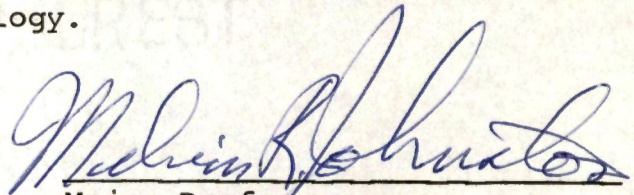


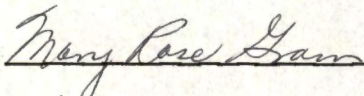
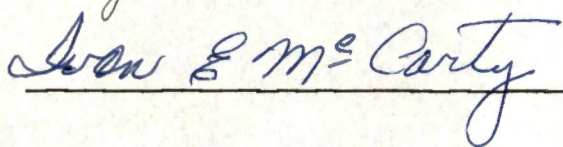
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To the Graduate Council:

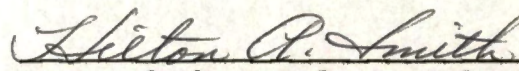
I am submitting herewith a thesis written by Amornrat Swatditat entitled "Relationship of Freezing Rates on the Quality of Freeze-Dried Chicken." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology.


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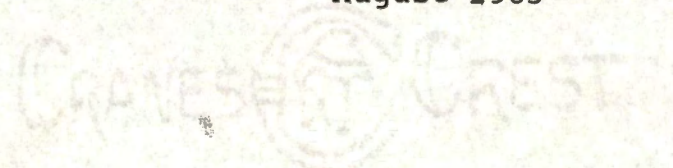
RELATIONSHIP OF FREEZING RATES ON THE QUALITY OF
FREEZE-DRIED CHICKEN

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Amornrat Swatditat

August 1965



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CHAPTER I

INTRODUCTION

Freeze-drying as a food preservation process is being developed in the second half of the twentieth century. It produces dehydrated foods of higher quality than the other conventional methods. The quality of the freeze-dried product must be high enough to compensate for the increased production costs. Products which appear to have the greatest immediate commercial potential in the freeze-dried form are sausage, beef steak, hamburger, pork chops, ham, shrimp, and chicken dices. The only major application of freeze-dried chicken has been in the manufacture of dehydrated soups.

Although the methods of preparation and properties of freeze-dehydrated poultry have been investigated by a number of workers, the factors affecting the quality of freeze-dried chicken are not all solved. Deterioration may occur any time from processing to storage room. There are additional research needs for freeze-drying process in processing, products, and equipment.

This study was made in an attempt to (1) illustrate the effect of the freezing rates on histological structure, (2) determine the effect of the freezing rates on organoleptic attributes of flavor, texture, and color, and (3) determine the effect of freezing rates on the dehydration ratio, rehydration ratio, per cent total nitrogen, and per cent total solids in rehydrating medium.

CHAPTER II

REVIEW OF THE LITERATURE

I. PROCESSING

Dehydration by freeze-drying is not a new field of food preservation. Flosdorf (11)* gave a good review of the early development of the process. Freeze-drying is simple in principle. The moisture is removed from the frozen product by sublimation without changing the form, color, or flavor of the product. Moisture content of the finished product is approximately 2 per cent, as indicated by Bird (5), Harper, and Tappel (19).

Tisher and Brockmann (37) pointed out that freeze-drying was better than other conventional means of drying. The freeze-dried product was porous, less dense than the original, little changed in color and normal in odor. Storage stability was excellent when it was protected against water vapor and oxygen. In the reconstituted product, color, odor, and flavor were normal and texture was tough.

* The numbers in parentheses represent similarly numbered references in the Bibliography.

Bird (5) indicated that the freeze-drying had better commercial application for meat products than other commodities because of the high processing cost.

In the freeze-drying processing technique, the products must be kept completely frozen during the drying process (19). The various methods of freezing have been used. Previous work (19) suggested that rapid freezing could be done in an air blast freezer, acetone chilled with dry ice, isopentane cooled with liquid nitrogen, and liquid carbon dioxide. The slow rate of freezing could be done in a still air cold room.

Ryan (29) indicated the relationship among pressure, temperature, and time during the freeze-drying process. He found that the time depended upon low pressure and temperature and other characteristics of the product. It was suggested (19) that plate temperature ranging from 20 to 130°F caused no significant variation in product quality. Yoa et al. (46) added that the interior product temperature of 96°F might prevent the product from heat damage during dehydration, and could be as high as 130°F. Pressure between 0.1-2.0 mm. was recommended.

In freeze-drying, Van Arsdel (39) noticed that water vapor was sublimed without allowing melt back. If the products were in a frozen state and a very fast pump down was used, the melt back as described by Ryan (29) would be eliminated.

II. HISTOLOGY

Muscle fiber is composed of myofibrils and myofilaments. Myofibrils are surrounded by a homogeneous matrix, sarcoplasm, and a membrane sheath, sarcolemma. Sarcolemma forms into muscle fibers and are separated by connective tissue, endomysium. Primary muscle fiber bundles are bound by large sheets of connective tissues, the perimysium. These primary bundles are composed of secondary bundles, and so forth. The edible tissue of poultry is composed of these muscle fiber bundles (15).

Lowe (25) reported the histological changes in fibers of uncooked and cooked poultry. The muscle fibers of a freshly killed chicken are usually wavy, but may be straight. During cooking, the fibers were separated and straightened. Wang et al. (41) employed the paraffin and celloidin embedding technique to study the effect of cooking and dehydrating

of beef by conventional drying methods. The tissues were sectioned at 10 microns and stained with hematoxylin and Van Gieson's. There was a direct relationship between fiber shrinkage and moisture loss during cooking and dehydration.

Koonz and Ramsbottom (24) studied the effect of freezing rates on uncooked poultry by the method suggested by Gersh (12), and noted that at slow rate of freezing (-15°F or above), the ice crystals formed intercellularly. The ice crystals became larger, fewer in number and bundles of muscle fibers were forced into compact groups. At -104°F small pieces of the sample froze in a few seconds. The ice crystals were very small and numerous and resembled fresh, unfrozen tissue. They were identified as an intra-fiber formation. A whole bird frozen at -55°F showed a different formation, because of slow freezing. The fibers appeared to be distorted and were characterized by a jagged outer surface. The ice crystals formed within the sarcolemma, parallel to the long axis of the fibers.

Wang et al. (40) studied different pre-frozen temperatures of the beef muscles before freeze-drying. The samples were divided into two portions. One portion was put

into absolute ethyl alcohol for histological study. The other was rehydrated and fixed in 10 per cent neutral formalin for histological processing. Sections were cut at 10 microns and stained with hematoxylin and Van Gieson's. The tissue that was pre-frozen, by immersing for three minutes in isopentane, and cooled to -150°C by liquid nitrogen, had microscopic size ice crystals formed in the intracellular spaces. They found that when pre-freezing in dry ice at -80°C for half an hour, the muscle fibers were altered, owing to mixed intra- and intercellular ice crystal formation. In a slower freezing rate, at -17°C in a cold room, the fiber bundles were packed together. This morphology resulted from complete intercellular freezing. Muscle fibers of the rehydrated tissue reconstituted best from the slow freezing rate.

Hiner et al. (20) studied the histological characteristics of beef as related to the temperature of freezing by the frozen section method. They examined both the longitudinal section and the transverse section in the frozen state. The staining and mounting methods were done by enrolling the section carefully on a cold slide. The sections were thawed and fixed in 70 per cent alcohol overnight, then stained with hematoxylin and eosin. The effect of ice crystal formation

at various temperatures--18, 0, -10, -40, and -114°F--were the same as in previous studies. At a slow rate of freezing, ice crystals formed in the intercellular fibers at a more rapid rate than in the intracellular fibers (27).

Woolrich and Bartlett (45) made microscopic observations of frozen food specimens using the same technique as the mineralogist employed for thin sectioning of brittle materials. The frozen specimen was cut on one side and cemented to a chilled microscope slide. It was then cut again to leave a thin section upon the slide. The prepared section was protected against dehydration by a drop of chilled ice-machine oil and a cover glass. They also used another method of mounting by pressing the unfrozen specimen upon a clean slide and freezing. The excess frozen material was cut away to make a thin section on the glass. The sections were examined by means of a petrological microscope. The ice crystals presented contrasting interference colors to other microscopic substances. They revealed that in rapid freezing, the smallest ice crystals were much larger than individual cells. One crystal contained many cells. The crystal lattice was continuous both inside the cell and in the intercellular lattice. They found in slow freezing,

that the cell walls were not punctured by growing ice crystals; however, there was an increase in osmotic pressure and an irreversible colloidal change.

III. REHYDRATION

Goldblith et al. (14) summarized that the rehydration of freeze-dried shrimp was affected by (1) temperature during dehydration, (2) cooking time and temperature, (3) rate of freezing, and (4) temperature of rehydration water. Rehydration decreased with long cooking time at high temperatures. Decreasing the freezing temperature of the rehydrating medium (212, 160, 130, 100, 70, and 40°F) increased the rehydration ratio. Yoa et al. (46) added that the rehydration ratio increased when the drying temperature increased.

Auerbach et al. (2) investigated five other factors which influenced the rehydration of freeze-dried muscle tissues: (1) orientation of muscle fibers, (2) thickness of the sample, (3) osmotic pressure of rehydrating solution, (4) pH of rehydrating solution, and (5) rehydration under vacuum. Transverse slices of muscle tissue rehydrated more rapidly and to a higher moisture content than the longitudinal slices. The rate and level of rehydration decreased as

the thickness of the sample increased. The highest level of rehydration occurred in solutions of decreased hypertonicity, with a pH of 7.0, regardless of the salt concentration.

Rehydration became more rapid and reached a higher level when conducted under vacuum. They observed no difference in the rehydration ratio when the temperatures of rehydrated medium were at 22 and 55°C.

Auerbach et al. (2) indicated that freshly prepared freeze-dried beef rehydrated to a level of 80 per cent to 100 per cent of its original moisture content. Regardless of the pre-freezing temperature, Wang et al. (40) pointed out that all freeze-dried uncooked meat rehydrated from 85 per cent to 90 per cent of the original water content.

Ballemtyne et al. (3) noted that typical freeze-dried cooked meat should be ready for eating after soaking in hot (180-212°F) water, broth, gravy, and so forth, or simmering for 10 minutes or less. This was supported by Sosebee et al. (32) in their work which employed the same procedure as Ballemtyne for obtaining the percentage of rehydration of freeze-dried sample.

Turner (38) suggested the method of rehydration of freeze-dried meat affected the quality of the final product.

The best results were obtained by the addition of 1.5 to 2.0 per cent sodium chloride (NaCl) and 0.1 to 0.15 per cent tetrasodium pyrophosphate ($\text{Na}_4\text{P}_2\text{O}_5 \cdot 10 \text{H}_2\text{O}$) to the water and rehydration under vacuum. These salts increased hydration and improved the water holding capacity of the product.

Goldblith et al. (13) indicated that the loss of water holding capacity was affected by protein denaturation. If the meat was cooked before freeze-drying, protein denaturation might be affected by the temperature of cooking, freezing, and freeze-drying (dehydration) with some toughening of the tissues. Heating at elevated temperatures caused protein denaturation as shown by Hamm and Deatherage (18). Increasing the temperature resulted in decreased solubility of globular protein and water holding capacity.

Deatherage and Hamm (9) reported the effect of freezing and thawing on hydration of the muscle proteins. Quick freezing with acetone-carbon dioxide ice mixture for 15 minutes at -55°C gave a very small but significant increase in the water holding capacity of the protein. It was pointed out that the formation of tiny ice crystals inside the cells caused a mechanical loosening of the tissue structure. Slow freezing at -15°C gave a significantly small decrease in the

water holding capacity due to destruction of protein structure by large ice crystals between the muscle fibers.

Hamm and Deatherage (17) noted that freeze-dried beef decreased in water holding capacity only in the isoelectric pH range of the muscle protein. The protein structure was a tighter network, probably due to the peptide chain, after drying, lay more closely together. The undesirable changes in meat during freeze-drying were due to the combination of freezing and dehydration process and were not identical with the effect of heat denaturation. Hamdy, et al. (16) added that freeze-drying caused the denaturation of protein with the resulting changes in permeability of the fibers. Suden et al. (34) found that denaturation of the sarcoplasmic proteins of pork resulted from freeze-drying with decreased concentration of nitrogen in the sarcoplasmic protein fraction.

Lowe (25) discussed the protein in muscle of poultry and divided it into two main types: (1) the intercellular or structural protein, composed mostly of collagen and elastin, and (2) the intracellular or protoplasmic proteins composed of myosin and nonmyosin fraction (globulin, myogen, and albumen). Myosin is a hydrophillic colloid, soluble in water. Its isoelectric point is pH 5.3. Actin is also a

hydrophillic colloid with an isoelectric point of pH 5.7.

Cole and Smithies (7) divided muscle proteins into four groups according to their solubility: (1) corpuscular protein including heamprotein soluble in dilute salt solution (0.15M) at neutral pH, (2) proteins of the muscle fiber (myosin, actin) soluble in strong salt solution, (3) proteins soluble in 0.1 N NaOH and insoluble in high concentrations of salt solution, and (4) connective tissue (collagen and elastin) insoluble in 0.1 N NaOH.

Previous work presented by Hunt and Matheson (22,23) showed that actomysin is an enzyme. It can hydrolyze adenosine triphosphate (ATP) and inorganic phosphate. The amount of the adenosine triphosphatase (ATPase) activity indicated the denaturation of actomysin, and was soluble in 0.5M potassium or sodium chloride solution.

Fat content was another factor that affected the low rehydratibility of the dehydrated meat as indicated by Doty et al. (10) and Tappel et al. (35).

Watt and Merrill (42) reviewed the composition of chicken (broiler) in Agriculture Handbook No. 8 as follows:

	Per Cent		
	<u>Water</u>	<u>Protein</u>	<u>Fat</u>
Light meat without skin			
Raw	77.2	20.5	1.5
Cooked, fried	59.5	32.1	6.1
Dark meat without skin			
Raw	77.3	18.1	3.8
Cooked, fried	57.5	30.4	9.3

IV. PALATABILITY STUDY

Bird (4) reported a palatability test developed by the U. S. Department of Agriculture to compare freeze-dried foods with canned or frozen foods. The freeze-dried items included beef, pork, chicken, seafoods, soups, and several mixtures of foods which were obtained from retail stores or directly from wholesale warehouses. The quality characteristics, general acceptability, appearance, flavor, juiciness, texture, and tenderness were evaluated by giving a score: five--very good, four--good, three--fair, two--poor, and one--very poor. F tests were used throughout the analysis. Most freeze-dried foods were acceptable, none received an unacceptable score, and two-thirds of them were as good as the conventionally processed foods. The freeze-dried product generally was rated poorer than the conventional product, except when it was a part of a mixture. Other

ingredients such as spices may mask the lack of flavor. There were some comments which indicated the freeze-dried chicken to be "tough," "woody," and "weak in flavor" when served plain.

Burke and Decareau (6) noted that the texture, flavor, and color of freeze-dried foods were the major organoleptic attributes. Connell (8) found that toughness and lack of juiciness in raw meat and fish were the most common defects of freeze-drying. This was related to particular changes in the myofibrillar proteins, actin and myosin. Myosin was readily denatured by freeze-drying. Carbonylamine browning reaction was another important cause of the deterioration of freeze-dried beef. Protein became insoluble and could have been responsible for toughening. Toughness could be developed in the absence of browning during the freeze-drying process.

Burke and Decareau (6) found that freeze-dried meat stored in the presence of oxygen became rancid. Maillard type reactions resulted in the development of a meatlike flavor followed by unpalatable, bitter, burnt, and haylike flavors. This reaction was accelerated by high storage temperatures and high moisture content. The terms "off flavor"

and "flavorless" were usually used for products such as sliced beef, beef stew, and dried chicken (43).

Harper and Tappel (19) pointed out that there was a color change involved in the deterioration of freeze-dried raw beef. There was a color loss or color change from pink to reddish brown to brown. During freeze-drying, the oxymyoglobin was deoxygenated. This free myoglobin was very labile to oxidation during storage and the color changed to tan.

Harper and Tappel (19) found that freeze-dried chicken was reasonably good. Because of rehydration characteristics, it could be cooked by ordinary methods to a product of good color and flavor, although it had a dry texture and was tough. Due to the low concentration of hematin compounds in chicken, especially in the white meat, oxidative deterioration of the protein progressed at a slow rate.

Tappel et al. (36) reported that precooked freeze-dried chicken was one of the best freeze-dried products in terms of organic properties. Freeze-dried chicken, packaged with desiccant and gassed with pure nitrogen, showed good storage stability during six months approximately at 100°F.

Seltzer (30) found that freeze-dried chicken required

unusual care or the product might be stringy and of poor shelf life. Dried chicken deteriorated very rapidly when exposed to air and stored in summer temperature. Fat oxidation was rapid too, unless the meat was protected by high vacuum and inert gas packing. The induction period of fat rancidity could be completed during processing and drying.

Bird (4) summarized that the quality of freeze-dried food was affected by many factors: the rate of freezing, the temperature and time of freezing, fat content of food, length of time in storage and storage temperature, temperature and rehydration method, moisture and oxygen content, ways the food was handled, and many others.

CHAPTER III

MATERIAL AND METHODS

The chickens used in this study weighed about two to two and a half pounds and were purchased in the local market. They were already separated into breasts and thighs and were kept in 40°F storage room until they were ready to process.

In preparation for freeze-drying, the chickens were weighed and cooked in boiling water in a steam jacketed kettle (7-9 pounds per square inch jacket pressure). The white meat was boiled for 15 minutes and the dark meat for 20 minutes. They were weighed after cooking. The meat was separated and diced into 3/8-inch cubes and weighed. The meat cubes were frozen at three different rates of freezing:

(1) 0°F still air cold room, (2) -30°F air blast freezer, and (3) -180°F immersion freezing in Freon 12. The frozen meat was removed from the freezer immediately and freeze-dried for 18 hours at 90°F. The pressure during freeze-drying ranged from 0.15 to 2 mm. mercury. The meat was weighed again after freeze-drying. The dehydration ratio was calculated. The freeze-dried meat was then stored at

room temperature in glass jars over calcium chloride.

During freeze-drying, thermocouples were inserted into the samples and on the shelf to record temperature rise against time of dehydration. The pressure was also read at the same time.

The freeze-drying unit was a Del-Vac Freeze-Dryer, Model 11212 RVM of American Sterilizer Company. The area of the drying shelf was 12 square inches. A Freon 22 coil was used as a condenser to freeze out the water vapor before it could enter the pump.

In the histological study, the meat was sampled at three intervals: (1) after cooking, (2) after freezing, and (3) after freeze-drying. The cooked meat was cut into 3/16-inch blocks and fixed in 10 per cent formalin in 90 per cent alcohol for 24 hours. The sections were dehydrated and infiltrated with paraffin. The frozen meat was fixed in a similar fixing solution for 24 hours and then cut into 3/16-inch blocks before transferring into 95 per cent alcohol. The sections were dehydrated and infiltrated with paraffin (21).

The freeze-dried samples were infiltrated directly in melted paraffin. The melted paraffin was poured into a test tube and the dehydrated blocks of tissue were dropped into

the melted paraffin. Vacuum was drawn at one hour intervals to speed up the rate of infiltration.

Palaplast with a melting point of 56-57°C was used as the tissue embedding media.

After all the tissues were infiltrated, they were embedded in paraffin. Both longitudinal and transverse sections were cut with rotary microtome at 15 microns.

The cooked and frozen sections were affixed to the slide with albumen fixative and water. The dry method of placing the freeze-dried sections on slides was used. The sections were flattened with the finger on the slides covered with a thin film of albumen fixative. The slides were warmed until the paraffin was just melted and were then cooled immediately. The sections were again flattened carefully while the paraffin was solidifying.

Subbed slides were used for freeze-dried longitudinal sections. They were prepared by dipping clean glass slides several times in subbing solution, then allowing them to air dry. The subbing solution was composed of 5 gm. gelatin, 0.5 gm. chrome alum and 1,000 ml. distilled water.

The section was then stained with eosin. The celloidin solution (0.2 per cent) was used to hold the tissue

together during staining of freeze-dried sections which were held horizontally while staining.

A triangle taste test was used for organoleptic evaluation of the freeze-dried chicken (26). Forty grams of freeze-dried chicken were placed in 160 ml. boiling water which contained 1 gm. of salt. The heat was turned off and the freeze-dried chicken was left in a covered container for 10 minutes. The chicken was drained for 2 minutes on tared eight mesh screen. Then both screen and chicken were weighed. The rehydration ratio was calculated. The water left from rehydration was also measured. The rehydrated freeze-dried chickens were kept warm in an oven at 150°F until they were ready to be served.

The frozen chicken was used as a control sample. The fresh chickens from the same source were frozen in the air blast freezer at -30°F. The frozen chickens were taken from the storage room and placed in boiling water containing 1 per cent salt in a steam jacketed kettle (7-9 pounds per square inch jacket pressure). The white meat was boiled for 30 minutes and the dark meat for 35 minutes. The meat was separated from the skin and bone and diced into 3/8-inch cubes. They were kept warm the same as the rehydrated

freeze-dried chicken.

The samples were judged for flavor, texture, and color. The flavor and texture evaluation was made under a red light. Five to six cubes of chicken were placed in white paper cups 1.5 inches in diameter. For color judgment, the samples consisting of about ten cubes were placed in evaporating dishes 3.5 inches in diameter. There were six different possible orders of presentation, AAB, ABA, BAA, BBA, BAB, and ABB. The way the samples were presented was randomized from Ten Thousand Random Digits given by Steel and Torrie (33) for each factor. Seven to ten judges were asked to indicate the odd sample and described briefly the difference they observed. The samples were presented alternately each time for freeze-dried chicken with different rate of freezing and the type of meat. The freeze-dried chickens were stored for a period of 8-10 weeks before being evaluated by a taste panel. The results from the triangle taste test were evaluated from the table of Probability in Triangular Taste Tests given by Roessler et al. (28)

The rehydrating water was analyzed for per cent total nitrogen by the Modified Kjeldahl Method by Anderson (1). Per cent total solids was determined by evaporating known

weight of sample in a hot air oven at 100°C for 4 hours (44).

The results of per cent total nitrogen, per cent total solids, dehydration ratio, rehydration ratio, and the milliliters of water left from rehydration were statistically analyzed using the analysis of variance and Duncan's Multiple Range Test. The analysis of variance was conducted according to the methods of Snedecor (31).

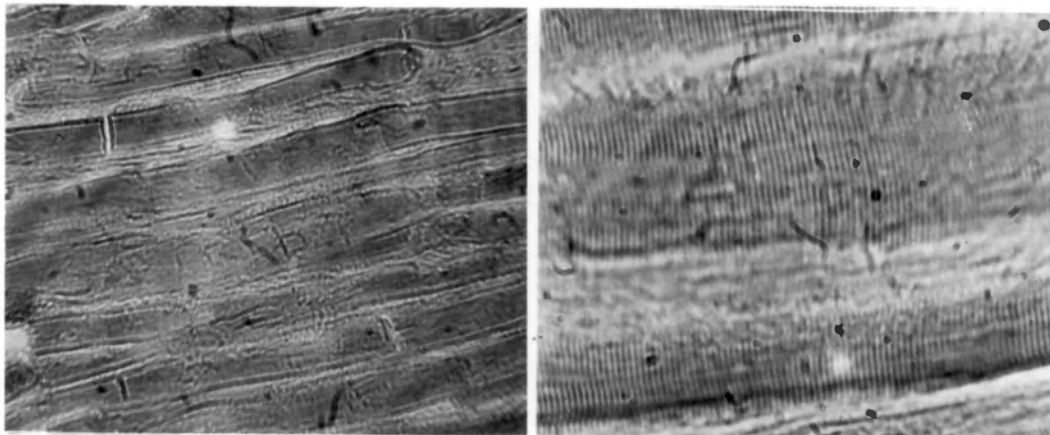
CHAPTER IV

RESULTS AND DISCUSSION

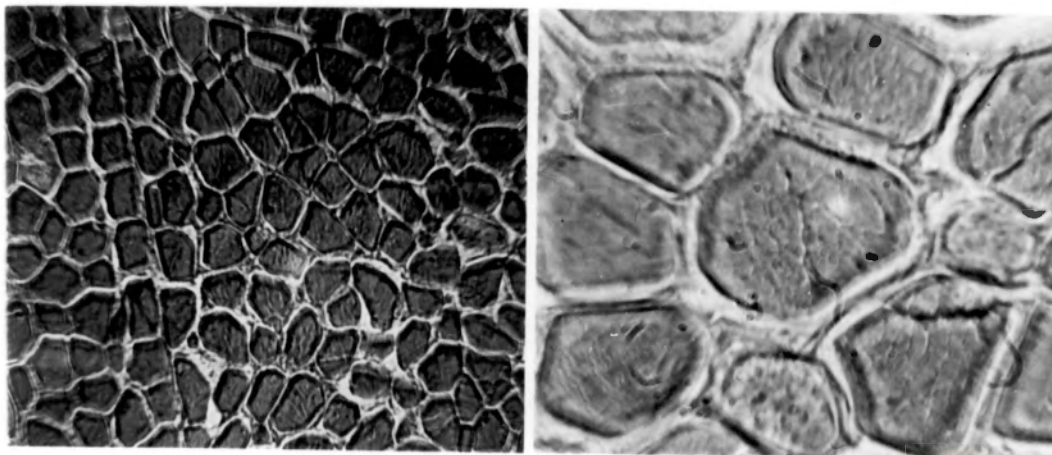
I. HISTOLOGICAL STRUCTURE

Several tissue sections were stained to observe the effect of ice crystal formation at different freezing rates. The muscle fibers of the control, cooked white meat, are shown in Plate I(a) for the longitudinal section and Plate I(b) for the transverse section. The frozen sections, Plate II, prepared by the method described previously did not show any difference from the control sections of Plate I. Plate III illustrates the longitudinal and transverse sections of freeze-dried white meat frozen at 0°F. The spaces between the fibers were large and non-uniform in size which might be due to the compaction of the muscle fibers. At freezing rate -30°F, the spaces between the fibers were small and non-uniform, as shown in Plate IV. The freeze-dried white meat sections frozen at -180°F, as illustrated by Plate V, were almost the same as the control.

Histological structures of the control, cooked,



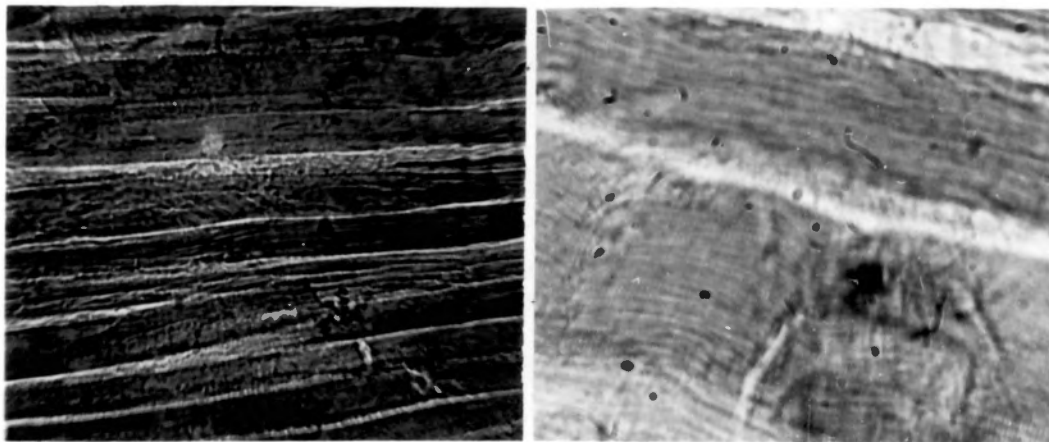
a. Longitudinal Section



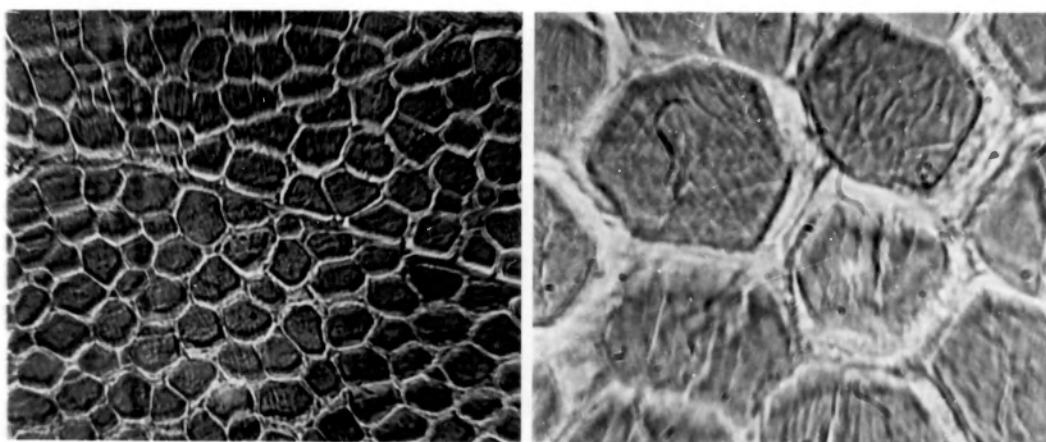
b. Transverse Section

PLATE I

PHOTOMICROGRAPH OF A CONTROL COOKED WHITE MEAT



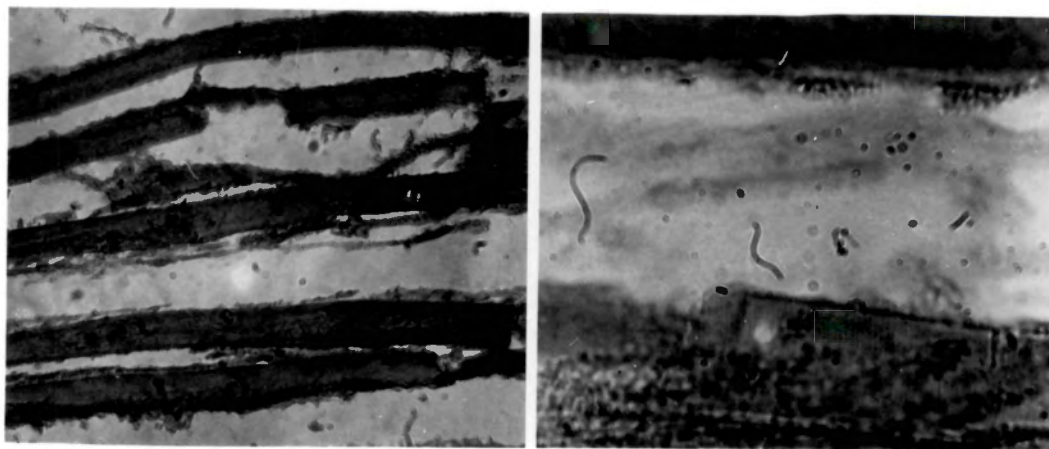
a. Longitudinal Section



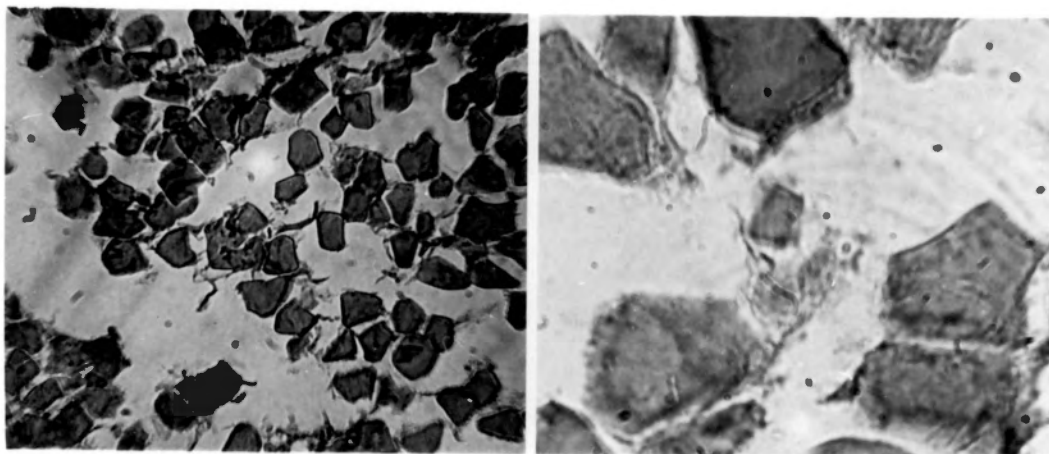
b. Transverse Section

PLATE II

PHOTOMICROGRAPH OF WHITE MEAT FROZEN AT 0°F



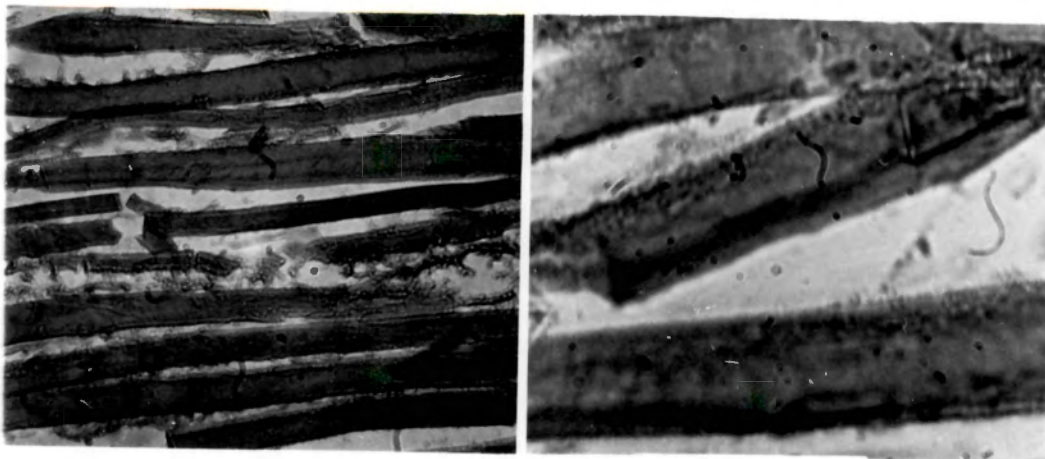
a. Longitudinal Section



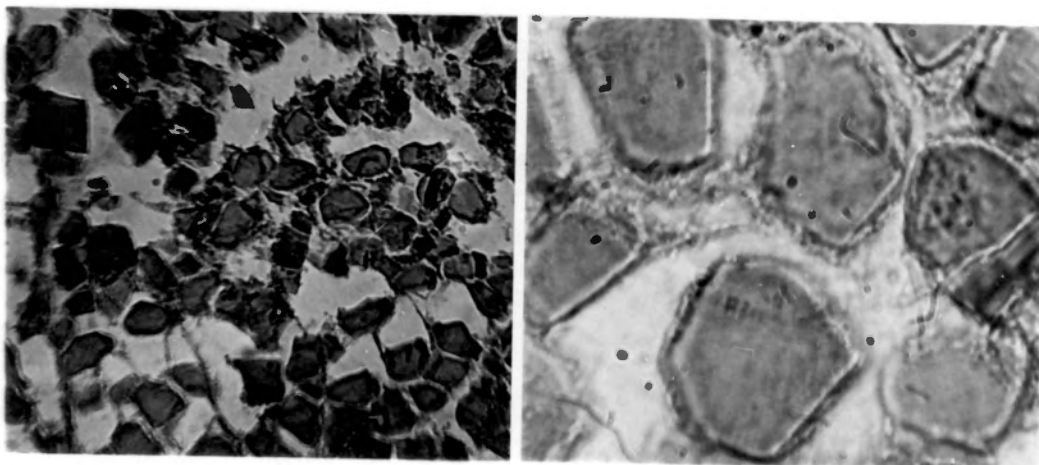
b. Transverse Section

PLATE III

PHOTOMICROGRAPH OF FREEZE-DRIED WHITE MEAT
FROZEN AT 0°F



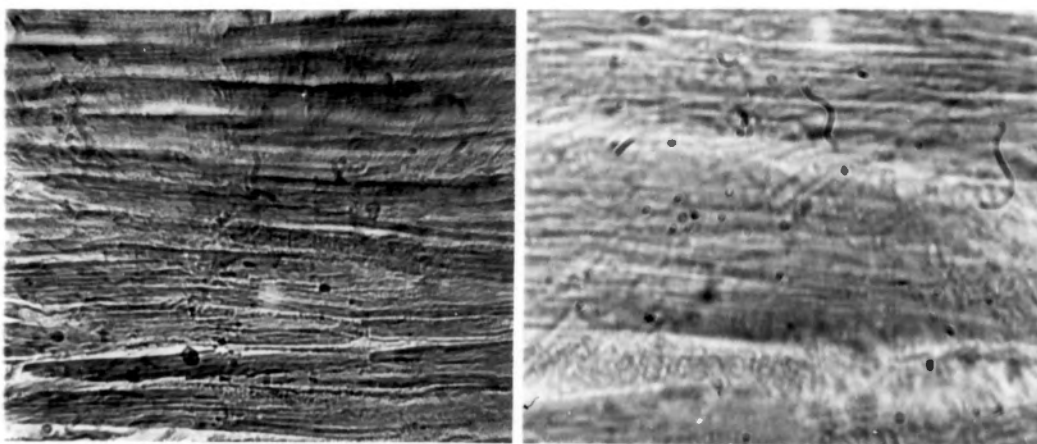
a. Longitudinal Section



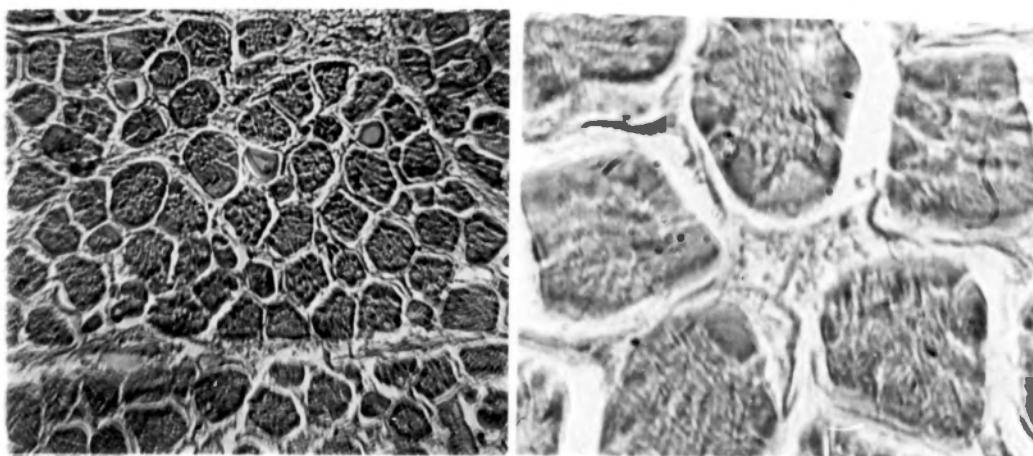
b. Transverse Section

PLATE IV

PHOTOMICROGRAPH OF FREEZE-DRIED WHITE MEAT
FROZEN AT -30°F



a. Longitudinal Section



b. Transverse Section

PLATE V

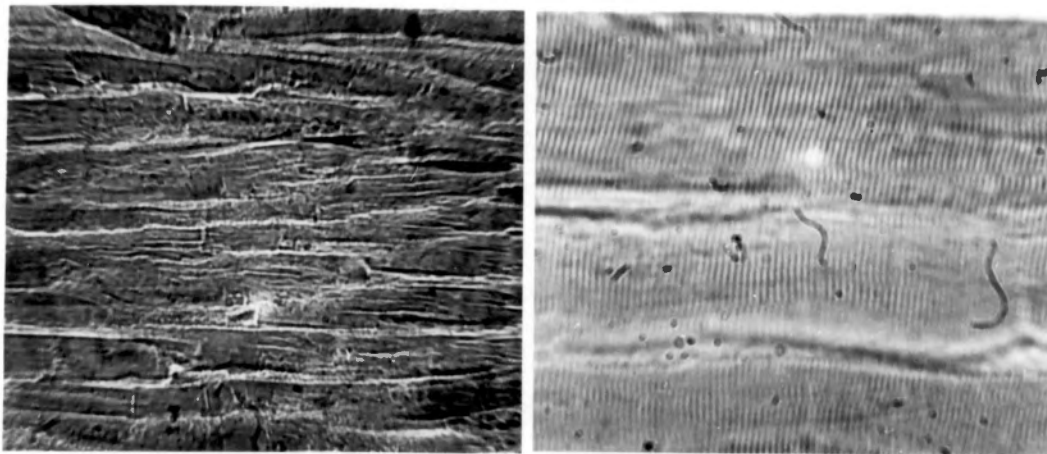
PHOTOMICROGRAPH OF FREEZE-DRIED WHITE MEAT
FROZEN AT -180°F

frozen, and freeze-dried dark meat, presented the same picture as the white meat, as shown in Plates VI through X.

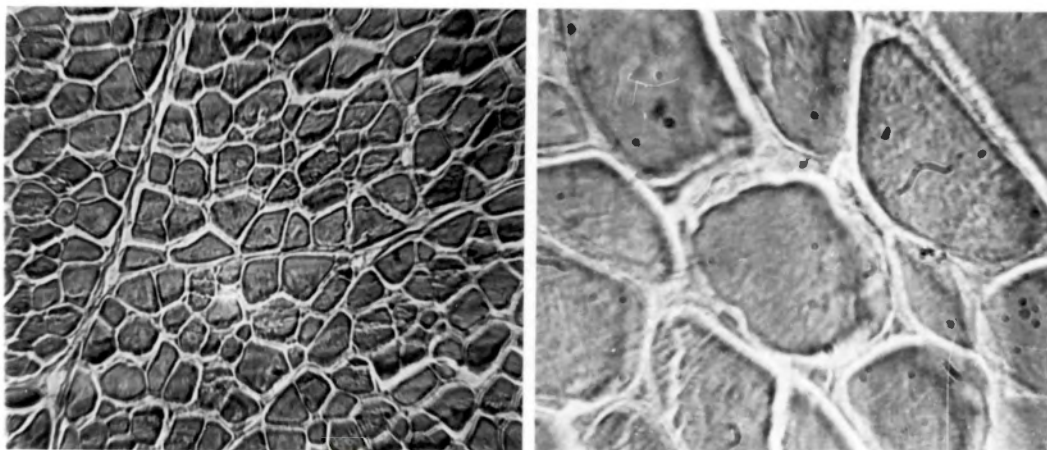
II. EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC CHARACTERISTICS OF TWO KINDS OF CHICKEN MEAT

White meat. Triangle taste test was conducted to evaluate flavor, texture, and color of freeze-dried chicken. The effect of the freezing rates on the organoleptic evaluation of flavor, as shown in Table I, indicates that the freeze-dried chicken frozen at 0°F gave variable results in flavor within replications; highly significant difference, significant difference, and no significant difference. At -30°F, there was a significant difference at the 0.05 level but at -180°F, there was no significant difference among replications. A summary of three replications showed a significant difference above 0.05 level among the three different rates of freezing.

The effect of the freezing rates on the organoleptic evaluation of texture of white meat, as shown in Table II, indicates that at 0°F, the results were the same as in flavor. At -30°F, only one replication showed a significant



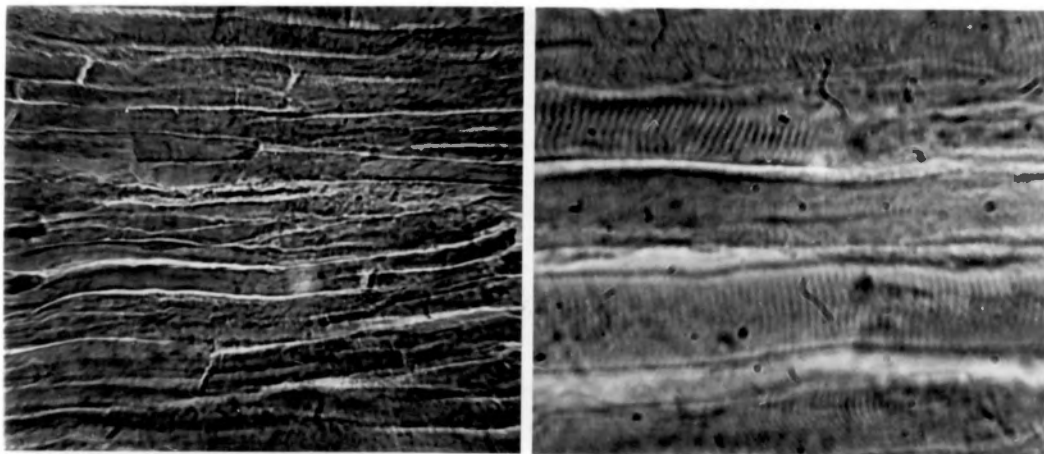
a. Longitudinal Section



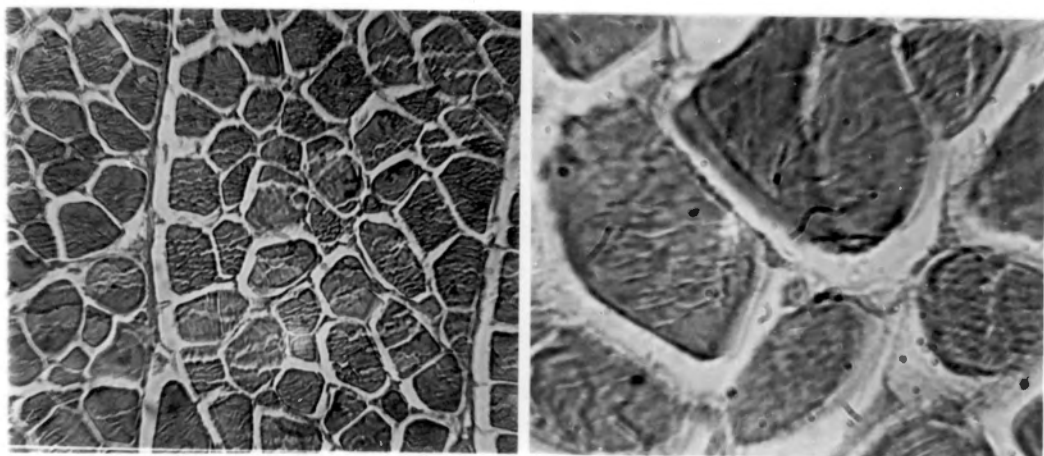
b. Transverse Section

PLATE VI

PHOTOMICROGRAPH OF A CONTROL COOKED DARK MEAT



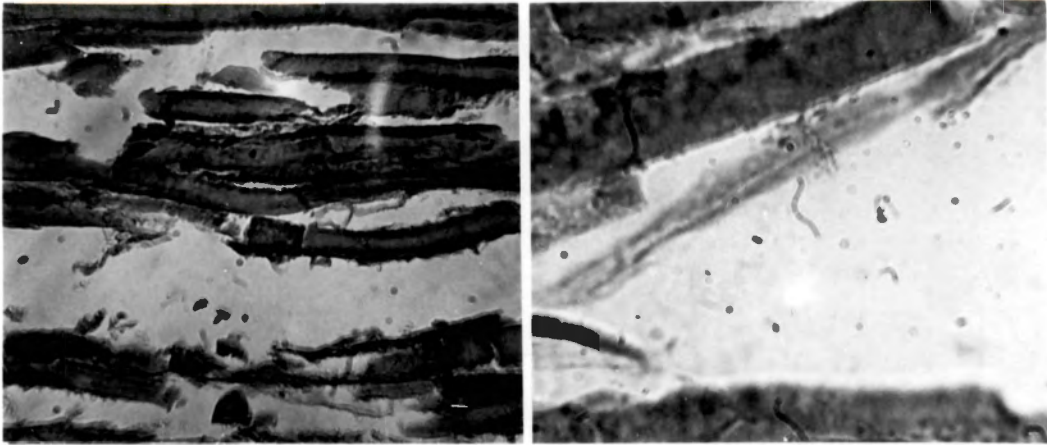
a. Longitudinal Section



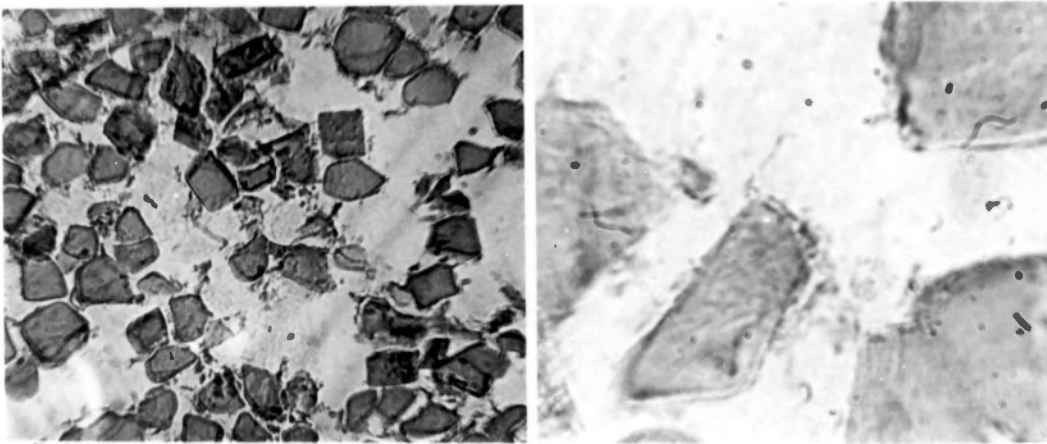
b. Transverse Section

PLATE VII

PHOTOMICROGRAPH OF DARK MEAT FROZEN AT -30°F



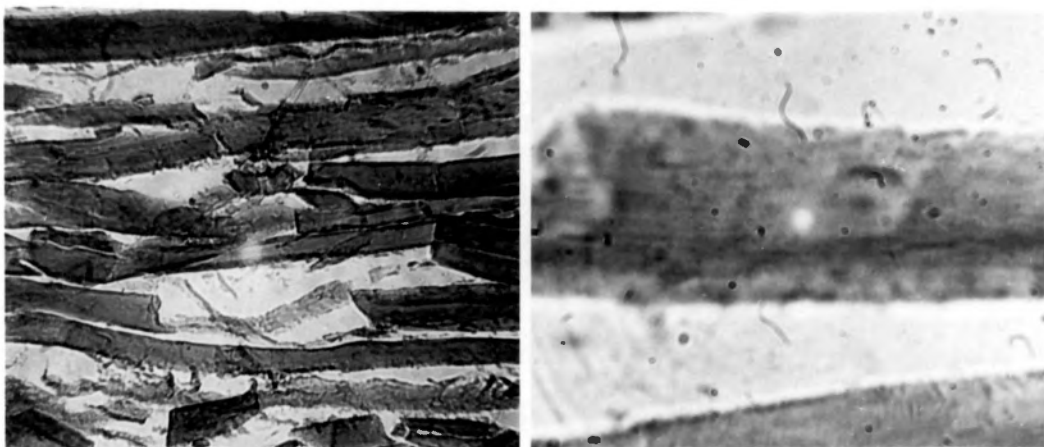
a. Longitudinal Section



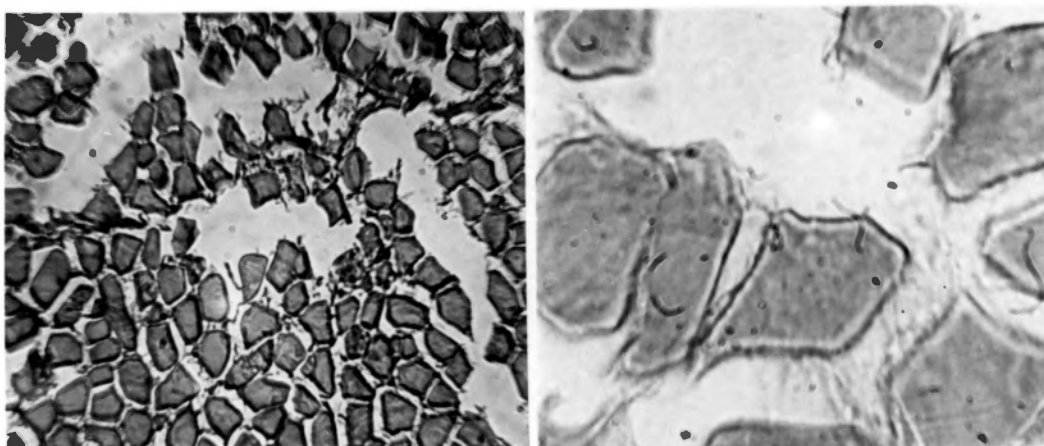
b. Transverse Section

PLATE VIII

PHOTOMICROGRAPH OF FREEZE-DRIED DARK MEAT
FROZEN AT 0°F



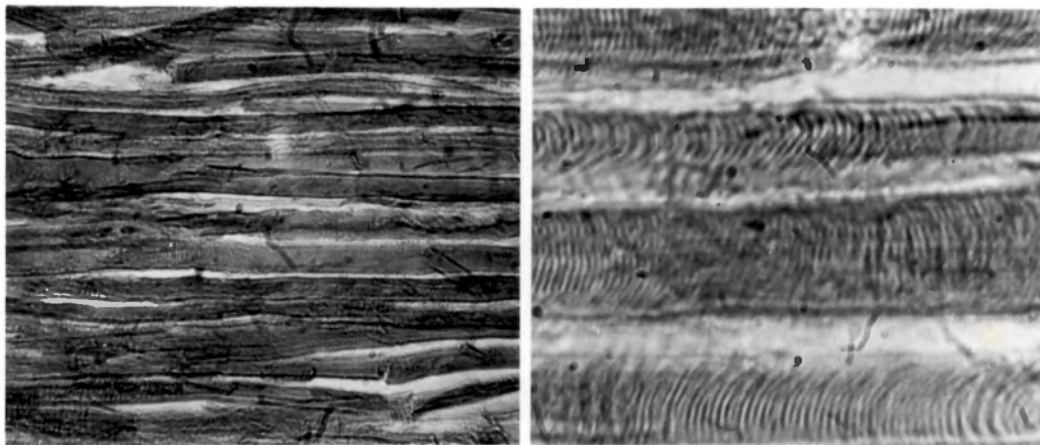
a. Longitudinal Section



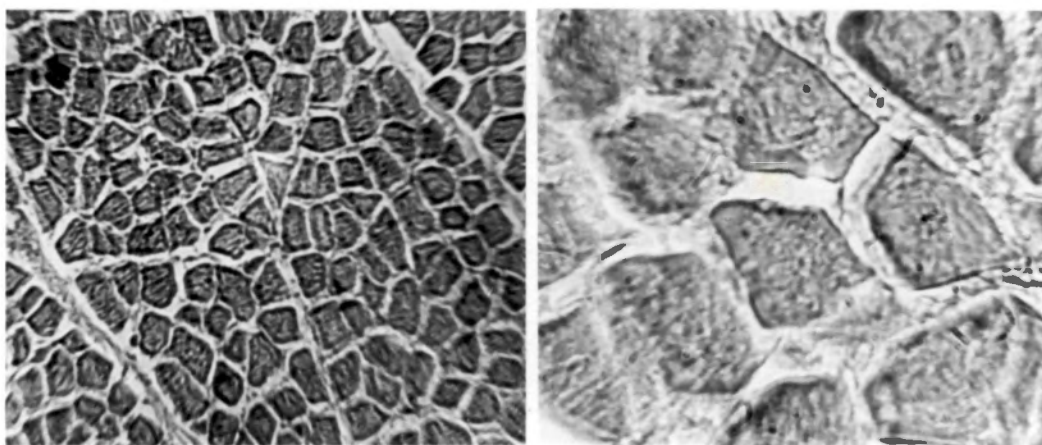
b. Transverse Section

PLATE IX

PHOTOMICROGRAPH OF FREEZE-DRIED DARK MEAT
FROZEN AT -30°F



a. Longitudinal Section



b. Transverse Section

PLATE X

PHOTOMICROGRAPH OF FREEZE-DRIED DARK MEAT
FROZEN AT -180°F

TABLE I

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF FLAVOR OF WHITE MEAT

	0°F			-30°F			-180°F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	7	9	9	10	10
No. of correct answers	7	7	6	7	5	6	5	6	5
Probability	.01	.05	NS	.05	.05	.05	NS	NS	NS

SUMMARY OF THREE REPLICATIONS

	0°F	-30°F	-180°F
No. of tasters	29	26	29
No. of correct answers	20	18	16
Probability	.001	>.001	>.05

TABLE II

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF TEXTURE OF WHITE MEAT

	0°F			-30°F			-180°F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	7	9	9	10	10
No. of correct answers	8	7	6	3	5	5	3	6	5
Probability	.001	.05	NS	NS	.05	NS	NS	NS	NS

SUMMARY OF THREE REPLICATIONS

	0°F	-30°F	-180°F
No. of tasters	29	26	29
No. of correct answers	21	13	14
Probability	.001	NS	NS

difference at 0.05 level and there was no significant difference at -180°F . The probability of three replications gave a highly significant difference for the 0°F rate. There was no significant difference at -30 and -180°F .

The effect of the freezing rates on the organoleptic evaluation of color of white meat, as shown in Table III, indicates that only one replication in each freezing rate showed a highly significant difference. The others showed a highly significant difference at the 0.01 and 0.001 level of probability. A summary of three replications showed a highly significant difference at three different rates of freezing.

Table IV presents some comments of the panelists concerning the samples. Most often expressed comments on the 0°F sample were that the freeze-dried chicken was strong, off-flavor, and dry. The freeze-dried chicken was not much different from the frozen chicken at -30°F and it was difficult to interpret the difference between the three samples of the triangle taste test at -180°F .

The panelists' comments, in general, indicate that the freeze-dried chickens were tough, dry, firm, and more chewy, though the statistical analysis of the organoleptic

TABLE III

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF COLOR OF WHITE MEAT

	0°F			-30°F			-180°F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	7	9	9	10	10
No. of correct answers	8	5	9	8	3	8	8	9	6
Probability	.001	NS	.001	.01	NS	.001	.001	.001	NS

SUMMARY OF THREE REPLICATIONS

	0°F	-30°F	-180°F
No. of tasters	29	26	29
No. of correct answers	22	19	23
Probability	.001	.001	.001

TABLE IV

THE COMMENTS OF THE PANELISTS IN ORGANOLEPTIC
EVALUATION OF WHITE MEAT

Factors	Treatments	Comments
Flavor	0°F	Strong and off flavor, dry and bad taste, less flavor of chicken.
	-30°F	Slight difference from the compared sample. Slight off flavor. Strong and smokelike flavor.
	-180°F	Really cannot tell much difference. Very mild flavor. Very bland flavor.
Texture	0°F	Tough, dry, stringy, more firm and chewy, less moist and less tender.
	-30°F	Not much difference, dryer and tougher, more chewy but not bad.
	-180°F	The three samples were about the same. Good texture, more chewy, tougher and dryer.
Color	0°F	Yellowish looking, more grey color, more neutral in color.
	-30°F	Slight grey color, whiter and less dark spot.
	-180°F	Slightly more yellow, more dark color.

scores indicated that the panel found only minor differences among the 0, -30, and -180°F, and the control sample.

The panelists' comments also indicate that the freeze-dried chicken had more grey color than the control.

The freeze-dried chicken was stored at room temperature. No attempt was made to protect the sample from the effects of exposure to light and oxygen. As a result, discoloration and fat oxidation proceeded at a rapid rate.

Dark meat. The effect of the freezing rates on the organoleptic evaluation of flavor of dark meat, as shown in Table V, indicates that at 0°F there was no significant difference, significant difference at 0.05 level, and highly significant difference at 0.001 level, respectively, in three replications. There was a significant difference at -30 F. At -180 F, only one replication showed no significant difference. A summary of three replications showed a highly significant difference above 0.001 level among the three different rates of freezing.

The effect of the freezing rates on the organoleptic evaluation of texture of dark meat, as shown in Table VI,

TABLE V

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF FLAVOR OF DARK MEAT

	0 °F			-30 °F			-180 °F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	10	10	7	8	10
No. of correct answers	5	7	9	9	7	9	6	4	9
Probability	NS	.05	.001	.001	.05	.001	.01	NS	.001

SUMMARY OF THREE REPLICATIONS

	0 °F	-30 °F	-180 °F
No. of tasters	29	30	25
No. of correct answers	21	25	19
Probability	>.001	>.001	>.001

TABLE VI

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF TEXTURE OF DARK MEAT

	0°F			-30°F			-180°F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	10	10	7	8	10
No. of correct answers	6	5	7	7	7	8	6	4	6
Probability	.05	NS	.05	.05	.05	.01	.01	NS	NS

SUMMARY OF THREE REPLICATIONS

	0°F	-30°F	-180°F
No. of tasters	29	30	25
No. of correct answers	18	22	16
Probability	>.01	>.001	>.01

indicates that only one replication showed no significant difference and there was a significant difference at -30°F . At -180°F only one replication showed significant difference at the 0.01 level. A summary of three replications showed a significant difference among the three different rates of freezing,

The effect of the freezing rates on the organoleptic evaluation of color of dark meat, as shown in Table VII, indicates that at 0°F , only one replication showed a significant difference at 0.05 level and there was no significant difference at -30°F . At -180°F , there was a significant difference among the three replications. The probability of three replications gave a significant difference for the 0 and -180°F rate. There was no significant difference at -30°F .

Table VIII presents some comments of the panelists that the freeze-dried dark meat was strong, off-flavor, and rancid.

The panelists also commented that the freeze-dried chicken was firm, chewy, dry, and tough, and that it was whiter in color than the control.

The freeze-dried dark meat was stored in the same condition as the white meat. The dark meat contained a

TABLE VII

EFFECT OF THE FREEZING RATES ON THE ORGANOLEPTIC
EVALUATION OF COLOR OF DARK MEAT

	0°F			-30°F			-180°F		
	1	2	3	1	2	3	1	2	3
No. of tasters	9	10	10	10	10	10	7	8	10
No. of correct answers	4	4	7	6	3	5	5	6	8
Probability	NS	NS	.05	NS	NS	NS	.05	.05	.01

SUMMARY OF THREE REPLICATIONS

	0°F	-30°F	-180°F
No. of tasters	29	30	25
No. of correct answers	15	14	19
Probability	.05	NS	>.001

TABLE VIII

THE COMMENTS OF THE PANELISTS IN ORGANOLEPTIC
EVALUATION OF DARK MEAT

Factors	Treatments	Comments
Flavor	0°F	Strong and off flavor, dry and rancid-like taste, terrible flavor.
	-30°F	Very strong flavor, slight off flavor, rancid-like taste.
	-180°F	Dry, very strong and off flavor, rancid.
Texture	0°F	Very firm and chewy, dry and tough.
	-30°F	Tough, dry and not very tender.
	-180°F	More tough and chewy, dry.
Color	0°F	More white, lighter in color.
	-30°F	Very little difference in all samples, less discoloration.
	-180°F	Whiter and dry looking.

higher fat content than the white meat (42). As a result the rancid flavor was detected more easily by the panel in the dark meat.

III. THE ABILITY OF THE INDIVIDUAL PANELIST TO DIFFERENTIATE THE ORGANOLEPTIC CHARACTERISTICS OF FREEZE- DRIED CHICKEN

In the triangle taste test, each panelist was asked to taste the three samples and indicate which of the two samples were identical; consequently the judge had only one chance in three to indicate correctly the odd sample. The ability of the individual to identify the odd sample was very important. This was reflected in the ability of the taste panel to establish significant differentiation among the treatments.

The ability of the individual panelist to differentiate the organoleptic characteristics of white meat, as shown in Table IX, indicates that half of the panelists could not identify the odd sample for flavor. There were six panelists who established no significant difference in identifying the odd sample for texture and two for color. For the total results, there were two panelists who gave no

TABLE IX

THE ABILITY OF THE INDIVIDUAL PANELIST TO DIFFERENTIATE
THE ORGANOLEPTIC CHARACTERISTICS OF WHITE MEAT

Individual	FLAVOR			TEXTURE			COLOR			TOTAL		
	A	B	C	A	B	C	A	B	C	A	B	C
1	9	5	NS	9	6	.05	9	7	.01	27	18	.001
2	7	7	>.001	7	5	.05	7	7	>.001	21	19	>.001
3	9	6	.05	9	2	NS	9	4	NS	27	12	NS
4	9	6	.05	9	4	NS	9	6	.05	27	16	.01
5	8	8	.001	8	8	>.001	8	8	>.001	24	24	>.001
6	9	5	NS	9	6	.05	9	6	.05	27	17	>.01
7	8	6	.05	8	5	NS	8	7	.01	24	18	>.001
8	9	5	NS	9	5	NS	9	7	.01	27	17	>.01
9	8	3	NS	8	2	NS	8	6	.05	24	11	NS
10	8	3	NS	8	5	NS	8	5	NS	24	13	.05

A = Number of testings.

B = Number of correct answers.

C = Probability.

significant difference for all taste tests of white meat.

Table X shows the ability of the individual panelist to differentiate the organoleptic characteristics of dark meat. There were two panelists who established no significant difference in identifying the odd sample for flavor, three for texture and six for color. There were two panelists who established no significant difference in identifying the odd sample for the total tests of dark meat.

When the result of all testings were combined, the chance of establishing no significant difference decreased, as shown in Table XI. There were two panelists who established no significant difference in identifying the odd sample for flavor, three for texture, and two for color. For the total number of testings, there was only one that gave no significant difference, but the others gave a highly significant difference above the 0.001 level.

IV. EFFECT OF THE FREEZING RATES ON THE DEHYDRATION RATIO

The effect of the freezing rates on the dehydration ratio of white meat, as shown in Table XII, indicates that there was very little difference in the dehydration ratio

TABLE X

THE ABILITY OF THE INDIVIDUAL PANELIST TO DIFFERENTIATE
THE ORGANOLEPTIC CHARACTERISTICS OF DARK MEAT

Individual	FLAVOR			TEXTURE			COLOR			TOTAL		
	A	B	C	A	B	C	A	B	C	A	B	C
1	7	5	.05	7	6	.01	7	3	NS	21	14	>.01
2	6	6	.001	6	4	.05	6	2	NS	18	12	.01
3	8	3	NS	8	3	NS	8	5	NS	24	11	NS
4	9	7	.01	9	6	.05	9	6	.05	27	19	>.001
5	9	9	>.001	9	9	>.001	9	8	.001	27	26	>.001
6	9	8	.001	9	5	NS	9	7	.01	27	20	>.001
7	9	6	.05	9	2	NS	9	4	NS	27	12	NS
8	9	5	NS	9	7	.01	9	3	NS	27	15	>.05
9	9	9	>.001	9	6	.05	9	6	.05	27	21	>.001
10	9	7	.01	9	8	.001	9	4	NS	27	19	>.001

A = Number of testings.

B = Number of correct answers.

C = Probability.

TABLE XI

THE ABILITY OF THE INDIVIDUAL PANELIST TO DIFFERENTIATE THE ORGANOLEPTIC
CHARACTERISTICS OF BOTH WHITE MEAT AND DARK MEAT

Individual	FLAVOR			TEXTURE			COLOR			TOTAL		
	A	B	C	A	B	C	A	B	C	A	B	C
1	16	10	.05	16	12	.001	16	10	.05	48	32	>.001
2	13	13	>.001	13	9	.01	13	9	.01	39	31	>.001
3	17	9	NS	17	5	NS	17	9	NS	51	23	NS
4	18	13	.001	18	10	.05	18	12	.01	54	35	>.001
5	17	17	>.001	17	17	>.001	17	16	>.001	51	50	>.001
6	18	13	.001	18	11	>.05	18	13	.001	54	37	>.001
7	17	12	>.001	17	7	NS	17	11	.01	51	30	>.001
8	18	10	.05	18	12	.01	18	10	.05	54	32	>.001
9	17	12	>.01	17	8	NS	17	12	>.01	51	32	>.001
10	17	10	.05	17	13	.001	17	9	NS	51	32	>.001

A = Number of testings.

B = Number of correct answers.

C = Probability.

TABLE XII

EFFECT OF THE FREEZING RATES ON THE DEHYDRATION
RATIO* OF WHITE MEAT

Replicate	-180°F	-30°F	0°F
1	3.13	3.10	3.28
2	3.21	3.30	3.28
3	3.30	3.34	3.35
Total	9.64	9.74	6.91
Mean	3.21	3.25	3.30
Statistical** significance at 0.05 level			

Analysis of variance of the dehydration ratio of
white meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00621	0.73
Remainder	6	0.00847	
Total	8		

$$* \text{ Dehydration Ratio} = \frac{\text{gms. of frozen cubes}}{\text{gms. of freeze-dried cubes}}$$

**Duncan's Multiple Range Test.

among three different rates of freezing. Neither Duncan's Multiple Range Test nor the analysis of variance showed a significant difference among the treatments.

Table XIII shows the effect of the freezing rates on the dehydration ratio of dark meat which gave the same result as the white meat. The dehydration ratio of dark meat was less than the white meat. The dark meat contained less moisture and required a longer cooking time than the white meat.

V. EFFECT OF THE FREEZING RATES ON THE REHYDRATION RATIO

The effect of the freezing rates on the rehydration ratio of white meat, as shown in Table XIV, indicates that there was very little difference in the rehydration ratio among the three different rates of freezing. Neither Duncan's Multiple Range Test nor the analysis of variance showed a significant difference among the treatments.

Table XV shows the effect of the freezing rates on the rehydration ratio of dark meat, which gave the same result as the white meat. The rehydration ratio of dark meat was lower than the ratio of white meat, due to the longer

TABLE XIII

EFFECT OF THE FREEZING RATES ON THE DEHYDRATION
RATIO OF DARK MEAT

Replicate	-30 °F	0 °F	-180 °F
1	3.23	3.26	3.16
2	2.97	3.08	3.21
3	3.10	3.15	3.16
Total	9.30	9.49	9.53
Mean	3.10	3.16	3.18
Statistical significance at 0.05 level			

Analysis of variance of the dehydration ratio of
dark meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00503	0.58
Remainder	6	0.00866	
Total	8		

TABLE XIV

EFFECT OF THE FREEZING RATES ON THE REHYDRATION
RATIO* OF WHITE MEAT

Replicate	-180 °F	-30 °F	0 °F
1	3.02	3.01	3.04
2	3.05	3.08	3.08
3	3.02	3.20	3.20
Total	9.09	9.29	9.32
Mean	3.03	3.10	3.11
Statistical significance at 0.05 level			

Analysis of variance of the rehydration ratio of
white meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00521	0.85
Remainder	6	0.00549	
Total	8		

*Rehydration ratio = $\frac{\text{gms. of rehydrated cubes}}{\text{gms. of freeze-dried cubes}}$

TABLE XV
EFFECT OF THE FREEZING RATES ON THE REHYDRATION
RATIO OF DARK MEAT

Replicate	0°F	180°F	-30°F
1	2.60	2.59	2.56
2	2.58	2.55	2.60
3	2.45	2.60	2.60
Total	7.63	7.74	7.76
Mean	2.54	2.58	2.59
Statistical significance at 0.05 level			

Analysis of variance of the rehydration ratio of dark meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00163	0.62
Remainder	6	0.00262	
Total	8		

cooking time. Higher fat content may have contributed to the low rehydratibility of dark meat (42).

VI. EFFECT OF THE FREEZING RATES ON THE MILLILITERS
OF WATER FROM REHYDRATION OF FREEZE-DRIED
CHICKEN

The effect of the freezing rates on the milliliters of water from rehydration of white meat, as shown in Table XVI, indicates that there was very little difference in the milliliters of rehydrating water among three different rates of freezing. Neither Duncan's Multiple Range Test nor the analysis of variance showed a significant difference among the treatments.

Table XVII shows the effect of the freezing rates on the milliliters of water from rehydration of dark meat, which gave the same result among the three treatments as did the white meat. The volume of the remaining rehydration water varied inversely with the rehydration ratio. The freeze-dried white meat absorbed more water than the dark meat.

TABLE XVI

EFFECT OF THE FREEZING RATES ON THE MILLILITERS
OF WATER FROM REHYDRATION OF WHITE MEAT

Replicate	-30°F	0°F	-180°F
1	68	68	66
2	65	65	65
3	62	63	66
Total	195	196	197
Mean	65.00	65.33	65.67
Statistical significance at 0.05 level			

Analysis of variance of the milliliters of water
from rehydration of white meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.333	0.064
Remainder	6	5.222	
Total	8		

TABLE XVII

EFFECT OF THE FREEZING RATES ON THE MILLILITERS
OF WATER FROM REHYDRATION OF DARK MEAT

Replicate	0°F	-30°F	-180°F
1	85	81	84
2	85	85	86
3	84	88	84
Total	254	254	254
Mean	84.67	84.67	84.67
Statistical significance at 0.05 level			

Analysis of variance of the milliliters of water
from rehydration of dark meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0	0
Remainder	6	4.67	
Total	8		

VII. EFFECT OF THE FREEZING RATES ON PER CENT TOTAL
NITROGEN AND TOTAL SOLIDS OF REHYDRATING WATER

Per cent total nitrogen. The effect of the freezing rates on per cent total nitrogen of rehydrating water of white meat, as shown in Table XVIII, indicates that freezing rate at -180°F gave the lowest mean and -30°F gave the highest mean. The freezing rate at -30°F showed a significant difference. The analysis of variance showed a highly significant difference at 0.01 level among the treatments, replicates and treatments against replicates.

Table XIX shows the effect of the freezing rates on per cent total nitrogen of rehydrating water of dark meat. The freezing rate at -30°F gave the lowest mean and 0°F gave the highest mean. There was a significant difference between freezing rates at -30°F and 0°F . The analysis of variance showed a highly significant difference at 0.01 level among the treatments and treatments against replicates. There was a significant difference among the replicates at the 0.05 level.

Per cent total nitrogen of white meat was higher than

TABLE XVIII

EFFECT OF THE FREEZING RATES ON PER CENT TOTAL
NITROGEN OF REHYDRATING WATER OF WHITE MEAT

Repli- cate	-180°F			0°F			-30°F		
	1	2	3	1	2	3	1	2	3
1	0.202	0.203	0.198	0.218	0.180	0.225	0.200	0.227	0.216
2	0.200	0.200	0.202	0.212	0.179	0.222	0.212	0.221	0.218
3	0.210	0.202	0.198	0.215	0.180	0.233	0.206	0.226	0.221
Total	0.612	0.605	0.598	0.645	0.539	0.680	0.618	0.674	0.656
Mean	0.204	0.202	0.200	0.215	0.180	0.227	0.206	0.224	0.218
Pooled Mean	0.202			0.207			0.216		
Statistical significance at 0.05 level									

Analysis of variance of per cent total nitrogen of
rehydrating water of white meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00049	49**
Replicates	2	0.00038	38**
T x R	4	0.00085	85**
Within Replicates	18	0.00001	
Total	26		

TABLE XIX

EFFECT OF THE FREEZING RATES ON PER CENT TOTAL
NITROGEN OF REHYDRATING WATER OF DARK MEAT

Repli- cate	-30°F			-180°F			0°F		
	1	2	3	1	2	3	1	2	3
1	0.122	0.132	0.120	0.135	0.128	0.125	0.126	0.126	0.138
2	0.122	0.126	0.114	0.132	0.129	0.123	0.129	0.132	0.134
3	0.117	0.132	0.117	0.125	0.126	0.125	0.129	0.138	0.143
Total	0.361	0.390	0.351	0.392	0.383	0.373	0.384	0.396	0.415
Mean	0.120	0.130	0.117	0.131	0.128	0.124	0.128	0.132	0.138
Pooled Mean	0.123			0.128			0.133		
Statistical significance at 0.05 level									

Analysis of variance of per cent total nitrogen of
rehydrating water of dark meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.00024	24**
Replicates	2	0.00004	4*
T x R	4	0.00010	10**
Within Replicates	18	0.00001	
Total	26		

dark meat. This was related to the amount of remaining rehydration water which was less for white meat.

Per cent total solids. Table XX shows the effect of the freezing rates on per cent total solids of rehydrating water of white meat. The freezing rate at -30°F gave the lowest mean and 0°F gave the highest mean. The Duncan's Multiple Range Test showed no significant difference among the treatments. The analysis of variance showed a significant difference at 0.05 level among the treatments, at 0.01 level among the treatments against replicates. There was no significant difference among replicates.

The effect of the freezing rates on per cent total solids of rehydrating water of dark meat, as shown in Table XXI, indicates that the freezing rates at -30°F gave the lowest mean and 0°F gave the highest mean. Duncan's Multiple Range Test showed a significant difference among the three treatments. The analysis of variance showed a highly significant difference at the 0.01 level among the treatments, replicates and treatments against replicates.

Per cent total solids of freeze-dried white meat was higher than dark meat, which was 2.46 and 2.07, respectively.

TABLE XX

EFFECT OF THE FREEZING RATES ON PER CENT TOTAL SOLIDS
OF REHYDRATING WATER OF WHITE MEAT

Repli- cate	-30°F			-180°F			0°F		
	1	2	3	1	2	3	1	2	3
1	2.36	2.36	2.41	2.49	2.51	2.42	2.46	2.34	2.64
2	2.37	2.52	2.48	2.47	2.50	2.38	2.45	2.32	2.64
3	2.37	2.54	2.37	2.44	2.51	2.39	2.49	2.53	2.63
Total	7.10	7.42	7.26	7.40	7.52	7.19	7.40	7.19	7.91
Mean	2.37	2.47	2.42	2.47	2.51	2.39	2.47	2.40	2.64
Pooled Mean		2.42			2.46			2.50	
Statistical significance at 0.05 level									

Analysis of variance of per cent total solids of
rehydrating water of white meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.01550	4.95*
Replicates	2	0.00582	1.86
T x R	4	0.02988	9.55**
Within Replicates	18	0.00313	
Total	24		

TABLE XXI

EFFECT OF THE FREEZING RATES ON PER CENT TOTAL SOLIDS
OF REHYDRATING WATER OF DARK MEAT

Repli- cate	-30°F			-180°F			0°F		
	1	2	3	1	2	3	1	2	3
1	1.94	2.13	2.01	2.01	2.06	2.11	2.01	2.27	2.20
2	1.96	2.05	2.01	2.00	2.02	2.14	1.97	2.25	2.20
3	1.94	2.13	2.01	1.99	2.06	2.13	1.98	2.23	2.18
Total	5.84	6.31	6.03	6.00	6.14	6.38	5.96	6.75	6.58
Mean	1.95	2.10	2.01	2.00	2.05	2.12	2.00	2.45	2.19
Pooled Mean		2.02			2.06			2.14	
Statistical significance at 0.05 level									

Analysis of variance of per cent total solids of
rehydrating water of dark meat:

<u>Source</u>	<u>d.f.</u>	<u>M.S.</u>	<u>F. ratio</u>
Treatments	2	0.03540	84.28**
Replicates	2	0.06252	148.86**
T x R	4	0.01171	27.88**
Within Replicates	18	0.00042	
Total	24		

CHAPTER V

SUMMARY

A study has been made to illustrate the effect of freezing rates on the histological structure of freeze-dried chicken, to determine the effect of the freezing rates on organoleptic evaluation, dehydration ratio, rehydration ratio, per cent total nitrogen, and per cent total solids of rehydrating water.

Under conditions of the experiments reported in this paper it was found that:

1. The different freezing rates affected the histological structure of both white and dark meat.
2. The flavor, texture, and color of freeze-dried chickens were statistically different from the frozen chicken except for the freezing rates at -30 and -180°F for texture of white meat and -30°F for the color of dark meat.
3. The freezing rates did not affect the dehydration ratio, the rehydration ratio and the amount of rehydrating water but did affect the per cent total nitrogen and total solids of rehydrating water.

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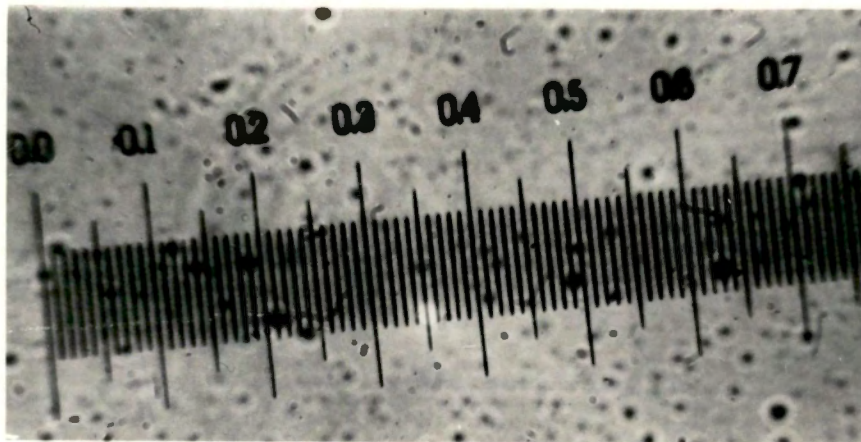


APPENDIX

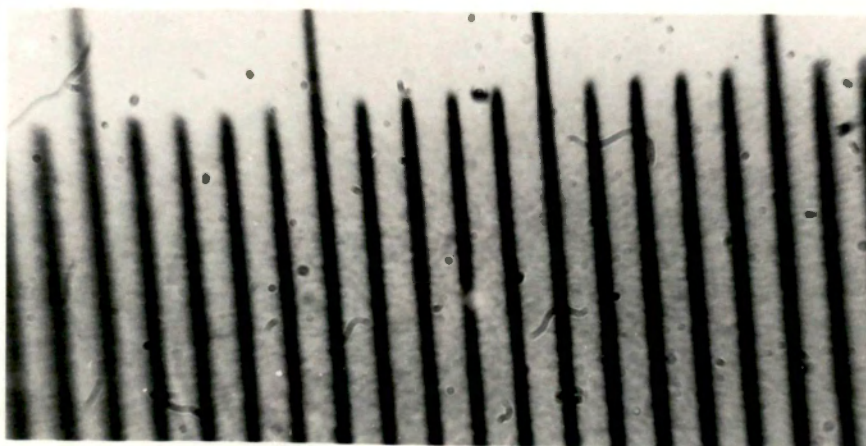
TABLE XXII

DATA OF PREPARATION CHICKEN FOR FREEZE-DRYING

	Weight of Fresh Chick- en (gm.)	Weight After Cook- ing (gm.)	Weight of Meat Cubes (gm.)	Weight of Bone and Skin (gm.)	Weight of Frozen Meat Cubes (gm.)	Weight of Freeze- Dried Meat (gm.)
<u>White Meat</u>						
0°F						
1	299.0	250.0	118.0	109.0	118.0	36.0
2	585.0	470.0	267.5	160.0	262.5	80.0
3	694.0	496.0	277.0	172.5	272.0	81.0
-30°F						
1	364.0	303.0	160.0	114.0	160.0	49.0
2	856.0	693.0	383.0	249.0	363.0	110.0
3	863.0	693.0	384.0	245.0	374.0	112.0
-180°F						
1	755.0	568.0	325.0	200.0	325.0	100.5
2	760.0	627.0	341.0	235.0	331.0	103.0
3	835.0	693.0	373.0	260.0	363.0	110.0
<u>Dark Meat</u>						
0°F						
1	470.0	360.0	180.0	150.0	180.0	58.0
2	791.5	631.0	312.5	258.0	307.5	100.0
3	830.5	664.0	335.5	267.5	330.0	105.0
-30°F						
1	305.0	251.0	141.0	91.0	141.0	45.0
2	757.5	559.0	271.0	241.0	266.0	90.0
3	724.0	543.0	256.0	241.0	251.0	81.0
-180°F						
1	379.0	302.0	142.0	118.0	142.0	45.0
2	662.5	491.0	249.0	202.0	244.0	76.0
3	687.0	531.0	269.0	217.0	262.0	83.0



a. Low Power--100X



b. High Power--430X

PLATE XI

SCALE OF LOW POWER AND HIGH POWER
IN MILLIMETERS

VITA

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