The process of drying by sublimation occurs in two stages. In the first stage the product is frozen to approximately -5°C. A vacuum is maintained to encourage the moisture in the solid to escape more readily. Pressure is created by the escaping vapor. The temperature of this vapor will be approximately the same as that of the product. At this point, 98 to 99 per cent of all moisture will leave the solid, or sublimate.

In stage two, the temperature of the product is raised to the point at which the maximum drying can occur. This drying will reduce the remaining moisture to 0.5 per cent, or less, of the weight of the final solids. Thus, approximately 99.5 per cent of the original moisture contained has been removed. To facilitate this final drying stage, an efficient evacuating system must establish a pressure which

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[6]Advances in Food Research, Vol. VII, edited by E. M. Mrak and G. F. Stewart, (New York: Academic Press, Inc., 1957), p. 172.

is lower than the vapor pressure of the product.[7]

Undesirable Changes Usually Noted in High Temperature or Vacuum Drying

"1. Pronounced shrinkage of solids.

2. Migration of dissolved constituents to the surface when drying solids.

3. Extensive denaturation of proteins.

4. Case-hardening. The formation of a relatively hard, impervious layer at the surface of a solid is caused by one or more of the first three changes. This impervious layer slows rates of both dehydration and reconstitution.

5. Formation of hard, impervious solids when drying liquid solutions.

6. Undesirable chemical reactions in heat-sensitive materials.

7. Excessive loss of desirable volatile constituents.

8. Difficulty of rehydration as a result of one or more of the above changes."[8]

Harper and Tappel[9] claim that freeze-drying partially overcomes these undesirable changes. Shrinkage and migration of dissolved materials is eliminated by keeping the product

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[7]Flosdorf, op. cit., pp. 29-33.

[8]E. M. Mrak and G. F. Stewart, op. cit., p. 175.

[9]Ibid.

frozen. This frozen state also inhibits chemical reactions and minimizes loss of volatile constituents. Reconstitution of the products is almost instantaneous. Moreover, the product may be subjected to long periods of nonrefrigerated storage without any serious impairment to its properties.

Previous Studies of These Four Types of Eggs

> "To determine if superior physical and functional properties of freeze-dried whole egg yolk could be found, determined the functional properties of albumen by the angel cake volume test, of yolk by the mayonnaise stability test, and of whole egg by the sponge cake volume test. Freeze-dried, glucose-oxidase-treated albumen was superior in the mayonnaise stability test. Although freeze-dried whole egg gave poorer performance in the sponge cake volume test than did fresh or frozen egg, it was nevertheless very superior to spray-dried egg."[10]

Mastic[11] reported that the flavor of custards prepared from dried whole egg solids were not as desirable as the flavor of fresh egg custards. The custard recipes used by Mastic were taken from Lowe's Experimental Cookery, except the volume of sugar was doubled. Homogenization of certain custards was done just prior to baking. A taste panel of seven individuals judged the custards.

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[10] T. Rolfes, P. Clements, and A. R. Winter, "The Physical and Functional Properties of Lyophilized Whole Egg, Yolk, and White." Food Technology 9, p. 569.

[11] M. E. Mastic, "The Effect of Homogenization on the Gelatin and Palatability of Baked Custards Prepared with Dried Whole Egg Solids." Unpublished Master's thesis, Michigan State University, 1959.

Due to the comparative newness of the freeze-drying of food products, and because of the expense involved, comparatively little has been done in this field. These factors were evident by the lack of literature available. Kline[12] predicted that, with improved technology and sales apparently evident, freeze-drying will become a prominent factor in the food processing industry.

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[12]Correspondence and interviews with R. W. Kline, PhD., Research Division, Armour and Company, Chicago, Ill.

CHAPTER II

EXPERIMENTAL PROCEDURE

The objective of this study was to compare flavor preferences of freeze-dried whole egg solids with other processed eggs and fresh eggs. The other processed eggs studied were: 1) spray-dried whole egg solids, and 2) frozen whole eggs. Baked custards were selected as the test medium because of the important part that eggs play in their composition, and because of their sensitivity to the quality and properties of eggs. A consumer-preference panel was utilized to determine which type of baked custard was preferred. Since the primary interest was concerned with egg characteristics, nutmeg and vanilla flavoring were not used because of their tendency to mask the flavor of the eggs.

Preparation of Processed Eggs

The processed eggs were obtained from a lot of 108 dozen commercial Grade A (light yolk) eggs, seven to ten days old. They were processed by the Research Division of Armour and Company, Chicago, Illinois, in the following

manner. Thirty-six dozen eggs were mixed, strained, and frozen. Thirty-six dozen eggs were enzymatically desugared by glucose-oxidase and spray-dried. The remaining thirty-six dozen eggs were enzymatically desugared by glucose-oxidase and freeze-dried. The eggs to be frozen were packed in 36 one and one-half pound cans, sealed, and frozen to a temperature of 0°F. (-17.7°C.) They were held at this temperature until used for the custard preparations.

The spray-dried and freeze-dried eggs were packed in plastic bags and held at room temperature. Approximately two weeks after processing, the frozen, spray-dried, and freeze-dried eggs were shipped to Michigan State University. Approximately one month after processing, the spray-dried and the freeze-dried eggs were repackaged from the large plastic bags to smaller bags, each of which contained 144 grams of processed eggs. The repackaging was done to discourage the possibility of excess moisture adhering to the product upon repeated openings of the larger plastic bags.

The fresh eggs were obtained from a specific pen of chickens at the Michigan State University Poultry Farm. They were stored under refrigeration and were two days old when used. Freshly processed homogenized milk was obtained

from the Michigan State University dairy on the same day of preparation and baking. The granulated sugar was from a common lot of beet sugar.

Recipes and Custard Preparation

Each of the three types of processed eggs and the fresh eggs were used each day to prepare the custards. The weights of ingredients used in the preparation of the four types of custards are shown in Table I.

The ingredients were weighed on a gram scale to the nearest 0.1 gram. Prior to addition of the other ingredients the milk was heated to 170°F. (76.7°C.) in the top portion of a two-quart capacity double boiler. The sugar and eggs were blended together in a Hobart mixer. The custards were baked in five-ounce, pyrex custard cups in a conventional electric oven on the day preceding the consumer-preference panel tests.

All custards were baked in a hot water bath to an end internal temperature of 190°F. (87.8°C.) The oven temperature was set at 350° (176.7°C.). Three lead wires from a Brown Electronik recording thermometer were used to measure and record temperatures. The ends of the three lead wires were placed in three custards arranged in the

TABLE I

RECIPES USED IN THE PREPARATION OF BAKED CUSTARDS[13]

Ingredient	Weights of Ingredients in Grams			
	Fresh	Frozen	Freeze-Dried	Dried
Milk (scalded)	488	488	560	560
Eggs: Fresh	96			
Frozen		96		
Freeze-Dried			24	
Dried				24
Sugar	50	50	50	50

[13]Belle Lowe, Experimental Cookery from the Chemical and Physical Standpoint. (New York: John Wiley and Sons, Inc., 1955, 4th Edition).

front, center, and rear of the baking pan. The different types of custards were varied with regard to baking position. This was done to discourage the possibility of one type of custard being placed in a position of more even heat within the oven than any other type of custard. Readings of the internal temperature of the custards were taken continuously until the desired 190°F. (87.8°C.) was attained.

Upon completion of baking, the custards were removed from the water bath and placed on an inverted metal tray and allowed to cool to room temperature. Immediately after cooling, the custards were individually covered with aluminum foil to prevent an intermingling of refrigerator odors and then placed in a refrigerator for storage until ready for use.

Approximately one hour prior to serving the panel, the custards were removed from the refrigerator, the aluminum foil was removed; and the custards were placed on plates according to the arrangement shown in Figure 1.

Panel Selection

The panel included both men and women and consisted of secretaries, faculty members, students, and technicians.

Figure 1.

Arrangement of Custard Specimens on the Plates

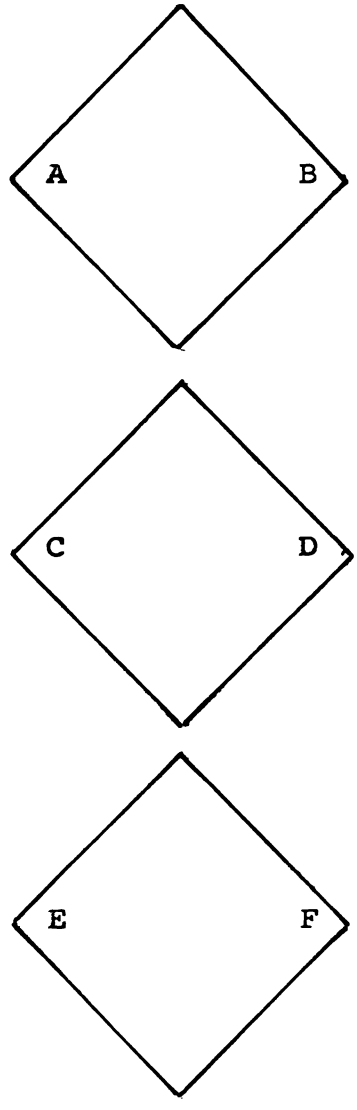

Plate No. 1

Plate No. 2

Plate No. 3

No special effort was exercised to obtain either expert or non-expert panelists; rather, they were selected on the basis of their availability for the duration of the experiment. Approximately 35 members were present each day to judge the products. Each panelist was advised of the importance of judging the products each day. It was anticipated that each panelist might not be able to participate daily because of sickness or other extenuating circumstances. This fact was taken into consideration in determining the statistical procedure used in the analysis.

Survey Methods and Panel Procedures

The custards were coded prior to baking so as to insure correct identification upon service. The code was as follows:

A - Fresh B - Frozen

C - Freeze-dried D - Dried

The preference for the custards was determined by a consumer test panel. Each panelist was given three plates--numbered 1, 2, and 3. One portion of two types of custards was placed on each plate. The panelist was instructed to taste both custards on plate number 1, and to select his preference. He was then requested to circle, on the answer

sheet, his preference; or, if no difference could be detected, to circle "no difference." (See Appendix B.) After scoring plate number 1, the panelist was instructed to proceed with plate numbers 2 and 3 in a similar manner.

When placing the custards on the plates, a system of coding was used so that the fresh egg custard did not appear in position A on plate number 1 more frequently than did the frozen, freeze-dried, or dried egg custard. Thus, each type of processed egg custard was placed in the different positions on the different plates an equal number of times, so as to reduce the possibility of bias.

The panel was given three days at the beginning of the study to become acclimated to the procedure. During these three days the system described above was used, with the exception that all specimens were identical, i.e., they were all from the same type of custard. This initial period permitted the panel to adjust to a new situation, to overcome the novelty, and to settle down to serious testing.

Table II illustrates the sequence and combination for testing the custards.

TABLE II

THE SEQUENCE AND COMBINATION FOR TESTING THE CUSTARDS

Week	Monday	Tuesday	Wednesday	Thursday	Friday
First	A vs B	A vs B	A vs C	A vs D	A vs B
	A vs C	B vs C	B vs C	B vs D	A vs C
	A vs D	B vs D	C vs D	C vs D	A vs D
Second	A vs B	A vs C	A vs D	A vs B	A vs B
	B vs C	B vs C	B vs D	A vs C	B vs C
	B vs D	C vs D	C vs D	A vs D	B vs D
Third	A vs C	A vs D	A vs B	A vs B	A vs C
	B vs C	B vs D	A vs C	B vs C	B vs C
	C vs D	C vs D	A vs D	B vs D	C vs D
Fourth	A vs D	A vs B	A vs B	A vs C	A vs D
	B vs D	A vs C	B vs C	B vs C	B vs D
	C vs D	A vs D	B vs D	C vs D	C vs D

A - Fresh
B - Frozen
C - Freeze-Dried
D - Dried

CHAPTER III

DATA AND DISCUSSION OF RESULTS

The panelists were instructed to judge each custard. After selecting a preference, the panelists circled this preference on the answer sheet (see Appendix B). Table III shows the summation of the responses given by the panelists.

The data was analyzed by the Chi Square (χ^2) Method. Arthur D. Little, Inc., in a survey of "Flavor Research and Food Acceptance," states that the analysis of the data can be accomplished in two ways, by either including or neglecting the "no difference" totals. The analysis of the data for this study was done both ways. Table IV shows the χ^2 values neglecting the "no difference" totals, and Table V shows the χ^2 values including the "no difference" totals.

TABLE III

TASTE PANEL RESPONSES

	Fresh	Frozen	Freeze-Dried	Dried	No Preference	Total
Fresh vs Frozen	69	91			176	336
Fresh vs Freeze-dried	82		109		150	341
Fresh vs Dried	87			152	100	339
Frozen vs Freeze-dried		67	120		156	343
Frozen vs Dried		88		123	130	341
Freeze-dried vs Dried			77	104	165	346

TABLE IV

COMPUTED χ^2 VALUES[14] (NEGLECTING "NO DIFFERENCE" TOTALS)

Products Compared	Values
Fresh vs Frozen	3.03
Fresh vs Freeze-Dried	3.81
Fresh vs Dried	17.68*
Frozen vs Freeze-Dried	15.02*
Frozen vs Dried	5.81*
Freeze-Dried vs Dried	4.03*

*Significant difference at the 95 per cent level ($\chi^2_{95\%}$ 3.84)

[14] J. P. Guilford, Fundamental Statistics in Psychology and Education. (New York & London: McGraw-Hill Book Company, Inc., 1942), p. 325.

TABLE V

COMPUTED χ^2 VALUES[15] (INCLUDING "NO DIFFERENCE" TOTALS)

Products Compared	Values
Fresh vs Frozen	1.44
Fresh vs Freeze-Dried	2.14
Fresh vs Dried	12.46*
Frozen vs Freeze-Dried	8.19*
Frozen vs Dried	4.18*
Freeze-Dried vs Dried	2.11

*Significant difference at the 95 per cent level ($\chi^2_{95\%}$ 3.84)

[15] Ibid.

Discussion of Results

The data was statistically analyzed by the Chi Square (χ^2) Method.[16] (see Appendix A) The χ^2 value, (neglecting the "no difference" totals), when comparing the fresh and frozen egg custards, was 3.03 (Table IV). This value statistically means that at the 95 per cent certainty level, with 1 degree of freedom, the fresh and frozen egg custards were not significantly different. The χ^2 value (including the "no difference" totals) was 1.44 (Table V). Again, this value means that the consumer taste panel could not distinguish between the two types of custards.

After completing the analysis of preference of the panel concerning fresh egg custards and freeze-dried custards, it can be said, statistically, that no difference could be detected. The χ^2 values were 3.81 (Table IV and 2.14 (Table V). Both values state that at the 95 per cent certainty level, with 1 degree of freedom, the panel could not distinguish between the fresh egg custard and the freeze-dried custard.

The computed χ^2 values for the comparison of fresh egg custards and dried egg custards were 17.68 (Table IV) and

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[16] Flavor Research and Food Acceptance. A survey of the scope of flavor and associated research, compiled from papers presented in a series of symposia given in 1956-1957, sponsored by Arthur D. Little, Inc. (New York: Reinhold Publishing Corp., 1958).

12.46 (Table V). It must be said in this comparison analysis that the panel could definitely detect a difference in the two types of custards and that they preferred the dried over the fresh egg custard. Again, this is at the 95 per cent certainty level with 1 degree of freedom.

Similarly, upon analyzing the data concerning the comparison of the frozen egg custard and the freeze-dried custard, it was evident that the panel preferred the freeze-dried. This was ascertained by the χ^2 values of 15.02 (Table IV) and 8.19 (Table V), again at the 95 per cent level of certainty with 1 degree of freedom.

Upon comparing the frozen egg custard and the dried egg custard, the χ^2 values were 5.81 (Table IV) and 4.18 (Table V). With 1 degree of freedom at the 95 per cent level of certainty, we must reject the premise that dried and frozen egg custards are non-distinguishable, and conclude that the panel prefers the dried.

The χ^2 value, when comparing the freeze-dried and the dried egg custards, was 4.03 (Table IV). This value statistically means that at the 95 per cent certainty level, with 1 degree of freedom, the freeze-dried and dried egg custards were different and that the panel

preferred dried over freeze-dried. The χ^2 value (Table V) was 2.11. This value means that the panel could not detect a difference.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Flavor preferences of freeze-dried eggs were compared with other processed eggs and fresh eggs. Baked custards were used as the test medium. The ingredients were eggs, milk, and sugar. Spices and flavoring were purposely omitted to avoid masking the flavor of the eggs. Sugar was used to an equal degree in each of the recipes. The weight-quantity of milk varied, depending on the type of egg used. An equal amount of milk was supplemented to offset the weight lost through drying and freeze-drying. A consumer preference panel was utilized to determine which type of baked custards was preferred.

The data was statistically analyzed by the Chi Square (χ^2) Method.

Statistical evidence showed that freeze-dried egg custards were preferred over frozen egg custards, but that the panel could not detect any significant difference between custards prepared from freeze-dried and fresh eggs. However, dried egg custards were preferred over freeze-dried.

Dried egg custards were also preferred over those using fresh and frozen eggs. The panel was unable to distinguish any difference between custards made from fresh eggs and those made from frozen eggs.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Advances in Food Research, Vol. VII. Edited by E. M. Mrak and G. F. Stewart, (New York: Academic Press, Inc., 1957).

Chambers's Technical Dictionary. Edited by C. F. T. Tweney and L. E. C. Hughes. (New York: The MacMillan Co., 1956.)

Flavor Research and Food Acceptance. A survey of the scope of flavor and associated research, compiled from papers presented in a series of symposia given in 1956-1957. (New York: Reinhold Publishing Corp., 1958.)

Flosdorf, Earl W., Freeze-Drying (Drying by Sublimation). (New York: Reinhold Publishing Corp., 1949.)

Freezing and Drying. Report of a Symposium held in June, 1951. (New York: Hafner Publishing Co., Inc., 1952.)

Guilford, J. P., Fundamental Statistics in Psychology and Education. (New York & London: McGraw-Hill Book Company, Inc., 1942.)

Justin, Margaret M., Lucile Osborn Rust, and Gladys E. Vail, Foods. (Houghton Mifflin Co., Boston. The Riverside Press, Cambridge, 1956.)

Lowe, Belle, Experimental Cookery from the Chemical and Physical Standpoint. (New York: John Wiley & Sons, Inc., 1955, 4th Edition.)

B. PERIODICALS

Rolfes, T., P. Clements, and A. R. Winter, "The Physical and Functional Properties of Lyophilized Whole Egg, Yolk, and White," Food Technology 9, p. 569 (1955).

C. UNPUBLISHED MATERIAL

Mastic, Marjorie E., "The Effect of Homogenization on the Gelatin and Palatability of Baked Custards Prepared with Dried Whole Egg Solids." Unpublished Master's thesis, Michigan State University, 1959.

D. OTHER SOURCES

Correspondence and interviews with R. W. Kline, PhD., Research Division, Armour and Company, Chicago, Illinois.

APPENDIX

APPENDIX A

χ^2_A = "No difference" totals neglected

$$\chi^2_A = \frac{(\text{Total fresh} - \text{Average of fresh \& frozen})^2 + (\text{Total frozen} - \text{Average of Fresh \& frozen})^2}{\text{Average of fresh \& frozen}}$$

Total fresh = F
Average of fresh & frozen = G
Total frozen = H

$$\chi^2_A = \frac{(F - G)^2 + (H - G)^2}{G}$$

χ^2_B = "No difference" totals included

$$\chi^2_B = \frac{\left(\text{Tot. fresh} + \tfrac{1}{2}\text{ no dif.} - \frac{\text{fresh + froz. + no dif.}}{2}\right)^2 + \left(\text{Tot. froz.} + \tfrac{1}{2}\text{ no dif.} - \frac{\text{fresh + froz. + no dif.}}{2}\right)^2}{\frac{\text{fresh + froz. + no dif.}}{2}}$$

$$\text{Total fresh} + \tfrac{1}{2}\text{ no difference} = M$$

$$\frac{\text{Fresh + froz. + no difference}}{2} = Q$$

$$\text{Total froz.} + \tfrac{1}{2}\text{ no difference} = R$$

$$\chi^2_B = \frac{(M - Q)^2 + (R - Q)^2}{Q}$$

APPENDIX B

ANSWER SHEET FOR PANELIST TO SHOW PREFERENCE

Date _____

FROM EACH PLATE SELECT AND CIRCLE YOUR PREFERENCE

PLATE	(Circle one)		
1	A	B	No difference
2	C	D	No difference
3	E	F	No difference

Name _____