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FOODSERVICE SYSTEMS: SENSORY AND MICROBIAL QUALITIES OF PRECOOKED CHILI AND SOUP STORED CHILLED OR FROZEN FOR 30 DAYS IN TWO TYPES OF CASINGS

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By

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ABSTRACT

FOODSERVICE SYSTEMS: SENSORY AND MICROBIAL QUALITIES OF PRECOOKED CHILI AND SOUP STORED CHILLED OR FROZEN FOR 30 DAYS IN TWO TYPES OF CASINGS

By

Sharon Marie Donnenwerth

Microbial and sensory qualities of soup and chili packaged in two types of plastic casings (polyethylene/nylon/polyethylene or P/N/P; polyethylene or PE) were evaluated after 30 $\pm$ 4 days of chilled ($-1^{o} \pm 1^{o}C$) or frozen storage ($-7^{o} \pm 1^{o}C$). All products were in excellent microbial condition at point of service. Consumer panels indicated no packaging preference for chili products but P/N/P was preferred for soup regardless of storage condition. Trained taste panels found few significant differences among chili products. Texture of vegetables in chilled P/N/P soup was rated significantly higher than for frozen P/N/P soup. Frozen PE soup was rated higher than frozen P/N/P soup for: color of vegetables, integrity of vegetables, texture of vegetables and aftertaste. Results indicated that PE casings were unacceptable for chilled storage while P/N/P casings were acceptable for chilled or frozen storage.

This work is dedicated to God our Father; to my parents for their love and support; and in memory of my dear friend, Debbie Minster Jones, who during her fight with cancer taught me a lot about faith, hope and perseverance.

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Chapter I

INTRODUCTION

Cook/chill and cook/freeze production methods have been used to improve the sensory and nutritional qualities of foods served in hospital and school foodservice systems, when compared to a conventional foodservice system. In cook/chill and cook/freeze foodservice systems entrees are produced in bulk, chilled and held chilled or frozen, prior to reheating and service to the customer. Since the introduction of cook/chill and cook/freeze technology in the 1960's and 1970's (Bjorkman and Delphin, 1966; McGuckin, 1969; Glew, 1973), until the present, there has been a debate as to which method of storage was better to preserve the sensory, nutritional, and microbial qualities of cooked foods.

Recent developments in plastic packaging and rapid chilling of cooked foods has resulted in a longer shelf life for chilled foods. Manufacturers of plastic food films have been able to develop plastic packaging with a wide range of properties by coextruding various resins within micro-seconds of each other, biaxially orienting them and subjecting them to irradiation (Ramey, 1984). Specific resins were chosen for their barrier properties, shrinkability, flexibility, strength, thermoformability and clipability to form a specific package for a given application. Plastic casings with a tolerance for wide

variations in temperature made possible rapid chilling of cooked foods packaged in plastic casings at 82°C and cooled to ≤5°C in 30 minutes (Ramey, 1984). Microbial growth was prevented during cooling and during product storage at a refrigerated temperature of -2°C to 0°C. The development of packaging which could be filled with food products at temperatures above pasteurization temperature (≥82°C), rapidly chilled to ≤5°C in 30 minutes, and stored at a lower refrigerated temperature, increased the shelf life of chilled foods from 72 hours to 60 days (Ramey, 1984). Therefore, the shelf life of chilled foods was closer to the shelf life of frozen foods. The purpose of the present study was to determine if a difference in sensory and/or microbial qualities existed between chilled and frozen foods packaged in either the Cryovac C-300® (Cryovac Division, W. R. Grace Co., Duncan, S. C.) casing or polyethylene (PE) casings. The Cryovac C-300 casing was a multilayer coextrusion of polyethylene/nylon/polyethylene with a high oxygen barrier. The PE casing was compared to the C-300 casing because it was marketed for uses similar to the C-300 but had a lower oxygen barrier.

The PE casing was cheaper than the C-300 casing but was not as strong as the C-300 casing. The PE casing required careful handling during filling of the casings, cooling, storage and reheating. Thus, the C-300 casing was more practical for a foodservice operation because it was

stronger and could be chilled in a mechanical chiller and reheated more rapidly than the PE casing.

Chapter II

REVIEW OF LITERATURE

Various foodservice systems have evolved from the traditional foodservice system during the past twenty years. Several foodservice systems are defined below. This review of literature will focus on the development of the cook/chill and cook/freeze foodservice systems. Several studies comparing the sensory and microbial qualities of foods prepared in cook/chill and cook/freeze foodservice systems will be summarized. Recent advances in packaging technology which resulted in new food packaging films for use in cook/chill or cook/freeze foodservice systems will also be discussed.

Alternative Foodservice Systems

In the conventional foodservice system, foods were prepared daily, on-site, for service to the customer. Problems associated with the conventional foodservice system were shortages of skilled labor; increasing labor costs; inefficient use of equipment and staff with peak production periods and slack times in the work day; and poor sensory quality of foods held hot for long periods of time during assembly and distribution of meals (Glew and Armstrong, 1981).

The cook/chill foodservice system began developing in the 1960's as an alternative to the conventional foodservice

system. In the cook/chill foodservice system, foods were cooked, chilled and held chilled for 24 hours before service to the customer (Unklesbay et al., 1977). The cook/freeze foodservice system began developing in the 1970's as another alternative to the conventional foodservice system. In the cook/freeze foodservice system, foods were cooked, chilled, frozen and held frozen from one day to six months before service to the customer.

Unklesbay et al. (1977) described food product flow in four foodservice systems: (a) conventional, (b) commissary, with cook/chill or cook/freeze production methods, (c) ready prepared foods and (d) assembly/serve. Conventional foodservice systems which used food products at all points along the food processing continuum from little or no processing to complete processing evolved from traditional foodservice operations. The traditional foodservice operation was labor intensive with meat processing, baking and vegetable preparation done on the premises. Conventional foodservice operators reduced labor requirements by purchasing pre-portioned cuts of meat, frozen potatoes, vegetables and desserts, confectionery mixes, and prepared fresh salads when available. Foods in the conventional foodservice system were prepared daily, on-site and held chilled or at serving temperature until service (Unklesbay et al., 1977).

The main feature of the commissary foodservice system was that production and service areas (referred to as

satellites) were located geographically in separated facilities. Commissary operations tended to acquire food products which had little or no processing. Products were prepared, packaged in bulk or individual servings, held frozen, chilled or hot; and transported to satellite facilities for reheating and service to customers (Unklesbay et al., 1977).

In ready prepared foodservice systems, completely prepared foods were purchased or menu items were prepared and stored chilled or frozen, always ready for final assembly and/or reheating before service to consumers within the same facility. In assembly/serve foodservice systems, frozen foods were purchased in bulk, pre-portioned or pre-plated forms. Foods were then portioned, assembled, transported, heated and served. Cook/chill and cook/freeze production techniques were used in both commissary and ready-prepared foodservice systems (Unklesbay et al., 1977).

Microbial Safety of Foods in Alternative Foodservice Systems

Use of cook/chill and cook/freeze production techniques have caused concern for the microbial safety of foods. Much of the concern about microbial safety of chilled foods has focused on the time that food products were in the temperature range favoring microbial growth (20°C to 50°C) during the chilling process (Millross et al., 1974). Longree (1972) stated that cooked foods should be chilled to 7°C or below within four hours, to assure minimal growth of bacteria. Much research has been done to determine if various chilling methods in foodservice systems were capable of meeting that standard (Tuomi et al., 1974; Bunch et al., 1976; Cremer and Chipley, 1977; Rollin and Matthews, 1977; Bobeng and David, 1978a; Bryan and McKinley, 1979; and Dahl et al., 1980).

Another concern about microbial safety of cooked foods was the possible growth of microbes during chilled storage, especially if products were held chilled for more than three days. Shelf life of chilled foods was often compared to shelf life of frozen foods and was considered a limitation of chilled foodservice systems (Livingston and Chang, 1979). Recent advances in rapid chilling of foods from 82^{o}C to 0^{o}C in less than one hour, with storage of chilled foods at 2^{o}C, increased shelf-life of chilled foods from four to six days up to six weeks (Livingston and Chang, 1979).

Development of Cook/Chill Foodservice Systems

One of the earliest uses of cook/chill production techniques was the Nacka System in Sweden (Bjorkman and Delphin, 1966). Hot entrees and vegetables were cooked to 80^{o}C, packaged in plastic bags (five portions per bag), air was extracted from the bag and the bag was sealed. Next, food products in bags underwent "pasteurization" by immersion in boiling water (100^{o}C) for three minutes. The purpose of pasteurization was to kill disease causing microorganisms which could have survived the cooking process

or recontaminated the product during the packaging process. Bags of product were then passed through a cooling tunnel for one hour. Bags were dried and stored in the refrigerator at 4°C for up to three weeks. Bags were reheated in boiling water for 30 minutes. A panel of experts and laymen judged the food quality to be comparable with that of conventionally prepared industrial food. Bjorkman and Delphin (1966) reported that in five years of production more than 10,000 bacterial tests on foods produced in this system were tested and found to be within acceptable limits. However, Bjorkman and Delphin (1966) did not define acceptable limits for microbial counts, nor did they report the methods used in the microbial analyses.

McGuckian (1969) reported use of a variation of the Nacka system by three hospital foodservice systems in South Carolina called the A.G.S. system (abbreviated for the names of the hospitals: Anderson, Greenville and Spartansburg). In the A.G.S. system, ingredients were assembled either raw or partially cooked, portioned, packaged under vacuum, pasteurized, and cooked for specified times in a thermostatically controlled water bath. The A.G.S. system differed from the Nacka system in that foods were packaged and cooked (or cooking was completed) in the bags, which would prevent recontamination of products following cooking. After cooking, packaged foods were chilled in an ice water tank, stored refrigerated at -2°C to 0°C for a shelf-life of at least 60 days (McGuckian, 1969). In the

A.G.S. system, foods were transported to satellites, reheated in the bags in a water bath for 30 to 40 minutes until product temperature was $\geq 71^{o}C$. When the meal was plated, the entree and vegetables were given an additional heat treatment for 10-20 seconds in a microwave oven to ensure that food items were hot.

The next significant event in the development of cook/chill foodservice systems was the elimination of the pasteurization step used in the Nacka and A.G.S. systems. The Food Laboratory at Natick tested quality of cook/chill foods processed with or without pasteurization and determined that quality of food was similar without pasteurization (Matthews, 1977). Researchers at the Natick Laboratory reported that cooked or baked menu items withstood refrigerated ($4^{o}C$) storage for up to nine days without spoilage or excessive microbial growth. Sensory evaluation of selected meats, fruits, vegetables and bakery items indicated that food quality was somewhat better with a chill system after storage for nine days than with a frozen system.

Kaud (1972) reported the use of a cook/chill foodservice system in which foods were prepared on-site for 24 hours in advance of service, chilled in bulk, portioned, stored chilled and reheated in microwave ovens in patient areas. Kaud reported improved food quality (hot foods hot, cold foods cold), decreased labor costs and increased productivity (measured by meals per man hour) resulted from

implementation of the cook/chill foodservice system compared to the previous decentralized foodservice system with kitchens on each floor.

Development of Cook/Freeze Foodservice Systems

One of the earliest uses of a cook/freeze foodservice system in a hospital was at Leeds Hospital in 1970 (Glew and Armstrong, 1981). Three foodservice systems (conventional with choice; conventional without choice; and cook/freeze with choice) were used in sequence, with a survey of consumer acceptance of food quality in each system conducted by mailing questionnaires to patients after they were discharged from the hospital. Consumers rated the cook/freeze system equal to the conventional system when a choice of entrees was offered in both systems. Glew and Armstrong (1981) identified two main problem areas associated with conventional foodservice systems as ineffective use of labor and equipment, with peak periods of utilization and slack periods with under-utilization of staff and equipment; and the long hot holding periods for foods during preparation, plating and distribution of patient meals. By centralizing food production, preserving cooked food and distributing it to service points, many of the problems previously associated with institutional feeding could be eliminated (Glew and Armstrong, 1981).

Millross et al. (1974) reported on the nutritional, microbial and economic implications in switching from a

conventional to a cook/freeze foodservice system. Although no details of methods were given, Millross et al. (1974) reported that nutrient retention (as measured by available lysine, and ascorbic acid content of cooked foods) was increased in the cook/freeze system, and microbial safety in the cook/freeze system was no more hazardous than in the conventional system. The capital costs in the cook/freeze system were higher than in the conventional system and were not offset by savings in wages.

Comparison of Cook/Chill and Cook/Freeze Foodservice Systems: Microbial Quality

Microbial safety of foods served in foodservice systems is a concern because many foods are capable of supporting microbial growth which could result in outbreaks of foodborne illnesses. A summary of surveillance data on the cause of outbreaks of foodborne disease associated with meat and poultry from 1968 to 1977 showed that improper cooling of cooked meat or poultry was the cause of the outbreak in 48% of the cases reported (Bryan, 1980). Much of the concern about the microbial safety of foods prepared in cook/chill or cook/freeze foodservice systems has focused on the standard for cooling of cooked foods recommended by Longree (1972). Longree (1972) stated that cooked foods should be cooled to $\leq 7^{\circ}C$ in four hours or less. Several researchers have studied the cooling time required for cooked products to reach $\leq 7^{\circ}C$ in cook/chill and cook/freeze foodservice

system (Tuomi et al., 1974; Bunch et al., 1976; Rollin and Matthews, 1977; Nicholanco and Matthews, 1978).

Bryan (1980) summarized surveillance data on outbreaks of foodborne disease associated with meat and poulty from 1968 to 1977. Improper cooling of cooked meat and poultry was the cause of the outbreak in 48% of all cases reported that were associated with meat and poultry. Other causes of foodborne outbreaks related to meat and poultry were: holding prepared foods more than 24 hours before service, 27%; infected persons touching cooked foods, 23%; inadequate reheating of cooked foods, 20%; improper hot storage of foods, 19%; and cross-contamination of cooked and raw foods, 15% (Bryan, 1980). Of those outbreaks reported, 65% resulted from foods eaten in foodservice establishments, 31% from foods prepared in the home and 4% from mishandling in food processing plants (Bryan, 1980). Clearly there is good reason to be concerned about the microbial quality of foods served in any foodservice system. It should also be noted that improper cooling of cooked meat and poultry was the cause of the outbreak in 48% of the cases reported. Cooling of cooked foods is an important step in both cook/chill and cook/freeze foodservice systems in preventing the growth of disease causing (pathogenic) microorganisms.

Several studies of cook/chill and cook/freeze foodservice systems have focused on the time-temperature relationship in cooked foods during cooling, freezing and chilled or frozen storage (Tuomi et al., 1974; Bauman, 1974;

Bunch et al., 1976; Rollin and Matthews, 1977; Nicholanco and Matthews, 1978; Bobeng and David, 1978a; Bobeng and David, 1978b). Microbial quality of cooked foods was controlled through adherence to time-temperature standards to minimize the time that cooked foods were in the temperature zone favorable for microbial growth, 21^{o}-$46^{o}C$ for foodborne pathogenic microorganisms (Bryan and McKinley, 1979). Longree (1972) recommended that cooked foods be cooled to $\leq 7^{o}C$ within four hours to prevent the rapid growth of microorganisms during the cooling of cooked foods. Longree's time-temperature standard for the cooling of cooked foods has been tested by several researchers (Bunch et al., 1976; Rollin and Matthews, 1977; Nicholanco and Matthews, 1978; Bobeng and David, 1978a; Bobeng and David, 1978b).

Kossovitsas et al. (1973) compared the effect of chilled holding and frozen storage on the sensory and microbial quality of cooked foods. Chicken a la King, Codfish in Cream Sauce and Broccoli with Cheese Sauce were prepared according to commercial recipes, packaged in individual mylar polyethylene film pouches, vacuumized, pasteurized, cooked and stored chilled at $2^{o}C$ or frozen at $-23^{o}C$. Chilled products were packaged, pasteurized and cooled by the method used in the Nacka System reported by Bjorkman and Delphin (1966). Frozen samples were not vacuumized or pasteurized. Samples for microbial study were inoculated with Clostridium perfringens and Salmonella Type

Paratyphi B. After 15 and 30 days of storage, all reheated, refrigerated samples gave negative results for the two organisms while frozen samples gave negative results for C. perfringens but positive results for Salmonella. After 15 days of storage, the taste panel could not detect any significant difference in appearance, flavor and consistency between frozen and refrigerated samples, while fresh controls were graded superior to either of the stored samples. At 30 days of storage, refrigerated samples were no longer acceptable as judged by the panel, while frozen samples where acceptable, but were inferior to fresh samples (Kossovitsas et al., 1973).

Tuomi et al. (1974) studied the microbial quality of ground beef gravy in a school satellite foodservice system. Cooked gravy was cooled to 43^oC and inoculated with Clostridium perfringens before being packed in bags and refrigerated for 16 hours at 6^oC. The number of viable cells after 16 hours in the refrigerator was influenced by the first six hours of cooling when the temperature of the gravy was in the range that permitted growth of C. perfringens (18^o - 50^oC). When gravy was reheated in a compartment steamer to an internal end temperature of 74^oC, no viable cells of C. perfringens were found (Tuomi et al., 1974). Although the gravy stayed in the temperature zone favorable for microbial growth longer than the four hours recommended by Longree (1972), once the gravy was reheated for service no viable cells of C. perfringens were found.

Bunch et al. (1976) determined the microbial quality of beef-soy loaves (25% soy) when processed according to system procedures in a hospital cook/chill foodservice system. Beef-soy loaves were initially cooked to 60°C before cooling and chilled storage at 5° ± 3°C for 24, 48, or 72 hours. During chilling of beef-soy loaves, the internal temperatures at the geometric center of the loaves did not reach ≤7°C in less than four hours as recommended by Longree (1972). Samples removed from loaves after chilled storage showed the largest increase in aerobic bacteria occurred during cooling. The largest increase in numbers of bacteria occurred when holding was for 72 hours. However, heating samples to 80°C in a microwave oven decreased the numbers of aerobic bacteria by an average of 100,000 organisms per gram. Final bacterial counts after microwave heating were all acceptable, so beef-soy loaves were considered to be in excellent microbial condition when they reached the consumer (Bunch et al., 1976).

Rollin and Matthews (1977) studied the temperature history of beef-soy loaves (25% soy) in a hospital cook/chill foodservice system. The purpose of their study was to determine if refrigeration equipment used in hospital/schools could meet the standard for cooling cooked entrees to ≤7°C in less than four hours as recommended by Longree (1972), and maintaining food temperature in the optimal range for microbial growth (16°-49°C) for ≤2 hours. Beef-soy loaves were cooled in pans in a walk-in

refrigerator at 4$\pm$ 3°C and required an average of 7-11 hours for the geometric center of the food mass to reach $\leq$7°C. Rollin and Matthews (1977) concluded that it was not possible to chill the beef-soy loaves through the 49°-16°C temperature range within 2 hours, nor was it possible to chill the beef-soy loaves to 7°C or less in four hours in a typical walk-in refrigerator.

Nicholanco and Matthews (1978) evaluated the quality of beef stew in a hospital cook/chill foodservice system. After preparation, 6 liters of beef stew were placed in a pan, covered with plastic wrap and placed in the walk-in refrigerator to cool. Temperature of the walk-in fluctuated from 6°C-10°C during the first nine hours of cooling. The temperature of the beef stew was >7°C during the first nine hours of cooling. At the end of 22 hours, the mean temperature in the stew was 5°C and the refrigerator temperature was 7°C. The temperature of the beef stew did not reach $\leq$7°C within the four hours recommended by Longree (1972). When the beef stew was reheated in microwave ovens, four samples did not reach the temperature recommended for microbial safety (74°C). Aerobic plate counts were highest during chilled storage and were lowest immediately after preparation and after reheating in microwave ovens. Mean aerobic plate counts during chilled storage ranged from 8.4×10^4 CFU/gm after 3 hours chilled storage to 14.5×10^4 CFU/gm after 19 hours chilled storage. The mean aerobic plate count was 6.6×10^4 CFU/gm both at the end of

preparation and after microwave reheating.

In summary, several researchers (Tuomi et al., 1974; Bunch et al., 1976; Rollin and Matthews, 1977; Nicholanco and Matthews, 1978) who studied the time-temperature relationship of cooked products during chilling reported that cooked products did not reach an internal temperature of 7^{o}C or less in four hours as recommended by Longree (1972). Although the cooked foods did not meet the time-temperature standard for cooling recommended by Longree (1972), the foods were in excellent microbial condition after reheating prior to service to the consumer.

Hazard Analysis, Critical Control Points

Until 1970-74, time-temperature relationships during cooling of cooked products were used to control the microbial quality of cooked products. Bobeng and David (1978a) adapted the idea of hazard analysis and critical control points from the food processing industry which had used hazard analysis for a number of years.

Bauman (1974) defined hazard analysis as the identification of sensitive ingredients, critical process points, and relevant human factors as they affect product safety. Critical control points were those processing determiners where loss of control would result in an unacceptable food safety risk (Bauman, 1974). Bobeng and David (1978a) applied hazard analysis to foodservice systems to control microbial quality. Specific time-temperature

recommendations were chilling foods to $\leq 7^{o}C$ ($45^{o}F$) in four hours or less, with chilled storage at $\leq 7^{o}C$ for 20 hours or less and reheating foods to $74^{o}C$-$77^{o}C$ (165-$170^{o}F$). For freezing cooked foods, time of freezing should be < 90 minutes at $\leq -28^{o}C$ ($-4^{o}F$), frozen storage ≤ 8 weeks at $\leq -18^{o}C$ ($0^{o}F$), minimal thawing time at $\leq 7^{o}C$ ($45^{o}F$) and reheating frozen foods to 74-$77^{o}C$ (Bobeng and David, 1978a).

Bobeng and David (1978b) assessed the quality of beef loaves prepared in a laboratory simulation of conventional, cook/chill and cook/freeze hospital foodservice systems to determine the effectiveness of Hazard Analysis Critical Control Point (HACCP) models. Aerobic plate counts (APC) were used to indicate microbiologic quality. APC's indicated that beef loaves prepared in all three systems had excellent microbial quality. The only problem with time-temperature standards in this study was that 5 hours were required for chilling loaves in the cook/chill system to $\leq 7^{o}C$ instead of the recommended four hours (Bobeng and David, 1978b).

Research has shown that foods prepared in a cook/chill foodservice system were of acceptable microbial quality at the point of service. However, the least amount of control appeared during the cooling process, with many products not being cooled to $\leq 7^{o}C$ in ≤ 4 hours as recommended by Longee (1972).

Sensory Quality Defined

Sensory evaluation of foods has long been used to objectively measure the quality characteristics of foods. Various methods and techniques, such as paired-comparison, ranking, threshold, flavor profile analysis, Hedonic scale rating and food acting rating scale, have been used to evaluate specific characteristics of food quality (IFT Sensory Evaluation Division, 1981).

Sensory evaluation can be used as a quality control tool in foodservice systems. Cichy (1983) stated that the average consumer associates quality with subjective personal preferences, as something liked or disliked, excellent, great or good. Sensory quality can be defined as an orderly classification of the chemical and physical characteristics of a product (Cichy, 1983). Sensory evaluation identifies the presence or absence of perceptible differences, pinpoints the important sensory characteristics of a product in a fast, quantifiable manner; and identifies particular problems that cannot be detected with other analytical techniques.

Comparison of Cook/Chill and Cook/Freeze Foodservice Systems: Sensory Quality

Several researchers have compared the sensory quality of foods prepared in cook/chill and cook/freeze foodservice systems (Jakobsson and Bengtsson, 1972; Zallen et al., 1975; Bunch et al., 1976; Bobeng and David, 1978b; Zacharias,

1979; Cremer, 1983; McDaniel et al., 1984). Sensory quality of freshly prepared foods has usually been rated higher than chilled or frozen foods. Some researchers have reported significant differences in sensory quality between chilled and frozen foods, while others have reported no significant differences in sensory quality for chilled or frozen foods. Studies comparing the sensory quality of foods prepared in cook/chill and cook/freeze foodservice systems are summarized below.

Jakobsson and Bengtsson (1972) compared the quality of frozen and refrigerated sliced beef in a laboratory simulation of commercial processing practices in Sweden. The study consisted of three treatments: (1) vacuum packaging with 0.5 ml headspace volume followed by pasteurization (80^{o}C) and chilled storage at 3^{o}C and 8^{o}C for up to 21 days; (2) vacuum packaging with 9 ml headspace volume followed by pasteurization and chilled storage at 3^{o}C and 8^{o}C for up to 21 days; and, (3) vacuum packaging with 9 ml headspace volume followed by frozen storage at -20^{o}C for two months (Jakobsson and Bengtsson, 1972). For sensory evaluation a nine grade preference scale for flavor and a nine grade intensity scale for off-flavor, juiciness and tenderness (1=extremely poor, no off-flavor and 9=extremely good, juicy or tender) was used. Panelists evaluated chilled, frozen and a fresh reference sample after 1, 7, 14, and 21 days of storage. Quality decreased with increasing time of refrigerated storage with flavor scores for

refrigerated beef significantly lower than flavor scores for frozen beef. Frozen beef was rated significantly higher for juiciness than was refrigerated beef. In all cases fresh beef was rated higher than frozen or refrigerated beef. Quality of cooked beef slices refrigerated at 3°C and 8°C were similar with quality deteriorating slightly faster at 8°C (Jakobsson and Bengtsson, 1972).

Zallen et al. (1975) compared the microbial and sensory quality of beef loaves (25% fat) prepared according to three procedures used in hospital foodservice systems; cook/chill, cook/pasteurized/chilled, and cooked/frozen/thawed (and refrigerated for 0 to 9 days). Beef loaves were initially cooked to an endpoint temperature of 74°C before being chilled or pasteurized (74°C) and placed in chilled storage (0°C and 6°C) or frozen storage (-18°C) for up to three weeks. A seven member trained taste panel evaluated beef loaves for odor, appearance, flavor and juiciness on a 9 point scale, with 9 the high score. Panelists evaluated four samples, fresh, chilled, chilled/pasteurized, and frozen/thawed, at each session.

The fresh (reference) loaves received significantly ($p < 0.01$) higher scores for odor, appearance, flavor and juiciness than any of the cooked loaves which had been stored (Zallen et al., 1975). Scores for chilled and chilled/pasteurized loaves were not significantly different. Scores for frozen/thawed loaves were significantly lower ($p < 0.01$) than for the other stored

loaves. Results of the taste panel indicated that there were no significant differences in quality characteristics for loaves stored chilled at 0°C and 6°C (Zallen et al., 1975). Zallen et al. (1975) concluded that the pasteurizing treatment was unnecessary based on sensory scores, total plate counts and TBA scores, which showed no significant differences between chilled loaves and chilled/pasteurized loaves.

Bunch et al. (1976) compared the sensory quality of beef-soy loaves (25% soy) prepared according to procedures in a hospital cook/chill system, after loaves were held chilled (7°C) for 24, 48, and 72 hours. A consumer panel of 31-40 college students evaluated the beef-soy loaves using a linear scale scoring system, with a 13 cm horizontal line and two endpoints (extremely undesirable to extremely desirable). Mean scores for overall acceptability were almost identical regardless of length of storage, with a mean score of 6.8 (maximum 13) which was not considered extremely desireable (Bunch et al., 1976).

Bobeng and David (1978b) compared the sensory quality of beef loaves prepared in a laboratory simulation of three foodservice systems: conventional, cook/chill and cook/freeze. Scores for both color of meat and uniformity of color were significantly different ($p < 0.05$) among systems. Both the cook/chill and cook/freeze loaves received lower scores for color and uniformity of color than did the conventional loaves. Flavor scores were significantly lower ($p < 0.01$) for the cook/chill and cook/freeze loaves than for the conventional loaves. The off flavors of the cook/chill and cook/freeze loaves were attributed to autoxidation since APC values were insignificant.

Zacharias (1979), reported on the sensory quality of chilled meals served to students in a school foodservice system. An initial poll of students showed that the acceptance of meals depended upon the taste, texture and appearance of the meals, with 85% of the students ranking taste as the most important criterion. A total of 23 dishes on the basis of meat, fish, eggs, vegetables, potatoes, pasta and rice were evaluated immediately after delivery in chilled conditions and during cold storage at 2°C. Two industrial plants and two large kitchens supplied a total of 80 samples, in multi-portion trays, which were evaluated on a 9 point scale for color, shape, odor, taste, consistency and texture, with 9 being optimum. Scores were divided into quality classes: scores from 9 to 7 (quality class A) corresponded to a very good - good quality, scores from 6.9-5.5 (quality class B) corresponded to a satisfactory quality, scores from 5.4 to 4 (quality class C) corresponded to a medium quality and scores from 3.9 to 1 (quality class D) corresponded to an unsatisfactory quality. After one day's storage at 2°C, 60% of the 80 samples were rated in quality class A and 37.6% in quality class B. With respect to influence of storage time, the strongest decrease was

nearly always noted for the attribute taste, whereas appearance and texture of the dishes changed far less. With increasing storage time (up to 10 days) the specific taste in all dishes containing a meat item became flat and increasingly masked by spices (Zacharias, 1979). After three days of cold storage ($2^{o}C$), 24.9% of all samples were rated in quality class A and 57% of samples were rated in quality class B, while after four days storage, the combined total for class A and B was 62% of total samples, which was lower than the 75% standard recommended by Zacharias (1979).

Cremer (1983) compared the sensory quality of freshly prepared spaghetti to the sensory quality of spaghetti subjected to four treatments: (a) 1 hour chilled storage, (b) 24 hour chilled storage, (c) 24 hours frozen storage, and (d) 24 hour frozen storage, followed by 24 hour chilled storage. Samples of spaghetti from each of the four treatments were evaluated after reheating in an institutional microwave oven and after reheating in an institutional convection oven. Chilled samples were held at $3^{o} \pm 4^{o}C$ and frozen samples were held at $-20^{o} \pm 8^{o}C$, then thawed at $3^{o} \pm 4^{o}C$. Meat sauce and spaghetti were prepared separately, combined, and cooked until the internal temperature reached $74^{o}C$. After cooking, 125 g portions of spaghetti were weighed into plastic foam cups covered with plastic lids for reheating in the microwave oven, or into lightweight aluminum containers, covered with aluminum wrap for reheating in the convection oven. Samples were stored, as previously indicated, before evaluation by an eight member trained taste panel using a linear score card, 15 cm line, word anchored at 1 and 14 cm.

The overall score for spaghetti and meat sauce was highest for the freshly prepared sample, but it was not different from the sample stored in the refrigerator for one hour and heated in the convection oven (Cremer, 1983). Scores were similar for samples held one hour or 24 hours chilled, whether or not they were reheated in the convection or microwave ovens. Samples held 24 hours frozen/24 hours chilled and reheated in the microwave or convection ovens and samples held 24 hours frozen which were reheated in the convection oven were similar in quality and received the lowest scores. With respect to holding treatments, Cremer (1983) concluded that chilled samples had better sensory scores and indicated an advantage for refrigerating rather than freezing or freezing then thawing food in foodservice systems.

McDaniel et al. (1984), evaluated the effects of various packaging treatments on quality of precooked roast beef held at 4^{o}C for up to 21 days. Boneless top round roasts weighing 1 to 1.5 kg were dry roasted to an internal temperature of 60^{o}C, cooled for one hour and packaged by one of three methods: (a) vacuum packaging, (b) packaged in 100% CO_2 atmosphere, or (c) packaging in 15% CO_2: 30% O_2: 55% N_2 atmosphere. Cryovac type B C205P barrier bags were used for all treatments. At each taste panel session, panelists

rated six samples (two from each treatment) on a sliding hedonic scale with endpoints labeled "dislike very much to like very much". In addition, panelists were asked to complete a food action rating scale by checking one of nine statements that would most closely represent their action, ranging from 1 = "I would eat this if I was forced to" to 9 = " I would eat this every opportunity I had".

Sensory scores for food action ratings for vacuum-packaged roasts were not different throughout the 21 day storage period. The roasts packaged in 100% CO_2 atmosphere or 15% CO_2; 30% O_2; 55% N_2 atmosphere possessed lower sensory scores at 14 and 21 days of storage as compared to values after 7 days of storage (McDaniel et al., 1984). The 100% CO_2 treated roasts were significantly lower in all quality characteristics except tenderness after 14 days of storage. The gas mixture treated roasts showed lower ratings for color and flavor after 21 days of storage as compared to the 7 days values. McDaniel et al. (1984) concluded that vacuum-packaged roasts had a slight advantage from a sensory standpoint and recommended further research to better understand the sensory quality advantages of vacuum packaged cooked beef as compared to 100% CO_2 -packaged cooked beef.

Several conclusions can be made from the review of literature related to the sensory quality of foods prepared in cook/chill and cook/freeze foodservice systems:

1. Freshly prepared foods have usually been rated higher than either chilled or frozen foods (Jakobsson and Bengtsson, 1972; Zallen et al., 1975; Bunch et al., 1976; Bobeng and David, 1978b; Cremer, 1983).
2. There were no significant differences in the sensory quality of foods held chilled for 24 hours, 48 hours, or 72 hours. Zacharias (1979) reported that on the third day of chilled storage, 24.9% of all samples were rated very good-good quality and 57% of all samples were rated satisfactory. However, on the fourth day of chilled storage, only 62% of all samples were rated in the very good-good and satisfactory quality classes (Zacharias, 1979). Cremer (1983) reported no significant difference in the sensory quality of spaghetti held chilled for one hour or 24 hours.
3. Sensory scores for chilled and frozen products were not significantly different (Zallen et al., 1975; Bobeng and David, 1978b). However, Cremer (1983) concluded with respect to various storage treatments (24 hours frozen/24 hours chilled; 24 hours frozen; 24 housschilled) that chilled spaghetti with meat sauce had better sensory scores than frozen or frozen/chilled spaghetti. Zallen et al., (1975) and Cremer (1983) reported

that frozen foods, thawed and held chilled for 24 hours, received significantly lower scores than chilled or frozen foods.

In conclusion, there is agreement that freshly prepared foods have better sensory quality than the same foods processed in cook/chill or cook/freeze foodservice systems. However, with respect to storage treatment, there is not agreement among researchers on whether chilled or frozen storage is better for sensory quality of cooked foods.

Packaging Materials

The purpose of food packaging is to ensure that the product reaches the ultimate consumer in prime condition as visualized by the manufacturer and to satisfy the legal requirements for the sale of the food. Pauling (1980) stated the following requirements for a food package:

1. There must be no up-take of flavors or additives.
2. There must be no deterioration in microbial quality.
3. Acceptable nutritional values must be retained.
4. It must be economical and safe to manufacture and distribute along the entire length of the manufacturer-to-consumer chain.
5. It must be capable of displaying product and brand name and other information required by law.
6. It must not present a hazard or a problem to the ultimate user in the purchase, opening, or

consumption of the product packaged.

Food processing and packaging evolved to provide a steady, year round food supply of many foods. Many materials have been used for food packaging including large leaves and skins, then woven fibers, paper, pottery, glass containers, metal cans, cellulose films, cellulose acetates, and finally, a wide range of thermoplastics (Goddard, 1980). The review of packaging materials will be limited to flexible plastic films, since packaging materials used in the present study were flexible plastic films.

A film is a thin flexible plastic sheeting having a thickness of 0.0254 cm or less (Sacharow and Griffin, 1970). Cellophane film was first introduced to the United States in 1924. Cellophane was manufactured from highly purified cellulose derived from bleached sulfite pulp (Sacharow and Griffin, 1970). Cellulose was then treated with sodium hydroxide solution and carbon disulfide to produce viscose. The viscose was extruded to produce a regenerated cellulose film which was washed, desulfurred, bleached, softened, dried and wound up as plain nonmoisture-proof film (Sacharow and Griffin, 1970). By incorporating various coatings and modifications, over 100 different grades of cellophane were available. Cellophanes were used in packaging baked goods, confectionery, meats, and overwraps (Sacharow and Griffin, 1970). Polymer coated varieties of cellophane called Saran were used for oily and greasy products. The annual usage of cellophane in food

packaging has steadily declined during 1965 - 1978, being replaced by polypropylene (Sacharow and Griffin, 1970).

A definition of various packaging terms would be helpful in order to understand the following literature review related to packaging. Cross-linking can occur between polymer molecules to form molecular chains or it could occur between polymer molecules and other substances. Cross-linking could be achieved by irradiation with electron beams or by means of chemical cross-linking agents such as organic peroxides (Whittington, 1968). Copolymers were formed by the copolymerization of two dissimilar molecules (Goddard, 1980). Examples of copolymers were ethylene-propylene, ethylene-butylene, ethylene-vinyl alcohol, and vinylidene chloride-vinyl chloride.

Orientation is the process of stretching a hot plastic article to realign the molecular configuration, thus improving mechanical properties. Stretching could be applied in one direction called uniaxial orientation or could be applied in two directions, called biaxial orientation (Whittington, 1968). Upon reheating, an oriented film would shrink in the direction(s) of orientation. Orientation would be useful in shrink packaging and for improving the strength of molded or extruded articles such as pipe and fibers.

Extrusion and co-extrusion are the processes by which films were manufactured. The extruder resembles a mincer into which granules are fed, heated and compressed until they fuse into a melt which was forced out through a slot or die to form the film (Goddard,1980). Co-extrusion was possible by combining adaptors to extrude simultaneously two or three different copolymers to form one film. Another means of forming multilayer films of different materials was by the process of lamination. Adhesive lamination allows the combination of incompatible materials, the incorporation of nonplastics and the manufacture of materials such as cross-laminated mono-oriented films, producing materials of extremely high strength (Goddard, 1980).

Common Food Packaging Films

Polyethylene has become the largest volume single film used in the flexible packaging industry. Polyethylene is a polymer of ethylene and is obtained by two processes. Low pressure or high density polyethylene (HDPE) was produced at temperatures between 60^{o}C and 160^{o}C and a pressure of 40 atm with alkymetal catalysts (Sacharow and Griffin, 1970). High pressure or low density polyethylene (LDPE) was obtained by exposing ethylene to temperatures between 150^{o}C and 200^{o}C at a pressure of about 1200 atm in the presence of traces of oxygen (Sacharow and Griffin, 1970).

Polythylene is a polyolefin which along with their copolymers and related types were the predominant plastics used in packaging. Goddard (1980) defined the polyolefins as low density and high density polyethylene, polypropylene and polybutylene as "standard" homologues:

ethylene -propylene and ethylene - butylene as copolymers; and the ionomers which incorporate sodium or zinc metallic ions to provide cross-linking. The polyolefins have similar properties being extensible, heat sealable, and good water vapor but poor gas-barriers. Those properties can be varied by different formulations, film processing techniques and by post-film treatments such as orientation (Goddard, 1980).

Other plastics used in flexible plastic films included polyvinyl chloride, polystyrene and polyamides. Polyvinyl chloride (PVC) in its plasticised form was very flexible, highly transparent, and had pronounced blocking tendencies. Those properties along with high gas permeability made PVC suitable for meat and vegetable wrapping as well as cling or stretch wrap applications (Goddard, 1980). Groomed sheet polystyrene in thicknesses from about 200 to 2500 um was used as a wrapping and for thermo forming into trays used in food packaging.

Polyamides are a range of materials made from different amino acids, characterized by a number suffix. Nylon 6,6.6 and 11 were most widely used as packaging films. Polyamides have good gas barrier performance, grease resistance and mechanical strength as well as a resistant to higher temperatures. Type 6.6 could withstand dry heat up to 250^{o}C and had been used as a roast-in bag (Goddard, 1980). The polyamides which were not good moisture barriers, were often used as a co-extrusion with LDPE, thus protecting the nylon and providing a good barrier to moisture. Polyesters were another class of polymers based on terephthalates (PETP). Polyesters have high mechanical strength and temperature stability and have barrier properties similar to the polyamide (Goddard, 1980).

Many types of plastic manufactured with specific properties such as oxygen barrier, extensibility, heat sealing properties, resistance to oils or alkalies and resistance to temperature extremes are available for use in food packaging. It is important that foodservice professionals using cook/chill and cook/freeze production systems know some of the physical properties and packaging requirements for use in their operation.

Chapter III

MATERIALS AND METHODS

Laboratory simulations of cook/chill and cook/freeze foodservice systems were used to compare the microbial and sensory qualities of foods packaged in two types of plastic casings. Foods were prepared using standardized recipes, packaged, chilled and stored chilled ($-1^{o}C \pm 1^{o}C$) or frozen ($-7^{o}C \pm 1^{o}C$) for 30 ± 4 days.

Two types of plastic casings were used to determine if one type of casing was better to retain the microbial and sensory quality of chilled or frozen foods. Microbial quality of experimental products was based on aerobic plate counts (APC) as well as tests for specific bacterial pathogens known to cause food poisioning: total coliforms, fecal coliforms, *Escherichia* coli, Salmonella, *Staphylococus aureus*, and *Clostridium perfringens* (Centers for Disease Control, 1983). Consumer and trained taste panels were used to evaluate the sensory quality of experimental products. Chili and vegetarian vegetable soup were chosen as the experimental products for this study because they were commonly used "pumpable" foods that could be prepared in the Cryovac foodservice system. The Cryovac foodservice system features preparation of large batches of soups, casseroles, sauces, and gravies which could be cooked in a steam jacketed kettle and pumped into plastic casings while the food temperature was above pasteurization temperature ($\geq 82^{o}C$).

Packaging Materials

The plastic casings used in this study (C-300 and PE) were chosen to determine their relative ability to store foods chilled or frozen. The C-300 casing, which is presently being marketed for storage of chilled foods held up to 45 days, was tested to determine if frozen foods stored in C-300 casings would retain product quality as well as chilled foods stored in C-300 casings. The PE casing was more permeable to oxygen than the C-300 casing. The PE casing was compared to the C-300 casing to determine the effect of oxygen on chilled and frozen chili and soup. Oxidation reactions are often the cause of undesirable changes in foods such as oxidative rancidity of fats and oils in various foods. In addition, many vitamins, pigments, and some amino acids and proteins are oxygen sensitive (Karel, 1975). Both types of plastic casing were supplied by Cryovac Division, W.R. Grace & Co. (Duncan, SC). C-300 was a Cryovac product while the PE was a common product of competitors which was often marketed for similar uses as the C-300 casing.

The C-300 casing was a five layer coextrusion of polyethylene/nylon/polyethylene with an olefin resin adhesive on each side of the nylon layer (Bieler and Howe, 1980). The laminate was cross-linked by irradiation in order to prevent delamination of the casing during the cooling or reheating process. The flexible casing permits the product to be mobile and flowable within the casing,

allowing a more rapid heat transfer from the product to the cooling medium. The PE casing in this study was a three layer coextrusion of polyethylene, without cross-linking. PE had previously been used for storage of frozen food in "boil-in-bag" pouches (Glew, 1973).

The C-300 casing was 91 to 94 cm long and 25 cm wide. The PE casing was 85 to 87 cm long and 25 cm wide. The oxygen transmission of the C-300 casing was 20-40 cc at 23^{o}C (m^2, 24 hours, Atm.; Cryovac, 1984), compared to 2,000 cc at 23^{o}C (m^2, 24 hours, ATM) for the PE casing (Koteles, 1984). The C-300 casing could withstand temperature extremes which could range from 100^{o}C during cooking to below 0^{o}C in freezer storage (Cryovac, 1984). The PE casing could withstand temperatures ranging from below 0^{o}C in freezer storage up to 90^{o}C (Koteles, 1984).

Preparation of Experimental Products

The chili and vegetable soup used in this study were prepared at University Hospital in Cleveland, Ohio. Two batches (303 liters/batch) of product were prepared and shipped to Michigan State University, East Lansing, Michigan. The first batch of product was prepared on January 18, 1984 and the second batch of product was prepared on March 7, 1984.

One batch of chili and one batch of vegetable soup were prepared on the same day, following standardized recipes currently used at University Hospital (Tables A-1 and A-2).

Each product was prepared in a 100 gallon steamjacketed kettle (SJK; Model No. INA/2-100, Groen Div./Dover Corp., Elk Grove Village, IL). The SJK was equipped with an automatic agitator and flexible hose through which product was pumped from the kettle at the end of preparation. Product was pumped from the kettle to the pump-fill station (Groen, Pump-fill Model, Elk Grove Village, IL) and into a plastic casing, which was filled with 3.8 liters of product. The casing preclipped on one end, was filled, clip-closed, cooled and stored. The food product flow diagram is shown in Figure 1.

Before preparation of the soup or chili each SJK was sanitized. The SJK was filled with a microquat/water sanitizing solution and allowed to circulate for 30 minutes while the agitator operated at speed 2 1/2. The SJK was then rinsed with hot water for 30 minutes. The sanitizing solution was pumped from the SJK through the hose in order to sanitize the hose.

Chili. Total preparation time for chili (by weight: 39.54% canned tomatoes, 34.89% kidney beans, 17.23% ground beef with 20% fat, 6.89% onions, 0.57% salt, 0.57% sugar, 0.29% chili powder, and 0.02% black pepper; Appendix A-1) was approximately 5 hours. From each of two batches, 40 casings of C-300 and 40 casings of PE were filled with 3.8 liters/casing of chili.

Figure 1. Hospital cook/chill and cook/freeze foodservice systems: Food product flow to compare microbial and sensory qualities of cooked chili and vegetable soup stored chilled or frozen in C-300[a] or PE[b] casings.

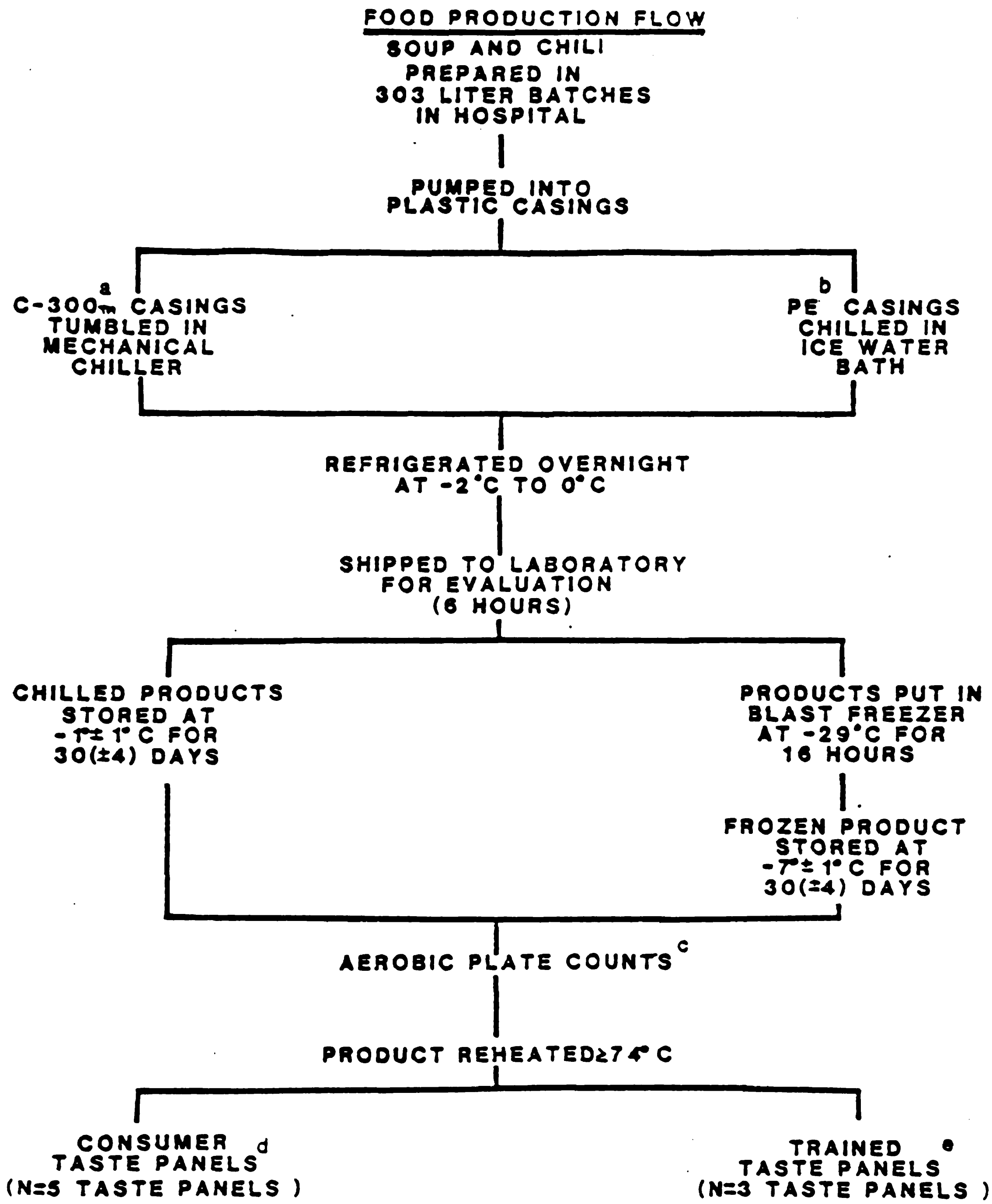
[a]C-300 casing was composed of a three layer laminate of polyethylene/nylon/polyethylene.

[b]Polyethylene (PE) casing was composed of polyethylene.

[c]Frozen products were thawed at -1C for 24 hours before samples were prepared for serial dilutions.

[d]60-75 panelists per taste panel.

[e]Number of panelists per panel was 13-17 panelists.


FOOD PRODUCTION FLOW
SOUP AND CHILI PREPARED IN 303 LITER BATCHES IN HOSPITAL
PUMPED INTO PLASTIC CASINGS
C-300™ CASINGS TUMBLED IN MECHANICAL CHILLER a
PE CASINGS CHILLED IN ICE WATER BATH b
REFRIGERATED OVERNIGHT AT -2°C TO 0°C
SHIPPED TO LABORATORY FOR EVALUATION (6 HOURS)
CHILLED PRODUCTS STORED AT -1°± 1°C FOR 30(±4) DAYS
PRODUCTS PUT IN BLAST FREEZER AT -29°C FOR 16 HOURS
FROZEN PRODUCT STORED AT -7°± 1°C FOR 30(±4) DAYS
AEROBIC PLATE COUNTS c
PRODUCT REHEATED≥74°C
CONSUMER TASTE PANELS d (N=5 TASTE PANELS)
TRAINED TASTE PANELS e (N=3 TASTE PANELS)

Vegetable Soup. Total preparation time for vegetable soup (by weight: 63.20% water, 11.36% tomato juice, 6.29% whole, canned tomatoes, 3.21% tomato puree, 2.96% celery, 2.47% carrots, 1.97% cabbage, 1.97% onions, 0.99% baby lima beans, 0.99% corn, 0.99% peas, 0.99% potatoes, 0.49% margarine, 0.49% green beans, 0.49% long grain rice, 0.45% salt, 0.15% sugar, 0.01% marjoram and 0.01% thyme; Appendix A-2) was approximately 3 1/2 hours. From each of two batches, 40 casings of C-300 and 40 casings of PE were filled with 3.8 liters/casing of soup.

Pumping Experimental Products Into Casings

Before the chili and soup were pumped into the plastic casings, the agitator speed was increased from 2 1/2 to 4 1/2, to ensure an even mixture of ingredients in each casing. Product was pumped from the SJK through the hose attached to the bottom of the kettle to the pump-fill station. Two employees were required during the filling process. One employee held the preclipped casing under the fill valve and operated the fill valve via the foot peddle. The second employee clipped and sealed the filled casings. A casing was filled with 3.8 liters of product in 4-5 seconds and the 40 casings of one type were filled in approximately 10 minutes. Then the 40 casings of the other type (C-300 or PE) were filled.

Printed "tag-type" labels identifying product and production date were attached to each casing at the closure

by placing the label at the neck of the casing as the clip was applied. Air was manually expressed from casings during the clipping process. The casing was grasped with the left hand above the product level while the right hand was used to pull upward on the free end of the casing. Then the casing was clipped at a point between the left and right hands. Any air remaining in the casings contracted during the cooling process.

Chilling Filled Casings

Filled C-300 casings which had been clipped were placed on a conveyor belt which transported the filled casings to the Washex Food Chiller, (Model No. 42124 GRN Washex Machinery Corp., Wichita Falls, TX). Refrigerated water cooled to 0^{o}-$1^{o}C$, circulated throughout the chiller during the cooling process. The flexible plastic casings allowed food products to flow back and forth in the casings while being tumbled in the chilled water. This action shortened the cooling period (compared to refrigerated storage) due to a faster transfer of heat from food products to the environment (Bieler and Howe, 1980). Soup and chili in C-300 casings were cooled from $82^{o}C$ to $\leq 4^{o}C$ in 45 minutes.

Soup and chili in PE casings were cooled in a SJK filled with ice water because the PE casing was not as strong as the C-300 casing. PE casings would not remain intact if tumbled during the cooling process in the food chiller. Chili and soup in PE casings were cooled from $82^{o}C$

to $\leq 4^{o}C$ in 75 to 90 minutes.

Once the products reached $\leq 4^{o}C$, they were removed from the chiller or ice water bath, placed in plastic racks, stacked on dollies and wheeled into the walk-in refrigerator ($-2^{o}C$ to $0^{o}C$) for overnight storage (Figure 1).

Shipment of Products

On the day following preparation of chili and soup, products were placed in corrugated boxes (Stone Container Co., Newberry, SC), 20 casings per box, and loaded into a truck for transportation to Michigan State University (MSU), East Lansing, MI for microbial and sensory evaluation. No refrigeration was required during shipment of products because the outside temperature was $-18^{o}C$ to $-12^{o}C$ on January 19th and $-13^{o}C$ to $-7^{o}C$ on March 8th. The time of shipment from Cleveland, OH to East Lansing, MI was approximately 6 hours (Figure 1). Chili and soup were unloaded at MSU; 20 bags of C-300 chili, 20 bags of PE chili, 20 bags of C-300 soup, and 20 bags of PE soup, were immediately placed in refrigerated storage ($-1^{o}C$). Similar quantities of chili and soup were blast frozen ($-29^{o}C$; Jamison Walkin Freezer) and placed in frozen storage ($-7^{o}C$; Figure 1).

Product Storage

Chili and soup packaged in C-300 and PE casings were stored chilled and frozen. Length of storage before sensory

and microbial evaluation was 30 ± 4 days.

Chilled storage was evaluated because it was the current storage method for C-300 casings marketed by Cryovac (Bieler and Howe, 1980). Chilled food stored at $-1^{o}C$ may be stored 30 to 45 days when prepared in the Cryovac system (Bieler and Howe, 1980). The storage temperature of $-1^{o}C$ inhibits growth of most microbes (Nickerson and Sinskey, 1972).

Frozen storage was evaluated to determine if the quality of frozen foods packaged in C-300 casings would be equal to the quality of chilled foods packaged in C-300 casings. C-300 casings were previously used only for chilled storage (Andres, 1977). PE had previously been used for storage of frozen food in "boil-in-bag" pouches (Glew, 1973).

The frozen storage temperature of $-7^{o}C$ ($20^{o}F$) was chosen to accelerate deterioration of product quality in order to compare the chilled product to a frozen product normally stored 3-6 months. Glew (1973) stated that quality loss during frozen storage was due to chemical and physical changes and was dependent on storage conditions. Quality changes in frozen food after three months storage at $-10^{o}C$ ($15^{o}F$) was roughly equivalent in changes after 6 months storage at $-12^{o}C$ ($10^{o}F$) or to 12 months storage at $-18^{o}C$ ($0^{o}F$) (Glew, 1973). Since little or no change in product quality would occur after 30 days storage at $-18^{o}C$ ($0^{o}F$), the higher frozen storage temperature ($-7^{o}C$) was used to

accelerate deterioration of product quality.

Chilled products were stored in a refrigerated cubicle (Chrysler Koppin Refrigeration Co., Detroit, MI) at $-1^{o}C \pm 1^{o}C$. Temperature of the cubicle was controlled by a Honeywell controller recorder (Model No: 15618826-4801-2-000-061, Honeywell Instruments, Minneapolis, Minnesota). The temperature was recorded daily by a laboratory technician. The relative humidity in the cubicle was measured daily by use of an electric psychrometer (Model No. 566, Bendix Environmental Process Instruments Division, Baltimore, Maryland). Frozen products were stored in a cubicle (Chrysler Koppin Refrigeration Co., Detroit, MI) at $-7^{o}C \pm 1^{o}C$. The temperature of the frozen cubicle was controlled and measured by the same method as for the chilled storage cubicle. Relative humidity was also recorded by the method previously described.

Microbial Analyses

The first purpose of the microbial analysis was to determine microbial quality of the chili and soup stored chilled or frozen in either C-300 or PE casings. A second purpose of the microbial analysis was to determine if the microbial quality of the products were equal to or if they were within acceptable limits before products were served to taste panelists.

Microbial analyses of both batches of chili and soup were completed at ABC Laboratories in Gainesville, Florida,

under the direction of Dr. S.J. Goodfellow, and confirmatory tests on aerobic plate counts (APC) were done at MSU. At ABC Laboratories each product was analyzed for total plate count, total coliforms, fecal coliforms, Escherichia coli, presence or absence of Salmonella, Staphylococus aureus and Clostridium perfringens. All analyses were done according to standard methods outlined in the Bacteriological Analytical Manual, by the FDA (1978).

Products were shipped from MSU to ABC Laboratories for microbial analysis. One casing of product for each of four variables was coded, placed in a styrofoam cooler (Model No. Low-boy, Insul-Pack Cooler, Destin, Florida) and sent via Emery Express. Chilled samples for microbial analysis were blast frozen for shipment (24 hours before shipment). Freezing the chilled samples was recommended by Cryovac to prevent microbial growth during shipment to ABC Laboratories. Due to the shipping schedule, chili and soup samples from the first batch of products had been stored for 25 days prior to shipment to ABC Laboratories, while samples from the second batch of products had been stored for 29 days.

At ABC Laboratories a 50 gram sample of product was blended with a phosphate buffer solution to prepare for serial dilutions from 10^{-1} to 10^{-4}. Inoculated plates for the total plate count were incubated at $20^{0}C$. Total coliforms, fecal coliforms and E. coli, were determined using the Most Probable Number (MPN) technique (FDA, 1978). A 30 gram sample of each product was analyzed for the presence or absence of Salmonella (FDA, 1978). At the ABC Laboratories a 25 gram sample of product was analyzed for S. aureus by a direct plating method on Baird-Parker agar medium (FDA, 1978). Plates were incubated at 35°C for 45-48 hours. Plates with colonies that appeared to be S. aureus were counted. Several suspected colonies of S. aureus were subjected to the Coagulase test to confirm their identification as S. aureus (FDA, 1978). At ABC Laboratories a 25 gram sample of product was analyzed for C.perfringens by a direct plating method on Tryptose-sulfite-cycloserine (TSC) agar enriched with egg yolk emulsion (FDA, 1978). Plates were incubated at 35°C under anaerobic conditions for 20-24 hours. Suspected colonies of C. perfringens were counted and subjected to confirmation tests for C. perfringens (FDA, 1978).

At MSU to prepare serial dilutions of 10^{-1} to 10^{-6} for APC's, 25 grams of product and 225 ml of sterilized 0.1% peptone water were aseptically placed in a sterile stomacher bag (Seward Medical, VAC House, London). The sample was homogenized in a stomacher (Stomacher Lab Blend Model 400, Tek Mar, Cincinnati, OH) for three minutes. Duplicate plates were placed on standard plate count agar (Fisher Scientific, Livonia, MI) using the pour plate method (Elliott et al., 1978). The inoculated plates were incubated for 48 hours at $32^{\circ} \pm 1^{\circ}C$. Plates with 30 to 300 Colony Forming Units (CFU) were counted using a Standard

Colony Counter I (Spencer Manufacturing, Buffalo, NY). APC's were reported as the average number of colonies per gram of product. Results of APC counts were compared to guidelines for the maximum acceptable number of microorganisms. Banwart (1981) suggested that 2,000 to 100,000 microorganisms per gram of food was the acceptable limit for APC's in frozen precooked foods.

Reheating of Products

Chili and soup in C-300 and PE casings were reheated in hot water to simulate production techniques which could be used in a hospital foodservice system. Products were reheated in a SJK filled with approximately 27 liters of water. The minimum recommended water temperature for reheating of product in C-300 casings was 85^{o}C (Bieler and Howe, 1980). Two or three casings of C-300 product were placed in a SJK (Groen Manufacturer, Model No: D-S-SP, Chicago, Illinois) filled with water heated to 90^{o}-100^{o}C. For products in PE casings, the water temperature was originally maintained at 90^{o}-100^{o}C. However after several of the PE casings developed holes during the reheating process, the water temperature was lowered to 71^{o}-82^{o}C to prevent holes in the PE casings. All products were reheated to an internal end temperature of $\geq$74^{o}C.

Internal end temperature of products in the casing was measured using a pocket test thermometer (Model No. 1231-14, Cooper Thermometer Co., Middlefield, Conn.) which had been calibrated to $\pm 1^{o}C$ in boiling water ($100^{o}C$). The casing was lifted from the SJK using protective rubber gloves (Model No. 9-430, Edmont Co., Coshocton, OH). The casing was placed on a stainless steel counter. The thermometer was held against the outside of the casing, near the center of the casing. The end of the casing was folded around the thermometer's stem. The thermometer was read when the needle stopped moving. If product temperature was $\leq 74^{o}C$, then the casing was returned to the SJK for additional heating. If the product temperature was $\geq 74^{o}C$, the casing was placed in a preheated thermal metal food container and transported to the testing site for the consumer or trained taste panel.

Consumer Taste Panels

Consumer taste panels were used to compare the quality of chilled and frozen chili and soup in C-300 and PE casings. Consumer taste panels were conducted to determine if the general public could detect differences between chilled and frozen samples in each type of casing.

A pilot consumer taste panel was completed to determine the procedure for the consumer panels. The pilot consumer panel was conducted at the MSU Dairy Store located in Anthony Hall (Farm Lane, MSU, East Lansing, MI). Panelists were faculty, staff, students and visitors who had been Dairy Store customers on the day of the taste panel. The Human Subjects Committee for research at MSU did give their

approval for consumer taste panels conducted at MSU.

The ballot for the pilot consumer taste panel was designed for a paired preference test, with no forced choice (Table A-3). The IFT Sensory Evaluation Division (1981) defined a paired preference test as one in which two samples were presented simultaneously or sequentially, with the test subject requested to express a preference. A forced choice may or may not be imposed; if it is, the subject must indicate a preference for one sample over another (IFT Sensory Evaluation Div., 1981). Since the purpose of the consumer panel was to determine if consumers had a preference for chilled or frozen products in C-300 or PE casings, panelists were not forced to state a preference. Panelists were allowed to indicate no preference on the ballot.

For the pilot consumer panel only C-300 chili and soup were used. The PE casing was not used for the pilot consumer panel because Cryovac was unable to provide PE casings in time for the pilot taste panel.

At the pilot consumer panel each panelist was simultaneously given two 59 ml (2 oz.) samples of chili or soup and a ballot (Table A-3). Each sample was served in a 177 ml (6 oz.) styrofoam cup (Dart Container Corporation, Stock No. 6J6, Mason, MI). The samples were coded with a random two digit number on the side of the cup. Each panelist was asked to indicate a preference for one sample over another or to indicate no preference.

The consumer taste panels were conducted at various times and locations in the MSU and East Lansing community. Different locations were used in an attempt to have a sample population representative of the adult population of the United States. Consumer panels were conducted at the MSU Dairy Store, the University United Methodist Church, East Lansing; the MSU Student Union Building; and Burcham Hills Retirement Center, East Lansing. Exact dates, times and locations for consumer panels are shown in Table A-4.

Four comparisons of combined main effects of storage and packaging were made during the series of consumer panels. The following four comparisons were made for both chili and soup:

1. Chilled C-300 vs. Frozen C-300
2. Chilled PE vs. Frozen PE
3. Chilled C-300 vs. Chilled PE
4. Frozen C-300 vs. Frozen PE

At consumer taste panels each panelist was asked to make one comparison for chili and one comparison for soup. Sampling order for product was randomized. For each comparison the consumer was simultaneously given two 59 ml portions of chili or soup in a 177 ml styrofoam cup coded with a two digit random number. Consumers were asked to fill out a ballot (Table A-5) giving their age, sex and indicating their response to the comparisons for chili and soup.

Chili and soup for each taste panel were reheated in

the casings to $\geq 74^{o}C$ by the method previously described (see Reheating Products). The casings of chili and soup were then placed in metal thermal food containers and transported to the testing site. For the consumer panel one casing of product for each comparison was poured into a stainless steel counter pan. The pans of chili and soup were placed in a preheated chafing pan partially filled with 2 liters of water. The chafing pan was heated by four to six cans (226.8g fuel/can) of solidified methane (Handy Fuel, Hotel Research Labs, Inc., Tenafly, NJ). A pocket test thermometer (Model No. 1231-14, Cooper Thermometer Co., Meddlefield, Conn.) was used to measure product temperature approximately every half hour during the consumer taste panels. Product temperature was maintained at $\geq 71^{o}C$ ($160^{o}F$) by using additional cans of fuel. Pans of chili and soup were covered with aluminum foil to help maintain the desired product temperature. Chili and soup were ladled into styrofoam cups using a 59 ml (2 oz.) stainless steel ladle (Model No. 58620, Vollrath, Sheboygan, Wisconsin). Panelists were given the samples, a ballot, pencil, 148 ml water in a paper cup and two plastic spoons. Panelists were instructed to taste the two samples and to decide which one they preferred. Panelists were instructed to retaste the samples until a decision was reached. Panelists marked their preference or indicated no preference on the ballot and listed reasons for their decision.

Trained Taste Panel

It was expected that the trained taste panel would detect differences that were not detected by the consumer panels. Amerine et al. (1965) described a laboratory panel as carefully selected, highly trained and hypercritical when compared to the general consumer. Baker et al. (1965) stated that consumer preference testing as opposed to laboratory testing was not specific and many consumers were indifferent to the characteristic being tested. Therefore, in the present study a trained taste panel was used to quantify the magnitude of differences in product quality under controlled laboratory conditions.

Quantitative descriptive analysis (QDA) is a technique for characterizing the perceived sensory attributes of a product in quantitative terms (Stone et al., 1974). The focus of QDA is on the psychophysical aspects of perception and the application of an interval scaling technique to the problem of flavor characterization. QDA was used in a group process to develop the ballots for the trained taste panel. Two separate QDA sessions were held to develop the ballot for chili and to develop the ballot for soup.

At the first QDA session, six panelists were asked to taste a sample of chili and write down the five or six most prominent sensory characteristics that they could distinguish. Panelists were instructed to include appearance, odor, taste, and mouth-feel characteristics (Table A-6). After each panelist had listed several sensory

characteristics, a group discussion followed. During the group discussion panelists reached a consensus to identify and quantify, in order of occurrence, the sensory properties of the chili. Panelists then developed word anchors for each sensory characteristic. The ballot for chili is shown in Table A-7. At a second QDA session, the same process was used to develop the ballot for soup (Table A-8).

The scale for each sensory characteristic was a 10 cm line with marks at 1, 5, and 9 cm. The scale was word anchored at each end of the 10 cm line. Panelists made a vertical mark across the line at the point which best reflects the magnitude of his or her perceived intensity of that characteristic (Stone et al., 1974). The panelists marks were converted to numerical scores to the nearest 0.1 cm, using a 10 cm template.

Panelists were faculty, graduate students and staff in the Department of Food Science and Human Nutrition, MSU. A total of 24 different panelists participated in the three taste panels. Eight panelists attended all three sessions, eight panelists attended two sessions and eight panelists attended only one session. The actual number of panelists at each session varied from 13 for the first session, 17 for the second session and 15 for the third session. Of the 24 panelists, 16 were females aged 20-40 and eight were males aged 20-40.

Taste panelists who did not attend QDA sessions were trained at a session two days prior to the first taste

panel. At the training session, panelists were given a ballot for chili and soup and were asked to rate one sample. The panelists discussed the ballot with the researcher to ensure that the panelists understood the ballot and the meaning of the word anchors for each sensory characteristic. Taste panelists who had attended QDA sessions did not require further training.

The trained taste panels were conducted in the Sensory Evaluation Laboratory, in the Food Science Building at MSU. Panelists were seated in individual booths with florescent lighting. Taste panelists were asked to attend three sessions to rate the samples. At each session panelists were sequentially given four samples of chili and four samples of soup. The order of presentation of samples to panelists was randomized. Half the panelists received chili samples and half the panelists received soup samples first.

A 59 ml portion of product was ladled into a 177 ml styrofoam cup (Dart Container Corporation, Stock No. 6J6, Mason, MI) and presented to panelists along with a ballot for each sample, plastic spoon, water at room temperature and a plain unleavened cracker. The samples were identified by a two digit random number on the styrofoam cup. Panelists were instructed to ask questions concerning the ballot during the taste panels to avoid confusion over descriptive terms.

Statistical Analysis: Consumer Taste Panel

To determine the statistical significance of the responses from each consumer panel, the results were plotted on the Decision Chart (Figure 2). The method for plotting the results on the chart is called sequential analysis (Bross, 1952). Sequential analysis has been used in the medical field to compare two treatments, to determine if there is a significant difference between the two treatments. The consumer ballots at each panel were numbered as they were received so the consumer responses would be plotted in the same order as they were received. For each chili or soup comparison, one treatment would be labeled "old" and one treatment would be labeled "new" in order to plot the consumer responses on the Decision Chart.

According to Bross (1952) "ties" in the present study or "no difference" responses can be dropped since each comparison by a panelist can be considered a separate "little" experiment to test the quality of the product subjected to two different treatments. If both treatments lead to the same result meaning there is "no difference" in quality, then the experiment provides no information as to which treatment is superior. Therefore, for our purposes, "no difference" responses were considered "ties" and were not included in the sequential analysis.

The responses of consumer panelists from each consumer taste panel were plotted on the Decision Chart until a decision was reached. One sample of chili or soup was

DECISION CHART

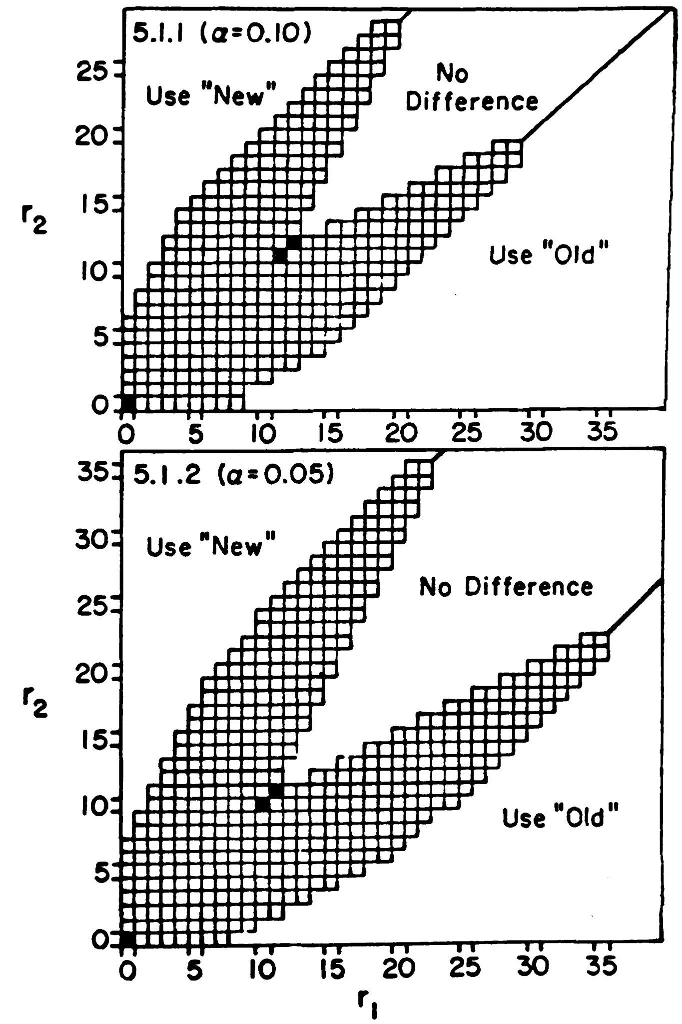


Figure 2. Decision Chart[a] for the statistical significance of consumer panelists responses to comparisons of chilled and frozen chili and soup in C-300 and PE casings.

[a]Bross, I. 1952. Sequential Medical Plans. Biometrics 8:188-205.

randomly designated as the "new" treatment while the other chili or soup sample for the comparison was designated as the "old" treatment. A decision for the "new" treatment would be indicated if the path of x's indicating consumers' responses, crossed the boundary into the clear area designated "new". A decision for the "old" treatment would be indicated if the path of x's indicating consumer responses, crossed into the clear area designated "old". When the path of x's goes up at a 45 degree angle and enters the clear area designated "no difference", then both treatments are considered equally good (Bross, 1952).

Statistical Analysis: Trained Taste Panel

Analysis of variance of the data was carried out using a completely randomized block design (Gill, 1978b). Data from the taste panel sessions were subjected to analysis of variance as follows:

Source of variation	DF
Panelists	23
Storage	1
Package	1
Storage x Package	1
Residual Error	69
Total	95

The 3-way analysis of variance (ANOVA) was completed using the program titled Statistical Package for the Social

Sciences (SPSS; Nie et al., 1975) run on a Cyber 750 CDC computer.

The ANOVA was calculated for each sensory characteristic. Differences in treatment combination means were identified using the Student's t-test or the Bonferoni t-test (Gill, 1978a). For sensory characteristics with a significant ($p \leq 0.05$) storage x package interaction, the Bonferoni t-test was used to determine differences among treatment combination means (Gill, 1978a). If only one of the two factors (storage or packaging) was tested, then the Student's t-test was used. For sensory characteristics in which the storage x package interaction was not significant, the main-effect test from the analysis of variance was considered sufficient (Gill, 1978a).

Chapter IV

RESULTS

Examination of the results for the microbial and sensory evaluation of chilled and frozen chili and soup packaged in C-300 and PE casings is necessary to answer the question as to whether chilled or frozen storage is better for product quality. A second question which needs to be answered is whether the C-300 casing or the PE casing is better for retention of product quality in chilled and/or frozen storage.

The mean temperature and relative humidity during product storage will be examined. Results of microbial analyses of chili and soup by ABC Laboratories and MSU will be presented. Results of consumer comparisons for chili and soup will be examined as well as results of sensory evaluation by the trained taste panel.

Product Storage

The mean temperature and relative humidity (R.H.) for chilled and frozen chili and soup stored for 30 ± 4 days in C-300 and PE casings are shown in Table 1. During storage of the chilled products, the mean temperature and standard error of the mean was -1.4^{o} $\pm 0.5^{o}$C for the first batch of products and $-1.2^{o} \pm 0.3^{o}$C for the second batch of products. The mean relative humidity was 63.0% ± 1.3% in the chilled storage cubicle for the first batch of products and

Table 1. Mean temperature and relative humidity (RH) for two batches[a] of chili and soup stored chilled and frozen in C-300 and PE casings.

Batch	Type of Storage							
	Chilled				Frozen			
	Temperature (°C)		R.H. (%)		Temperature (°C)		R.H. (%)	
Batch 1								
	-1.4[b]	±0.5[c]	63.0[d]	±1.3	-4.3[b]	±0.9	54.1[d]	±2.1
Batch 2								
	-1.2[e]	±0.3	70.4[f]	±1.9	-5.9[e]	±0.3	60.2[f]	±4.0

[a]First batch of chili and soup was produced on 01/18/84, second batch produced on 03/07/84.
[b]N = 26
[c]Standard error is equal to Standard Deviation divided by the square root of N.
[d]N = 15
[e]N = 23
[f]N = 20

70.4% ±1.9% for the second batch of chilled products. The relative humidity in the chilled storage cubicle was 10% higher during storage of the second batch of products than for the first batch.

The mean temperature for frozen storage was higher during storage of the first batch of products (-4.3^{o} $\pm 0.9^{o}C$) and fluctuated more than the mean temperature during storage of the second batch of products (-5.9^{o} $\pm 0.3^{o}C$). The relative humidity was lower during storage of the first batch of frozen products (54.1 ±2.1%) and varied less than the relative humidity during storage for the second batch of frozen products (60.2 ±4.0%).

Microbial Analyses

Results of microbial analyses performed by ABC Laboratories are in Table 2. Results of microbial analyses reported in Table 2 were the average of plate counts (Colony Forming Units per gram or CFU/gm) reported for both batches of chilled and frozen chili and soup. The results of microbial analysis for each batch of products are reported in Tables A-9 and A-10. For test results reported as <3, <10, or<100 CFU/gm for each batch of product (Table A-9 and A-10), the test results were reported in Table 2 as <3, <10, or <100 CFU/gm rather than reporting an average for those tests.

The aerobic plate count (APC) was used to indicate the general microbial quality of chilled and frozen chili and

Table 2. ABC Laboratories: Microbial analyses[a,b] of chilled and frozen chili and soup stored for 30±4 days[c] in C-300 and PE casings.

Product	Total (Aerobic) Plate Count (CFU/gm)	Total Coli-forms (MPN)	Fecal Coli-forms (MPN)	E. Coli[d] (MPN)	Salmo-nella[e] (+or-)	S. Aureus[f] (CFU/gm)	C. Perfrin-gens[g] (CFU/gm)
CHILI							
Chilled C-300	1,700	9	<3	3	--[h]	<3	<10
Frozen C-300	200	<3	--	--	--	<3	<10
Chilled PE	250	<3	--	--	--	<3	<10
Frozen PE	200	<3	--	--	--	<3	<10
SOUP							
Chilled C-300	200	<3	--	--	--	<3	<10
Frozen C-300	25,050	<3	--	--	--	<3	<10
Chilled PE[i]	800	<3	--	--	--	<3	<10
Frozen PE	550	<3	<3	--	--	<3	<10

[a]Analyses performed by A.B.C. Research, Gainsville, Florida

[b]All counts were the average (N=2) of plate counts (Colony Forming Units per gram) or MPN (Most Probable Number) estimates of microorganisms from analysis of both batches of chili and soup. Results of analyses for each batch of products are reported in Tables A-10 and A-11.

[c]Products were analyzed before reheating and service to consumers. Products from the first batch of products had been stored for 25 days prior to shipment to the laboratory, while products from the second batch had been stored for 29 days prior to shipment to the laboratory for analysis.

[d]Escherichia coli.

[e]Results of analysis for Salmonella were reported as positive (+) or negative (-) for presence of Salmonella in a 30 gm sample of product.

[f]Staphylococus aureus.

[g]Clostridium perfringens.

[h]Indicates result was negative.

[i]Chilled PE soup from the first batch of product was omitted because the shipping container was not large enough to accommodate all eight samples.

soup. APC's were reported as the number of Colony Forming Units (CFU) per gram and are shown in Table 2. The APC is the most commonly employed test to indicate the microbial quality of foods (Elliot et al., 1978). As shown in Table 2, all samples of chili and soup had APC's of <100,000 CFU/gm. Longree (1972) stated that precooked foods with <100,000 CFU per gram were generally considered safe for human consumption. Frozen C-300 soup had the highest APC with 25,050 CFU/gm (Table 2).

Total coliforms includes *Escherichia coli*, *Citrobacteria freundii*, *Enterobacter aerogenes*, *Enterobacter cloacae* and *Klebsiella pneumoniae* (Banwart, 1981). Coliforms are common inhabitants of the intestinal tract of humans and animals, and are both fecal and nonfecal in origin. Coliforms do include psychotrophic types capable of multiplying at 3^{o}-10^{o}C in refrigerated foods but do not survive at freezer or pasteurization temperatures. The presence of large numbers of coliforms in cooked foods could indicate contamination of the food after cooking (Banwart, 1981). As shown in Table 2, the counts for total coliforms were low, being less than three for all samples except the chilled C-300 chili which had four. Banwart (1981) reported that the microbial specifications for precooked frozen foods purchased for the military can have a maximum total coliform count of <100 CFU/gm. So all samples tested for total coliforms were within recommended microbial limits for precooked frozen foods (Banwart, 1981).

As shown in Table 2, most chili and soup samples were negative when tested for fecal coliforms. The chilled C-300 chili and the frozen PE soup, had less than three CFU/gm for fecal coliforms. Fecal coliforms are relatively specific for fecal material of warm blooded animals. Fecal coliforms are destroyed by pasteurization (80°C) or normal cooking temperature and should die rapidly during freezing (Banwart, 1981). While no standard exists for microbial counts for fecal coliforms, the count should be low or no fecal coliforms should be present.

As shown in Table 2, most chili and soup samples were negative when tested for *Escherichia coli*, only the chilled C-300 chili had a count of less than three CFU/gm for *E. coli*. *E. coli* is the most prominent fecal coliform and inhabits the intestinal tract of man and warm-blooded animals. Some microbiologists believe that only the presence of *E. coli* is indicative of fecal contamination of food (Banwart, 1981). Although *E. coli* dies in frozen storage, in a product with gravy the death rate is lower and some *E. coli* may survive frozen storage for several months. The U.S. military purchase specifications for frozen foods require all food to be negative when tested for *E. coli* (Banwart, 1981).

To summarize, all chili and soup samples were of acceptable microbial quality with respect to most probable number (MPN) estimates for microbial counts for total coliforms, fecal coliforms and *E. coli*.

As indicated in Table 2, all samples of chili and soup were negative when tested for Salmonellae. Banwart (1981) stated that lSalmonellae decline in numbers at a rate similar to E. coli in many refrigerated foods. The thermal resistance of salmonellae is also similar to the thermal resistance of E. coli. The U.S. Military purchase specifications for frozen precooked foods specifies that all samples must be negative when tested for Salmonellae.

Results of tests for Staphylococcus aureus (coagulase-positive staphylococci) are shown in Table 2. All samples of chili and soup had less than three CFU/gm when tested for S. aureus. The presence of large numbers of S. aureus would be an indication of a potential health hazard due to staphylococcal enterotoxin, as well as questionable sanitation practices (Banwart, 1981).

Tests for Clostridium perfringens indicated that all chili and soup samples had less than 10 CFU/gm (Table 2). Vegetative cells of C. perfringens in the growth phase are very sensitive to chilling and freezing. Tests on frozen or chilled foods often reveal only the level of C. perfringens spores which survive chilling and freezing well (Elliot et al., 1978).

In summary, all chili and soup samples were of acceptable microbial quality with respect to microbial counts for total coliforms, fecal coliforms, E. coli, Salmonellae, S. aureus and C. perfringes (Banwart, 1981). Microbial counts for the APC were also within the maximum

limit for APC's recommended at ≤100,000 CFU/gm by Longree (1972).

Results of the confirmatory APC's conducted at MSU are shown in Table 3. The results of the APC's performed at MSU are not comparable to the APC's performed at ABC Laboratory because the plates were incubated at different temperatures. ABC Laboratory used the FDA's method for total (aerobic) plate counts and incubated the plate at 20°C. The APC's performed at MSU were done according to the method by Elliot et al., (1978) and were incubated at 32°C. APC's reported by MSU in Table 3 were the average of plate counts from both batches of chili and soup. Results for each batch are shown in Table A-11. APC's reported by MSU were generally lower than APC's reported by ABC Laboratory, due to the difference in incubation temperature. Again, all plate counts were <100,000 CFU/gm as recommended by Longree (1972).

Reheating of Products

Approximate reheating times for all products are shown in Table 4. All products were reheated to an internal end point temperature (EPT) of ≥74°C. The frozen PE chili had the longest reheating time with 90 minutes required for the PE chili to reach an EPT of ≥74°C. Chili and soup in PE casings required more reheating time because the water temperature was lower than the water temperature used to reheat the chili and soup in C-300 casings. The water

Table 3. MSU Labs: Mean aerobic plate counts (APC)[a,b,c] for chilled and frozen chili and soup stored for 30 ±4 days[d] in C-300 and PE casings.

PRODUCT	APC (CFU/gm)
CHILI	
Chilled C-300	5
Frozen C-300	47
Chilled PE	150
Frozen PE	5
SOUP	
Chilled C-300	5
Frozen C-300	5,000
Chilled PE	25,000
Frozen PE	50

[a]Analysis performed by MSU using the method by Elliot et al., (1978).
[b]APC's reported are the average (N=2) of plate counts from analysis of both batches of chili and soup.
[c]Samples were analyzed prior to reheating for sensory evaluation.
[d]Chili and soup from the first batch of products had been stored for 25 days before microbial samples were taken, while chili and soup from the second batch had been stored for 24 days prior to analysis.

Table 4. Approximate reheating times[a] in hot water[b,c] for chilled and frozen chili[d] and soup[d] in C-300 and PE casings.

	Product			
	Chili		Soup	
Packaging	Chilled (min.)	Frozen (min.)	Chilled (min.)	Frozen (min.)
C-300	50	75	35	40
PE	60	90	40	45

[a]Time reported was the time usually required for the product to reach an internal endpoint temperature of ≥74°C. Exact times were not recorded when reheating products because products were reheated to the specified temperature.
[b]For C-300 casings, water temperature in steam jacketed kettle (SJK) was 90°-100°C.
[c]For PE casings, water temperature in the SJK was 71°-82°C.
[d]Each casing contained 3.8 liters of product.

temperature for reheating products in PE casings was maintained at 71°-82°C to prevent leaks in the casings. The water temperature for reheating products in C-300 casings was maintained at 90°-100°C because that was the temperature recommended for rapid reheating of products in C-300 casings (Bieler and Howe, 1980).

Consumer Taste Panels

Consumer taste panels were conducted to determine if the general public could detect differences in sensory quality of chilled and frozen chili and soup in each type of casing. Several taste panels were conducted at the MSU Dairy Store, located on the MSU campus. Taste panels were also conducted at two locations in East Lansing. See Table A-4 for a complete listing of panel locations, comparisons and main effect studied. Results from the consumer panel at the MSU Union Building (2/20/84) were not included because the temperature of the soup at the time of service to panelists had dropped from $\geq$60°C to $\leq$44°C. The soup was ladeled into styrofoam cups approximately 20 minutes prior to service and placed in an insulated hot cart. Apparently the temperature of the soup decreased while it was in the hot cart. The temperature of the soup at the point of service to panelists should have been $\geq$60°C (Cardello and Maller, 1982). Cardello and Maller (1982) reported on consumer acceptability of water, selected beverages and foods as a function of serving temperature. For solid and

semi-solid foods that are normally served hot, acceptability increased monotonically with increasing temperature (Cardello and Maller, 1982). Since the preferred serving temperature for soup was 60°C, the actual serving temperature could have affected the outcome of the soup comparison for the panel at the MSU Union Building. The chili comparison for the taste panel at the MSU Union Building could not be evaluated because a small leak had developed in the PE casing during reheating. Water from the reheating medium had leaked into the casing, but was not discovered until the PE casing was cut open and the chili was poured into a pan. So results of the taste panel conducted at the MSU Union Building were not included.

Results of the consumer panel at Burcham Hills Retirement Center (2/21/84) for chili were included but results of the soup comparison at the Burcham Hills consumer panel were excluded. Although the number of panelists at the Burcham Hills panel (36 panelists) was less than the 50-75 panelists needed to qualify as a consumer panel (IFT Sensory Evaluation Division, 1981), a decision was reached for the chili comparison. Results of the soup comparison were omitted because there were not enough panelists to reach a decision.

Responses of consumer panelists for each chili or soup comparison were plotted on the Decision Chart using the method previously described (Bross, 1952). A summary of the results of consumer panel comparisons for chilled and frozen

chili and soup are shown in Table 5. Results of the sequential analysis of consumer responses for each chili and soup comparison were plotted on Decision Charts and are shown in Figures A-1 to A-7.

Whether or not consumers preferred chilled or frozen product depended on which product was tested and in what casing the product was packaged. Also whether or not consumers preferred product in C-300 or PE casings depended on which product was tested and whether the product had been stored chilled or frozen.

<u>Chili Comparisons</u>. Whether consumers preferred chilled or frozen chili depended on in which casing the chili was packaged. Chilled C-300 chili was preferred when compared to frozen C-300 chili for the consumer panel located at the University Methodist Church on 02/19/84 (See Table A-4). The comparison of chilled C-300 chili and frozen C-300 chili was repeated during the consumer panel located at the MSU Dairy Store on 02/21/84. At the second consumer panel, panelists did not detect a difference between chilled and frozen C-300 chili. The comparison of chilled and frozen C-300 chili was repeated because the researcher felt that the results of the first consumer comparison for chilled C-300 and frozen C-300 chili was only marginally in favor of the chilled C-300. This comparison was of primary importance and the researcher wanted to be sure that a consumer preference for chilled C-300 chili existed.

Table 5. Consumer taste panel results for comparisons of chilled and frozen chili and soup packaged in C-300 and PE casings.

Comparison	Main Effect Studied	Results[a]	
		Chili	Soup
Chilled C-300 vs. Frozen C-300	Storage	Chilled C-300 Preferred or No Difference	No Difference
Chilled PE vs. Frozen PE	Storage	Frozen PE Preferred	Frozen PE Preferred
Chilled C-300 vs. Chilled PE	Packaging	No Difference	Chilled C-300 Preferred
Frozen C-300 vs. Frozen PE	Packaging	No Difference	Frozen C-300 Preferred

[a]Statistically significant difference, $p \leq 0.05$.

However, results of the second consumer taste panel did not agree with results for the first consumer taste panel. The Decision Chart for the chilled C-300 vs. frozen C-300 comparisons are shown in Figure A-1.

In comparing chilled and frozen chili in PE casings, the frozen PE was preferred (Table 5). Several consumer panelists commented on the ballot that the chilled PE chili had an off-flavor, which was difficult to describe. The flavor of the chilled PE chili was described as old, flat, or refrigerated. The flavor of the frozen PE chili was described as spicier, more flavorful, zestier, more tomato flavor than the chilled PE chili and had no off-flavor or aftertaste. Consumers preferred the frozen PE chili. The Decision Chart for the chilled PE chili vs. frozen PE comparison is shown in Figure A-2.

For both chili comparisons in which packaging was the main effect studied, consumers could not detect a difference between chili samples in either comparison (See Table 5). In comparing chilled C-300 chili and chilled PE chili, no difference was detected. In comparing frozen C-300 chili and frozen PE chili, again no difference was detected by consumer panelists. Decision Charts for chili comparisons in which packaging was the main effect studied are shown in Figures A-3 and A-4.

In summary, whether consumers preferred chilled or frozen chili in C-300 or PE casings depended on which main effect (storage or packaging) was studied. With respect to

storage for chili in C-300 casings, consumers preferred the chilled C-300 chili or they could not detect a significant difference between chilled and frozen chili in C-300 casings. With respect to storage for chili in PE casings, frozen PE chili was preferred. With respect to packaging, consumers did not detect differences in sensory quality of chilled or frozen chili in either casing.

Soup Comparisons. Whether consumers preferred chilled or frozen soup depended on in which casing the soup was packaged (Table 5). In comparing chilled C-300 soup and frozen C-300 soup, no difference in sensory quality was detected by consumers. In comparing chilled PE soup and frozen PE soup, the frozen PE soup was preferred. The Decision Charts for the soup comparisons in which storage was the main effect studied are shown in Figures A-5 and A-6.

For the soup comparisons in which packaging was the main effect studied, chilled or frozen soup in C-300 casings was preferred over chilled or frozen soup in PE casings. For soup, there was a package effect with consumers showing a preference for chilled and frozen soup packaged in C-300 casings (See Table 5). The Decision Charts for the soup comparisons in which packaging was the main effect studied are shown in Figure A-7.

As shown in Table 5, consumers did not detect differences between chilled and frozen soup in C-300

casings. This comparison was evaluated by two consumer taste panels (See Table A-4 for date and location of panels). The consumer panel at the Dairy Store on 02/17/84, compared chilled C-300 soup and frozen C-300 soup. Consumers at that panel did not detect a significant difference between the two soup samples. This comparison was repeated at the Dairy Store again on 04/05/84. The second consumer panel also did not detect a significant difference in sensory quality between chilled and frozen soup in C-300 casings. The comparison was repeated because this comparison was of primary importance to the research. The researcher wanted to be sure that consumers did not detect significant differences between chilled and frozen soup in C-300 casings. The Decision Charts are shown in Figure A-5 for the chilled vs. frozen soup in C-300 casing comparisons.

In comparing chilled and frozen soup in PE casings, the frozen PE soup was preferred. The Decision Chart for this comparison is shown in Figure A-6. Consumer panelists preferred the frozen PE soup because it had more flavorthan the chilled PE soup. Several panelists described the flavor of the frozen PE soup as richer or fuller than the flavor of the chilled PE soup. The flavor of the chilled PE soup was described as flat, bland, watered down and it had an unpleasant aftertaste. One panelist described the taste as a plastic taste, while another panelist described the taste of the chilled PE soup as having a clinical taste. The

frozen PE soup was preferred over the chilled PE soup.

For both soup comparisons in which packaging was the main effect studied, soup in the C-300 casing was preferred over soup in the PE casing for chilled and frozen storage.

In comparing chilled C-300 soup and chilled PE soup, consumers preferred the flavor of the chilled C-300 soup (Figure A-7). The chilled PE soup again was described as having a metallic taste, bitter taste, tasted flat or was more watery than the chilled C-300 soup.

In comparing frozen soup in C-300 and PE casings, the C-300 soup was preferred. The flavor of the frozen C-300 soup was described as stronger, spicier, richer and the vegetables were crisper. Again the flavor of the frozen soup in PE casing was described as having an unpleasant aftertaste, a metallic taste, was too bland or tasted more watery than the frozen C-300 soup.

In summary, consumer's preference for chilled or frozen soup was dependent on in which casing the soup was packaged. Consumers did not have a preference for chilled or frozen soup in C-300 casings. Consumers did have a preference for frozen soup in PE casings. For both soup comparisons in which packaging was the main effect studied, consumers preferred soup in C-300 casing whether the soup was chilled or frozen. The reason most often given by consumers for their preference for soup in C-300 casings was due to an unpleasant aftertaste for soup in PE casings.

Trained Taste Panel

A trained taste panel was used to evaluate the sensory quality of chilled and frozen chili and soup in C-300 and PE casings. It was expected that the trained taste panel would detect differences between samples that were not detected by the consumer panels. Panelists evaluated each sample of chili and soup for several sensory characteristics using a 10 cm line with marks at 1, 5 and 9 cm. The ballots for chili and soup are shown in Tables A-8 and A-9.

In general the trained taste panel detected few significant differences in the sensory quality of chilled or frozen chili in C-300 or PE casings. Results of the analysis of variance (ANOVA) for the chili samples showed only three sensory characteristics which had a significant storage x package interaction. There was no significant difference among chili samples for overall acceptability. The trained taste panel did detect significant differences among chilled and frozen soup in C-300 or PE casings for several sensory characteristics. Results of the ANOVA for the soup samples showed several sensory characteristics which had a significant storage x package interaction in the ANOVA. Frozen soup in PE casing was rated significantly higher with respect to overall acceptability than frozen soup in C-300 casing. A closer examination of the results provided below specifies which significant differences among chili and soup samples were detected by the trained taste panel.

Sensory Evaluation of Chili. Results of the trained taste panel evaluation of chilled and frozen C-300 and PE chili are shown in Table 6. Mean scores, standard error of the treatment combination means ($\sqrt{MSE/n}$), statistical significance of main effects and the storage x package interaction are shown in Table 6.

As shown in Table 6, storage was statistically significant for aroma. Since the packaging effect was not significant and the storage x package interaction was not significant for aroma, the four treatment combination means (i.e., chilled C-300 chili, frozen C-300 chili, chilled PE chili, and frozen PE chili) need not be compared. A comparison of the average of the means for chilled chili (5.15) versus the average of the means for the frozen chili (4.80) showed a significant difference ($p<0.10$) with the chilled chili rated higher than the frozen chili with respect to aroma.

For integrity of beans, the packaging effect was significant ($p <0.001$). As shown in Table 6, the storage effect and the storage x package interaction were not significant for integrity of beans. The average mean score for chili in PE casings was significantly higher (7.35 versus 5.75) than the average mean score for chili in C-300 casings. So trained taste panelists preferred the integrity of beans in the chili packaged in PE casings regardless of which storage method was used.

Three sensory characteristics had a statistically

Table 6. Trained Taste Panels: Treatment combination (T.C.) mean scores, standard error of T.C. means and significance of F values for sensory quality of chilled and frozen chili in C-300 and PE casings.[a]

CHARACTERISTIC[b]	STORAGE				Standard Error of T.C. Mean	ANOVA, Significance of F-values[d]			
	CHILLED		FROZEN						
	C-300	PE	C-300	PE		Storage(A)	Packaging(B)	Panelist(C)	AxB
Appearance	6.2	6.2	6.3	6.1	0.22	ns	ns	****	ns
Aroma	5.2	5.1	4.7	4.9	0.19	*	ns	****	ns
Texture	4.4	4.3	6.4	6.7	0.21	ns	ns	****	ns
Integrity of Beans	5.9	7.3	5.6	7.4	0.22	ns	****	****	ns
Temperature	7.9	8.0	7.3	6.2	0.22	**	****	****	**
Spiciness	3.8	4.3	4.0	4.1	0.14	ns	ns	****	**
Beany Flavor	6.2	5.5	5.9	6.2	0.31	ns	ns	****	*
Meaty Flavor	5.4	5.3	5.5	5.8	0.32	ns	ns	****	ns
Greasiness	6.3	6.6	6.3	6.4	0.17	ns	ns	****	ns
Aftertaste	7.6	7.1	7.7	7.6	0.18	ns	ns	****	ns
Overall Acceptability	6.5	6.6	6.5	6.3	0.17	ns	ns	****	ns

[a] Mean of three sessions, n=48 observations, eight panelists attended all three sessions, eight panelists attended two sessions and eight panelists attended one session.
[b] Scale of 0-10, where 10 = optimum score
[c] Standard error of T.C. means is $= \sqrt{MSE/n}$
[d] * $p<0.10$, ** $p<0.05$, *** $p<0.01$, **** $p<0.001$, ns = not significant

significant storage x package interaction, temperature, spiciness, and beany flavor; a further comparison of differences between means was done using the Bonferroni t-test (Gill, 1978a). The comparison of means for temperature, spiciness and beany flavor are shown in Table 7.

With respect to temperature, there was a significant difference between mean scores for chilled PE and frozen PE chili or frozen C-300 and frozen PE chili. The frozen PE chili rated lower in both cases.

A comparison of mean scores for spiciness showed a significant difference between chilled C-300 chili and chilled PE chili with a higher mean score for the chilled PE chili (Table 7). A comparison of mean scores for beany flavor showed no statistically significant differences between mean scores ($p < 0.05$).

In summary, the trained taste panel detected few significant differences in the sensory quality of chilled or frozen chili in C-300 or PE casings. Results of the analysis of variance for the chili samples showed only three sensory characteristics which had a significant storage x package interaction. A comparison of mean scores for those characteristics having a significant storage x package interaction (temperature, spiciness, beany flavor) showed that frozen PE chili was rated lower than either chilled PE chili or frozen C-300 chili. Spiciness was rated significantly higher for chilled PE chili than for chilled

Table 7. Trained Taste Panels: comparison of treatment combination mean scores [+] for sensory evaluation of chilled and frozen chili packaged in C-300 and PE casings.

Characteristic	Packaging	Storage	
		Chilled	Frozen
Temperature#	C-300	7.9^{Aa}	7.3^{Aa}
	PE	8.0^{Aa}	$6.2^{B***b***}$
Spiciness#	C-300	3.8^{Aa}	4.0^{Aa}
	PE	4.3^{Ab*}	4.1^{Aa}
Beany Flavor#	C-300	6.2^{Aa}	5.9^{Aa}
	PE	5.5^{Aa}	6.2^{Aa}

[+]Comparison of mean scores for sensory characteristics which had a significant storage x package interaction in the ANOVA. Two means in the same row were significantly different if they have different uppercase superscripts. Two means in the same column for a given characteristic were significantly different if they have different lower case superscripts.

*Indicates level of significance: *$p \leq 0.10$ **$p \leq 0.05$, ***$p \leq 0.01$, ****$p \leq 0.001$.

[#]Comparison of means by Bonferroni t-test (Gill, 1978a).

C-300 chili. A comparison of mean scores for beany flavor showed no significant differences between mean scores. In general, the trained taste panel did not have a preference for chilled or frozen chili in either casing.

Sensory Evaluation of Soup. Results of the sensory evaluation of chilled and frozen soup in C-300 and PE casings are in Table 8. All sensory characteristics for the soup samples except aroma and greasiness showed a significant storage x package interaction in the three way ANOVA. Sensory scores for aroma and greasiness will be discussed first because the storage x package interaction was not significant in the ANOVA for aroma and greasiness. A comparison of mean scores for all sensory characteristics for soup except aroma and greasiness are in Table 9.

For aroma the packaging effect was significant in the ANOVA but storage and the storage x package interaction were not significant (Table 8). The mean for aroma for soup in C-300 casings was 4.95 compared to the mean for soup in PE casings of 4.55. Results of this comparison of means using the student's t-test (Gill, 1978a) showed a significant difference with the soup in C-300 casings rated significantly higher ($p<0.10$) than soup in PE casings.

For greasiness the packaging effect was significant in the ANOVA but storage and the storage x package interaction were not significant (Table 8). The mean score for soup in C-300 casings was 5.15 and the average mean score for soup

Table 8. Trained Taste Panels: Treatment combination (T.C.) mean scores, standard error of T.C. mean and significant of F values for sensory quality of chilled and frozen vegetable soup in C-300 and PE casings.

Characteristic[b]	Storage: Chilled C-300	Storage: Chilled PE	Storage: Frozen C-300	Storage: Frozen PE	Standard Error of T.C. Mean	ANOVA, Significance of F-values[d]: Storage (A)	Packaging (B)	Panelist (C)	AxB
Aroma	4.8	4.7	5.1	4.4	0.20	ns	*	****	ns
Degree of Separation of Broth	4.0	4.6	4.5	4.1	0.23	ns	ns	****	*
Consistency of Broth	3.6	3.1	3.3	3.5	0.18	ns	ns	****	*
Color of Broth	6.2	5.2	5.9	6.4	0.19	**	ns	****	****
Color of Vegetables	5.5	5.1	4.7	6.0	0.24	ns	*	****	***
Integrity of Vegetables	4.9	4.8	4.2	5.5	0.26	ns	**	****	***
Temperature	6.9	5.1	6.8	6.3	0.26	**	****	****	***
Flavor of Broth	4.7	3.3	4.7	4.7	0.21	**	**	****	**
Texture of Vegetables	5.9	6.6	4.4	6.4	0.22	****	****	****	***
Greasiness	5.2	5.6	5.1	6.0	0.17	ns	****	****	ns
Aftertaste	6.9	6.9	6.8	7.6	0.21	*	ns	****	**
Overall Acceptability	5.6	5.1	5.3	6.0	0.18	*	ns	****	****

[a]Mean of three sessions, n=48 observations, eight panelists attended all three sessions, eight panelists attended two sessions, eight panelists attended one session.

[b]Scale of 0-10, where 10 is optimun

[c]Standard error of the row means is equal to $\sqrt{MSE/n}$

[d]$^{*}p \leq 0.10$, $^{**}p \leq 0.05$, $^{***}p \leq 0.01$, $^{****}p \leq 0.001$, ns = not significant

Table 9. Trained Taste Panels: comparison of treatment combination mean scores[+] for sensory evaluation of chilled and frozen vegetable soup packaged in C-300 and PE casings.

Characteristic	Packaging	Storage: Chilled	Storage: Frozen
Degree of Separation of Broth[#]	C-300	4.0^{Aa}	4.5^{Aa}
	PE	4.6^{Aa}	4.1^{Aa}
Consistency of Broth[#]	C-300	3.6^{Bb}	3.3^{Bb}
	PE	3.1^{Bb}	3.5^{Bb}
Color of Broth[@]	C-300	6.2^{C}	5.9^{C}
	PE	5.2^{C}	6.4^{D****}
Color of Vegetables[$]	C-300	5.5^{e}	4.7^{e}
	PE	5.1^{e}	6.0^{f****}
Integrity of Vegetables[$]	C-300	4.9^{g}	4.2^{g}
	PE	4.8^{g}	5.5^{h**}
Temperature[#]	C-300	6.9^{Ii}	6.8^{Ii}
	PE	5.1^{Ij***}	6.3^{Jj***}
Flavor of Broth[#]	C-300	4.7^{Kk}	4.7^{Kk}
	PE	3.3^{Kl***}	4.7^{L**k}
Texture of Vegetables[#]	C-300	5.9^{Mm}	4.4^{N***m}
	PE	6.6^{Mm}	6.4^{Mn***}
Aftertaste[$]	C-300	6.9^{o}	6.8^{o}
	PE	6.9^{o}	7.6^{p***}
Overall Acceptability[@]	C-300	5.6^{Q}	5.3^{Q}
	PE	5.1^{Q}	6.0^{R****}

[+]Comparison of mean scores for sensory characteristics which had a significant storage x package interaction in the ANOVA. Two means in the same row with different uppercase superscripts were significantly different. Two means in the same column for a given characteristic were significantly different if they have different lower case superscripts.

[*]Indicates level of significance: *$p \leq 0.10$, **$p \leq 0.05$, *** $p \leq 0.01$, **** $p \leq 0.001$.

[#]Comparison of means in same row and same column by Bonferroni t-test, m=4 (Gill, 1978a).

[@]Comparison only of means in the same row using Student t-test (Gill, 1978a).

[$]Comparison only of means in the same column using Student t-test (Gill, 1978a).

in PE casings was 5.8, a significant difference (p <0.001) for packaging. Apparently, the soup in C-300 casings appeared greasier than the soup in PE casings.

As shown in Table 9, chilled PE soup had significantly lower mean scores than frozen PE soup for several characteristics: color of broth, temperature, flavor of broth, and overall acceptability. In the C-300 casing there were no significant differences between mean scores for chilled and frozen soup, except in the case of texture of vegetables, where the mean score was significantly higher for the chilled C-300 soup.

In comparing chilled C-300 soup and chilled PE soup, there were significant differences between mean scores for temperature and flavor of broth. The mean score for the chilled C-300 soup was higher in both cases. In comparing frozen C-300 and frozen PE soup, there were significant differences in mean scores for these characteristics: color of vegetables, integrity of vegetables, temperature, texture of vegetables, and aftertaste. For these characteristics the mean score for frozen PE soup was significantly higher than the mean score for the frozen C-300 soup, except for temperature where the mean score was higher for the frozen C-300 soup.

In comparing chilled and frozen soup in PE casings, the frozen PE soup received higher mean scores for several characteristics. So frozen storage would be better than chilled storage for soup in PE casings. In comparing

chilled and frozen soup in C-300 casings, few differences between mean scores would indicate that either chilled or frozen storage could be used for soup in C-300 casings, although the scores for chilled soup were consistently a bit higher than for frozen soup in C-300 casings.

For chilled storage, there were only two characteristics which had significant differences between mean scores for C-300 and PE soup. Either casing may be nearly equally suited for chilled storage of soup. For frozen storage of soup in C-300 and PE casings, soup in PE casings had higher mean scores for several characteristics. For frozen storage of soup, the PE casing appears to retain product quality better than frozen soup in C-300 casings.

Chapter V

DISCUSSION

Further examination of the results for the microbial and sensory evaluation of chilled and frozen chili and soup packaged in C-300 and PE casings is necessary to answer the question as to whether chilled or frozen storage is better for product quality. A second question which needs to be answered is whether the C-300 casing or the PE casing is better for retention of product quality in chilled and/or frozen storage.

Several factors which could have affected the results of the microbial analyses or the sensory evaluation need to be examined. Factors to be discussed include microbial analysis, reheating method, and the age and sex of consumer panelists. Results of the consumer taste panels and trained taste panel will be examined to determine if any relationship exists between consumer and trained taste panel results.

Product Storage: Temperature

Chilled storage was evaluated because it was the current storage method for C-300 casings marketed by Cryovac (Bieler and Howe (1980). Chilled food stored at $-1^{o} \pm 1^{o}C$ may be stored 30 to 45 days when prepared in the Cryovac system (Bieler and Howe, 1980). Frozen storage was evaluated to determine if the quality of frozen foods

packaged in C-300 casings would be equal to the quality of chilled foods packaged in C-300 casings. The frozen storage temperature of -7°C (20°F) was chosen to accelerate deterioration of product quality in order to compare the chilled product to a frozen product normally stored 3-6 months. Glew (1973) stated that quality loss during frozen storage was due to chemical and physical changes and was dependent on storage conditions. Since little or no change in product quality would occur after 30 days storage at -18°C (0°F), the higher frozen storage temperature (-7°C) was used to accelerate deterioration of product quality.

Fluctuations in storage temperature, especially for frozen foods, can contribute to deterioration of frozen foods (Kramer, 1979). Kramer (1979) stated that losses in sensory quality and vitamins increased with time-temperature conditions of storage, and were greater under fluctuating (±5°C) temperatures conditions than at constant (±1°C) temperature conditions. In frozen storage of foods, fluctuations in temperature are inevitable due to the operation of the freezer (Griswold et al., 1979).

Fluctuations in the freezer temperature called cycling are due to the operation of the compressor which only operates when the freezer compartment reaches a set temperature and stops when the temperature drops to a set temperature (Griswold et al., 1979). The effects of temperature fluctuations should be minimized in well wrapped packages (Griswold et al., 1979).

As shown in Table 1, the fluctuations in storage temperature for both chilled and frozen products was greater during storage of products from batch one, with the frozen storage temperature fluctuating more than the chilled storage temperature. Not only does the temperature fluctuation affect product quality, but the time-temperature relationship also affects product quality. Kramer (1979) stated that there is an exponential relationship between temperature and time to produce a given degree of quality change for most products. Generally, for every 5°C increase in storage temperature, the rate of quality loss increased 2-2 1/2 times (Kramer, 1979). Tressler (1968) stated that in the case of precooked foods solidly frozen, changes in quality were due to chemical reactions. The rate of those chemical reactions increased 2 1/2 times when temperature increased 10°C (18°F). Although researchers agree to the general principle that an increased storage temperature decreases optimum storage time, there is not agreement on the exact decrease in storage time for a given increase in storage temperature. Tressler (1968) stated that temperature fluctuations between -5°C and +5°C did not significantly affect product quality when compared to the same product stored at a constant temperature of 0°C for the same length of storage. Based on the mean storage temperatures shown in Table 1, the temperature fluctuations were not large enough to greatly affect the sensory quality of the chilled and frozen chili and soup.

Microbial Analyses

In general, results of the microbial analyses indicated that all chili and soup samples were within acceptable microbial limits for the specific organisms tested. (See Table 2 and Table 3) The aerobic plate count (APC) was used as an indicator of the microbial safety of chilled and frozen chili and soup. Longree (1972) recommended a limit of $\leq$100,000 CFU/gm for APC's for precooked foods. The U.S. Military purchase specifications for precooked frozen foods also has a microbial limit of $\leq$100,000 CFU/gm for APC's.

Results of the APC's performed by ABC Laboratory (Table 2) are not comparable with APC's performed by the researcher at MSU (Table 3). ABC Laboratory incubated the plates at 20°C while the plates at MSU were incubated at 32°C. Elliott et al., (1978) stated that aerobic plates made from foods spoiled in the refrigerator may yield colony counts one or more log cycles higher when incubated at 4°-28°C than when incubated at 35°-37°C.

A closer examination of the APC's for each batch of chili and soup shows that for the first batch of products the APC's for the frozen soup (Table A-9) were higher than the APC's for the chilled soup. For the second batch of chili and soup (Table A-10) the chilled soup had higher APC's than the frozen soup. Since many microorganisms do not survive freezing temperatures, it was expected that APC's from frozen samples would be lower. Banwart (1981) stated that coliforms, fecal coliforms, and C. perfringens vegetative cells in the growth phase, usually die during freezing. However, spores of C. perfringens are known to survive quite well during chilling and freezing (Elliott et al., 1978). Although E. coli dies in frozen storage, in a product with gravy the death rate is lower and some E. coli may survive frozen storage for several months (Banwart, 1981). Since the counts for C. perfringens and E. coli were low (Table A-9), it is unlikely that the higher APC's for frozen soup were due to these organisms. The higher plate count for the frozen soup could be due to lack of temperature control at some point during product preparation, cooling, storage and shipment to the laboratory for analysis. Since only one casing of product for each variable was analyzed for microbial counts, there could have been variation within the batch. The result of the APC for frozen soup from the first batch of products (Table A-9) could also be due to laboratory error during testing.

How do the microbial results in the present study compare with microbial results from other studies? Several studies in which researchers assessed the microbial quality of foods prepared in a cook/chill or cook/freeze foodservice system will be discussed (Nicholanco and Matthews, 1978; Bebeng and David, 1978b; Cremer et al., 1985).

Nicholanco and Matthews (1978) evaluated the microbial quality of beef stew in a hospital cook/chill foodservice system. APC's were highest during chilled storage and were lowest immediately after preparation and after reheating in microwave ovens. Mean APC's during chilled storage ranged from 8.4 x 10^4 CFU/gm after three hours storage to 14.5 x 10^4 CFU/gm after 19 hours storage. The microbial counts reported by Nicholanco and Matthews (1978) are higher than APC's reported in the present study. Nicholanco and Matthews (1978) cooled the beef stew in a walk-in refrigerator at 5^{o}-10^{o}C. The temperature of the beef stew did not reach $\leq 7^{o}$C until after nine hours. The longer cooling time could have contributed to the higher plate counts. Bobeng and David (1978b) assessed the quality of beef loaves prepared in a laboratory simulation of conventional, cook/chill and cook/freeze foodservice systems. APC values for beef loaves in all three systems were $\leq$350 CFU/gm after baking, during storage, thawing and after reheating in a microwave. Bobeng and David (1978b) concluded that adherence to the time-temperature standards in the Hazzard Analysis Critical Control Point (HACCP) model was sufficient to ensure microbial safety of foods served in these foodservice systems. Although APC's for the chilled beef loaves reported by Bobeng and David (1978b) were in agreement with APC's in the present study, it should be noted that the chilled storage was only 24 hours for beef loaves compared to 30 $\pm$ 4 days in the present study.

Cremer et al., (1985) assessed the microbial quality of chicken and noodles prepared in a hospital cook/chill foodservice system which was similar to the hospital

cook/chill foodservice system simulated in the present study. The chicken and noodles was prepared in a steam jacketed kettle equipped with a mechanical stirrer, pumped hot from the kettle into plastic casings, (≤74°C) clip-closed and chilled in an air agitated water both at 3.4 ± 1.1°C. After cooling, the product was stored in a walk-in refrigerator at 1.3 ± 0.9°C for 30 days.

The casing was a cross-linked, coextruded multi-layer transparent film with an oxygen transmission rate of 20-100 cc per square cm per 24 hours at 22.8°C (Cremer et al., 1985). Samples of chicken and noodles were analyzed for total mesophilic aerobic plate count (incubated at 35°C for 48 hours), total psychrotrophic aerobic plate counts (incubated at 7°C for 10 days), coliforms and staphylococci. Cremer et al., (1985) reported that the mean total plate counts increased in numbers as the refrigerated storage time increased from zero to four weeks (24 days) but were all within acceptable microbial limits. All mesophilic and psychrotrophic APC's were ≤500 CFU/gm after four weeks storage (Cremer et al., 1985).

For the present study, the APC's for chilled or frozen chili and soup were all ≤100,000 CFU/gm as recommended by Longree (1972). Several researchers have evaluated the mircobial quality of foods prepared in cook/chill, cook/freeze or conventional foodservice systems (Bunch et al., 1976; Zallen et al., 1975; Nicholanco and Matthews, 1978; Bobeng and David, 1978b; Cremer et al., 1985). Food products evaluated were prepared, cooked, and stored using various methods, packaging, storage temperatures, and length of storage. Food products were of acceptable microbial quality having ≤100,000 CFU/gm (Bunch et al., 1976; Zallen et al., 1975; Nicholanco and Matthews, 1978; Bobeng and David, 1978b; Cremer et al., 1985). The chilled and frozen chili and soup in the present study were also of acceptable microbial quality at the point of service to the consumer.

Reheating of Products

Casings of chili and soup were reheated in a steam jacketed kettle (SJK) filled with approximately 27 liters of water. Chili and soup in C-300 casings were reheated in water at 90°-100°C because Bieler and Howe (1980) recommended a minimum water temperature of 85°C for the rapid reheating of products in C-300 casings. However, product in the PE casings were reheated in a steam jacketed kettle with water at 71°-82°C. When the researcher attempted to reheat chili in PE casings in water at 90°-100°C, the PE casings developed large holes, so the water temperature was lowered to 71°-82°C. The frozen chili in PE casings required the longest reheating time (90 minutes) due to the lower water temperature. The researcher attempted to reheat all chili and soup samples to the same endpoint temperature ≥74°C. However, due to the difference in water temperatures, some chili and soup samples in C-300 casings were ≥85°C when they were removed from the SJK.

Also, it was difficult to control the temperature of the water in the SJK because the temperature was adjusted by closing or opening the steam valve to the SJK. Use of a thermostatically controlled water bath to reheat the chili and soup could have resulted in a more uniform end point temperature for all samples.

Product temperature was measured with a pocket test thermometer approximately every half hour during taste panels, but was not recorded. Product temperature was generally maintained at 71°C (160°F) during taste panels. The temperature of some pans of chili and soup were $\geq$71°C (160°F) or $\leq$60°C (140°F) when product temperature was determined. The temperature of the frozen PE chili was usually 74°C when removed from the SJK, while the temperature of the frozen C-300 chili was usually 77°C. Large differences in product temperature during taste panels could have affected the outcome of consumer preference panels or trained taste panel results. It was easier to maintain product temperature at the consumer panels because only four products (two pans of chili and two pans of soup) were used. During trained taste panels, there were eight pans (four chili, four soup) and it was more difficult to keep all products at the same temperature.

Results of the trained taste panel did show a significant storage x package interaction with respect to temperature for chili and soup. A comparison of mean scores with respect to temperature (Table 7) showed a significant difference between mean scores. Frozen PE chili was rated significantly lower than frozen C-300 chili or chilled PE chili. The difference in water temperature for reheating chili in C-300 and PE casings could be responsible for frozen PE chili being rated lower.

A comparison of mean scores with respect to temperature for soup also showed significant differences between means (Table 9). The chilled PE soup was rated significantly lower than either chilled C-300 soup or frozen PE soup. Frozen C-300 soup was rated significantly higher than frozen PE soup but was not significantly different than the mean score for chilled C-300 soup with respect to temperature. Again, differences in water temperature during reheating of products could have contributed to differences in product temperatures during the trained taste panel.

Sensory Quality of Chilled and Frozen Chili and Soup

The sensory quality of chilled and frozen chili and soup, packaged in C-300 and PE casings, and stored for 30 ± 4 days was evaluated by consumer and trained taste panels. Consumer taste panels were conducted to determine if the general public could detect differences in chili and soup samples in the present study. It was expected that consumers might have a preference for chili or soup subjected to a given storage and packaging treatment but that consumers would not be able to quantify any differences detected. Amerine et al., (1965) stated that in general

consumer acceptance testing as opposed to laboratory testing, the direction of preference was not specific and that many consumers were indifferent to the characteristics being tested. Consumers might agree with laboratory panel findings in direction but usually do not agree in magnitude (Amerine et al., 1965).

In the present study it was expected that the trained taste panel would detect differences that were not detected by consumers. Therefore, the trained taste panel was used to quantify the magnitude of differences in product quality under controlled laboratory conditions.

Consumer Taste Panels

Whether consumer panelists preferred chilled or frozen product depended on which product was tested and in what casing the product was packaged. Whether consumers preferred chilled or frozen chili in C-300 or PE casings depended on which main effect (storage or packaging) was studied. With respect to storage condition for chili in C-300 casings, consumer panelists preferred chilled C-300 chili at one panel but had no preference for chilled or frozen chili in C-300 casings at another panel (Table 5). With respect to storage condition for chili in PE casings, panelists preferred frozen chili in PE casings. For chili comparisons in which packaging was the main effect studied (Table 5) consumer panelists had no preference for chilled samples in either casing and had no preference for frozen samples in either casing.

Whether consumers preferred chilled or frozen soup also depended on in which casing the soup was packaged (Table 5). Consumers did not have a preference for chilled or frozen soup in C-300 casings, but did prefer frozen soup in PE casings. For soup comparisons in which packaging was the main effect studied, consumers preferred soup packaged in C-300 casings for both chilled and frozen storage (Table 5).

Were there other factors which could have affected the outcome of consumer panels such as the sex or age of panelists. How do results for the consumer panels in the present study compare to previously reported works by other researchers. How do results from the consumer panel for the present study compare to results for the trained taste panel.

Chili Comparisons. For the chili comparison in which storage was the main effect studied, consumers preferred chilled chili in C-300 casings at one panel (2/19/84, University Methodist Church), but did not have a preference for chilled or frozen C-300 chili at a second panel (2/21/84, Dairy Store). The difference in the conclusion of the two taste panels could be due to differences in length of hot holding of the chili samples during the taste panels. The panel at University Methodist Church (Table A-4) took place after Sunday morning services, so a larger

number of panelists (n=78) tasted the chili in a shorter time period. For the panel at the MSU Dairy Store on 2/21/84, a longer time period of four hours was required to obtain enough responses from panelists to reach a decision as panelists responses were plotted on the Decision Chart (Figure A-1). If product quality did deteriorate during hot holding, then it may have been more difficult to detect any differences that did exist between chili samples.

In comparing chilled and frozen chili in PE casings consumer panelists preferred frozen PE (Figure A-2). Based on comments from consumers, written on the ballots for this comparison, it appeared that panelists preferred the taste of the frozen PE chili. Several panelists mentioned that the chilled PE chili had an off-flavor. The flavor of the chilled PE chili was described as old, flat or refrigerated. The off-flavor of the chilled PE chili could be due to oxidation reactions, such as oxidative rancidity of any fats or oils in the chili (Karel, 1975). The PE casing was more permeable to oxygen than the C-300 casing. The oxygen transmission rate of the PE casing was 2,000 cc at 23^{o}C (m^2, 24 hours, Atm) (Koteles, 1984) compared to 20-40 cc at 23^{o}C (m^2, 24 hours, Atm) for the C-300 casing (Cryovac, 1984). The flavor of the frozen PE chili was described as spicier, more flavorful, zestier and more tomato flavor than the chilled PE chili. Changes in quality of the chili in PE casings due to oxidation reactions would occur at a slower rate in the frozen chili, since the rate of deterioration is dependent on temperature (Glew, 1973).

For both comparisons in which packaging was the main effect studied, consumer panelists detected no significant differences due to packaging. Consumer panelists had no preference for chili in either casing for chilled storage or for frozen storage (Table 5). If there were differences in quality of chili samples due to packaging, they were not detected by consumer panelists.

Zacharias (1979) used school children to compare the sensory quality of 23 dishes, including meat entrees, vegetables, potato, pasta and salads, held chilled at 2^{o}C for from one to ten days. Zacharias (1979) reported that with increasing storage time the specific taste in all dishes containing a meat item became flat and increasingly marked by spices. Zacharias (1979) concluded that sensory quality rating of chilled meals evaluated by school children was most dependent upon the taste, texture and appearance. When asked to indicate these three attributes in order of priority 85% of all students noted taste as the most important (Zacharias, 1979).

In the present study, consumer panelists also often mentioned the taste of the product when stating their preference for a specific chili sample. It is interesting that consumer panelists detected an off flavor in chilled PE chili when it was compared to frozen PE chili, but panelists did not detect an off flavor in chilled PE chili when it was compared to chilled C-300 chili.

Soup Comparisons. For soup comparisons in which storage was the main effect consumers did not detect a significant difference in chilled and frozen samples for soup in C-300 casings. With respect to storage for soup in PE casings, consumers preferred frozen PE soup (Table 5). The comparison for chilled versus frozen soup in C-300 casings was made by consumers at two separate taste panels (Table A-4) and both panels reached the same conclusion (Figure A-5). Based on results of the present study it appears that consumer acceptability of chilled soup in C-300 casings is as good as for frozen soup in C-300 casings.

With respect to storage condition for soup in PE casings, consumers preferred the frozen PE soup. Consumers described the flavor of chilled PE soup as flat, bland, watered down, and it had an unpleasant aftertaste. For both soup comparisons in which packaging was the main effect studied, soup in the C-300 casing was preferred over soup in PE casings for both chilled and frozen soup. Once again panelists mentioned flavor as the reason for their product preference. Again the flavor of the chilled PE soup was described as having a metallic taste, bitter taste, tasted flat or was more watery than the chilled C-300 soup. The flavor of the frozen PE soup was also described as having an unpleasant aftertaste. The flavor of the chilled C-300 soup and the frozen C-300 soup were described as stronger, spicier, fuller and richer.

Zacharias (1979) reported that cooked vegetables held

chilled at $2^{o}C$ from one to ten days, had a flavor described as flat, acid, pungent and stale after ten days chilled storage. The chilled foods were rated by school children who had rated taste as the most important attribute in acceptance of a food product (Zacharias, 1979).

A comparison of consumer panel results for the present study to results from previous work is difficult since few researchers have used consumer panels to compare foods prepared in cook/chill and cook/freeze foodservice systems. Other factors which could affect the outcome of consumer responses should be considered. The sex or age of consumer panelists could have affected the responses of panelists if males or females preferred either chili or soup. Age could affect consumer panel results if taste sensitivity is related to age and if consumer panels were unbalanced with respect to age of panelist.

For the present study, consumer panelists responses for chili comparisons, classified by sex, are shown in Table A-12. Consumer responses for soup comparisons classified by sex are shown in Table A-13. The age and sex of consumer panelists by panel location is shown in Table A-14.

As shown in Table A-14, the majority of taste panelists for panels one, three, four, and five were in the 20-29 and 30-39 age group. At those panels, few panelists were ≤ 20 years old or ≥ 60 years old. For taste panel number two, there were a larger number of panelists in the <20 age group. Panel two was conducted after a Sunday morning

service at University Methodist Church and had more children than any of the other panels. Also at panel two, there were more panelists in the ≥60 age category. There is not agreement among researchers on the effect of age on taste sensitivity. In researching taste thresholds, Aubek (1959) in Amerine, et al., (1965) reported no significant impairment of taste sensitivity prior to 60 years of age. Above age 60, there were significant decreases in sensitivity to salty, sour, sweet, and bitter. No sex differences were observed for the decline in taste threshold sensitivity (Aubek in Amerine, et. al., 1965). Cooper et al., (1959) in Amerine et al., (1965), found that curves for development and decline started in the late 50s and affected sour less than the other tastes.

For the present study, since the majority of consumer panelists were in the 20-50 year age group and taste sensitivity is not affected until ≥60 years of age, the researcher concluded that age did not affect consumer panelists.

Sex of panelists could have an effect on the outcome of the consumer panels if the panels were not composed of equal members of males and females. Panels one and four had about the same number of males and females, while panels two and five had about 10 more males than females. Panel three had twice as many males as females. So with the exception of panel three, the consumer panels were composed of approximately equal numbers of males and females. Bradley et al., (1954) in Amerine et al., (1965) reported that the preference ratings of women as a group did not differ significantly from those of men. Women's responses extended over a greater range than those of men, but individual women tended to be more consistent in their ratings than individual men (Bradley et al., 1954, in Amerine et al., 1965). In studies of canned fruit conducted in California, female consumers were more definite in their preferences than males, who gave less homogeneous responses as a group and preferred sweeter samples than did women (Bradley et al., 1954, in Amerine et al., 1965).

In the present study more males than females indicated no preference responses for chili and soup comparisons (Table A-13 and Table A-14). This would seem to support Bradley's findings that female consumers were more definite in their preferences than males (Bradley et al., 1954 in Amerine et al., 1965). However, Bell (1956) in Amerine et al., (1965) reported that preferences for breads of different formulation were unaffected by age and sex. Amerine et al., (1965) concluded that due to incomplete and inconclusive investigations, it was difficult to predict preference behavior of specific age group or of males versus females for most food products.

An examination of consumer panelist responses classified by sex (Table A-12 and A-13) shows that most of the consumer panels had approximately the same number of male and female panelists. However, the consumer panel for the chilled C-300 soup versus chilled PE soup comparison at the MSU Dairy Store (2/21/84) had twice as many males as females. Responses of consumer panelists from the MSU Dairy Store on 2/21/84 classified by sex of panelists and product preference are in Table 10. The observed frequencies and expected values for each cell are shown. Using the test statistic $q = \sum_{i=1}^{r}\sum_{j=1}^{c}[(Oij-Eij)^2/Eij]$ the hypothesis that the effects of the row citerion are independent of effects of the column criterion was tested (Gill, 1978a). The calculated test statistic of 0.287 was less than the critical value $X^2_{0.05,1} = 3.841$ (Gill, 1978b). Since the hypothesis of independence for the effects of sex of panelists on the product preference was not rejected, it was concluded that sex of panelists did not affect the outcome of the consumer taste panel at the MSU Dairy Store on 2/21/84.

In summary, consumer's preference for a given storage condition depended on the type of casing in which the product was packaged. For the chilled C-300 versus frozen C-300 comparison for both chili and soup, consumers in general did not detect significant differences in sensory quality. It would appear that the C-300 casing retains product quality as well during frozen storage as it does during chilled storage. With respect to storage for products packaged in PE casings, consumers preferred frozen chili and soup in PE casings. The chilled chili and soup in PE casings had an aftertaste which consumers did not like.

Table 10. Observed frequency and expected values[a] for consumer taste panel responses[b] to the consumer comparison of chilled C-300 chili versus chilled PE chili.

Sex of Panelists	Product		Total
	Chili C-300	Chili PE	
Male	31 (30.2)	10 (10.8)	41
Female	11 (11.8)	5 (4.2)	16
Total	42	15	57

[a]Numbers in parenthesis () were the expected values calculated as the product of the row total x the column total, divided by the total number of observations (Gill, 1978a).

[b]Location of consumer taste panel, MSU Dairy Store, 2/21/84.

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For both comparisons in which packaging was the main effect and chili was the product being tested, consumers had no preference for product in one casing. With respect to packaging conditions for soup comparisons, consumers preferred soup in C-300 casings. Difference in product quality due to packaging for chili comparisons might not be great enough for consumers to detect, or might be masked by the spice in the chili itself. For both packaging comparisons for soup, consumers detected differences in product quality and preferred the soup in C-300 casings for both chilled and frozen storage. Therefore, the researcher concludes that consumers would accept chilled or frozen "pumpable" foods packaged in C-300 casings.

Trained Taste Panel

The trained taste panel detected few significant differences in the sensory quality of chilled or frozen chili in C-300 or PE casings. Results of the ANOVA for the chili samples showed only three sensory characteristics (temperature, spiciness, and beany flavor) which had a significant storage x package interaction. Results of the trained panel in the present study are in agreement with results from the consumer panels which also in general did not have a strong preference for one chili sample compared to another chili sample.

The trained taste panel did detect significant differences among chilled and frozen soup samples in C-300

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or PE casings for several sensory characteristics (Table 8). Consumer panelists did not have preferences among soup samples except for in the comparison for chilled C-300 soup versus frozen C-300 soup, in which consumers had no preference (Table 5). Results of the consumer panel and the trained taste panel indicate that the difference in sensory quality of chilled and frozen soup in C-300 or PE casings were greater in soup than for chili samples or were easier to detect.

Sensory Evaluation of Chili. Aroma was significant ($p \leq 0.05$) for the storage effect in the ANOVA for chili. Since the packaging effect was not significant, nor was the interaction significant, it is not known which chili sample was preferred by panelists with respect to aroma. The mean score for aroma for the frozen PE chili was lowest, but a comparison of means showed no significant differences between mean scores (Table 6). Very few consumer panelists made comments on the aroma of chili samples.

For integrity of beans, the packaging effect was significant ($p<0.001$), but the storage effect and interaction of main effects was not significant (Table 6). A comparison of mean scores with respect to integrity of beans showed a significant advantage for chili in PE casings. The beans in the PE chili might have been more intact than beans in the C-300 chili because chili in PE casings were cooled in an ice water bath while chili in

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C-300 casings were tumbled in a mechanical chiller (see Methods, Chilling Filled Casings). Few consumer panelists mentioned the preference for a given sample of chili. However, a few consumer panelists did mention that the chilled or frozen PE chili was more chunky or thicker than the chilled or frozen C-300 chili.

Three sensory characteristics had a statistically significant storage x package interaction; temperature, spiciness, and beany flavor (Table 6). A further comparison of means showed a significantly lower mean score with respect to temperature for frozen PE chili. This could be due to differences in water temperature during reheating the chili in C-300 and PE casings. The temperature of chili in C-300 casings was 74^{o}-77^{o}C when removed from the SJK, while the temperature of the chili in PE casings was usually 74^{o}C.

With respect to spiciness, mean score for the chilled PE chili was significantly higher than the mean score for chilled C-300 chili. Consumers often listed the spiciness of a chili sample as the reason for their preference. Some consumer panelists preferred a specific chili sample because it was spicier than the other chili sample. However, other consumer panelists preferred a specific chili sample because it was less spicy than the other chili sample. For individual panelists their response to spiciness could be influenced by their preference for a mild chili or a spicier chili.

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storage x package interaction (Table 6) a further comparison of means showed no significant differences between means. The standard error of the mean scores for beany flavor was 0.31 and was larger than the standard error for several other sensory characteristics (Table 6). So there was not agreement among panelists with respect to beany flavor.

In general, the trained taste panel did not have a strong preference for chilled or frozen chili in either casing. The results of the trained taste panel were inconclusive as to which storage and packaging combination panelists preferred for chili.

How do trained taste panel results for the present study compare to previously reported works? Jakobsson and Bengtsson (1972) reported a clear flavor advantage was obtained for frozen precooked beef after two months storage at -20^{o}C over the pasteurized, refrigerated, cooked sliced beef stored at +3^{o}C for only a few days. In the present study taste panelists did not detect differences in chilled and frozen chili in C-300 and PE casings. Changes in quality of the cooked ground beef in the chili could have been masked by the sauce, spices or other ingredients, especially in the chili. Kossovitsas et al. (1973) reported that after 15 days chilled storage at 2^{o}C and frozen storage at -23^{o}C, taste panelists could not detect significant differences in appearance, flavor and consistency between chilled and frozen samples of Chicken a la King, Codfish in Cream Sauce and Broccoli with Cheese Sauce. However at 30 days o

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days of storage the chilled samples were acceptable but interior to fresh samples (Kossovitsas et al., 1973).

Bobeng and David (1978b) found significant differences ($p<0.01$) for flavor scores among systems in comparing beef loaves prepared in the conventional, cook/chill and cook/freeze production systems. The conventional loaves were rated significantly higher, with no difference between cook/chill and cook/freeze samples. The microbial quality measured by total aerobic plate counts was excellent for all three systems (Bobeng and David, 1978b). Thus, the results of the present study were in agreement with Bobeng and David (1978b) with few significant differences between chilled and frozen chili.

Although freshly prepared products were included by other researchers in comparisons of chilled versus frozen precooked food, freshly prepared products were not used in the present study because the purpose was to compare the sensory and microbial quality of chilled and frozen products in two types of plastic casings. Also there is general agreement among other researches that freshly prepared products received higher sensory scores than chilled or frozen products (Jakobsson and Bengtsson, 1972; Kossovitsas et al., 1973; Zallen et al., 1975; Bobeng and David, 1978b).

Cremer et al., (1985) concluded that for chicken and noodles stored for four weeks at $1.3^{o} \pm 0.9^{o}C$, no significant differences in general acceptability occurred and no flavor changes indicated the effectiveness of the plastic storage bags in

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bags in preserving food quality. The mean scores for overall acceptability of chili samples in the present study range from 6.3 to 6.6 on a scale from one to ten. Generally, chili samples were in moderately good quality.

Sensory Evaluation of Soup. All sensory characteristics for the soup samples except for aroma and greasiness showed a significant storage x package interaction in the ANOVA (Table 8). For soup in C-300 casings there were few significant differences between mean scores for chilled and frozen soup, except in the case of texture of vegetables, where the mean score was significantly higher for the chilled C-300 soup (Table 9). Results of the trained taste panel sensory evaluation for soup in C-300 casings are in agreement with the consumer panel comparison for soup in C-300 casings. Consumer panelists did not have a preference for chilled or frozen soup in C-300 casings (Table 5). Consumer and trained taste panelists concluded that chilled or frozen soup in C-300 casings were of equal sensory quality.

As shown in Table 9, chilled PE soup had significantly lower mean scores than frozen PE soup for several sensory characteristics; color of broth, temperature, flavor of broth and overall acceptability. Again, results of the consumer panels are in agreement with the trained taste panel for comparisons of chilled and frozen PE soup. Consumer panelists also preferred frozen soup over chilled

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soup in PE casings (Table 5). Consumer panelists often mentioned the flavor of the chilled PE soup as being undesirable. The flavor of chilled PE soup was described as an unpleasant aftertaste, flat and old.

The trained taste panel rated frozen PE soup significantly higher than frozen C-300 soup for several sensory characteristics: color of vegetables, integrity of vegetables, texture of vegetables, aftertaste and overall acceptability. The trained taste panel results are not in agreement with the consumer panel results because consumers preferred frozen C-300 soup when compared to frozen PE soup. Consumer panelists also preferred chilled C-300 soup when compared to chilled PE soup (Table 5). Perhaps the trained taste panel and consumer taste panels did not reach the same conclusion because the trained panelists detected additional differences between frozen C-300 soup and frozen PE soup that were not detected by the consumer panel. Amerine et al. (1965), described a laboratory panel as carefully selected, highly trained and hypercritical when compared to the general consumer. Zacharias (1979) reported that 85% of the school children participating in the sensory evaluation of chilled meals, rated taste as the most important criterion in sensory quality of a food product. Perhaps the consumer panelists in the present study based their preference for frozen C-300 soup or frozen PE soup on the taste of the two samples. The trained taste panelists preferred the flavor of broth in the frozen PE soup or chilled C-

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chilled C-300 soup when compared to the flavor or broth in the chilled PE soup (Table 9).

The difference in chilling methods for soup in C-300 and PE casings could have an effect on the integrity or texture of the vegetables. The difference in water temperature in reheating the soup in C-300 and PE casings could also have an effect on the integrity or texture of vegetables.

Trained panelists rated aftertaste for frozen soup in PE casings significantly higher than frozen soup in C-300 casings. Apparently the trained panelists did not find the aftertaste of the PE soup as objectionable as did consumer panelists. However, it should be noted that there could be a batch effect. Consumers compared soups from the first batch of products produced on 1/18/84 while trained panelists rated soup samples from the second batch of products produced on 03/07/84 (Table A-4). However, consumer panelists compared chilled and frozen soup in C-300 casings with product from the first batch of soup at the panel on 02/17/84 and from the second batch of products on 4/10/84 and reached the same conclusion, no difference in sensory quality of chilled or frozen soup in C-300 casings (Figure A-4).

In summary, mean scores for soup in C-300 casings showed only one significant difference for chilled or frozen soup in C-300 casings: texture of vegetables, with chilled C-300 soup scoring higher than frozen C-300 soup. For soup in PE cas

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in PE casings several sensory characteristics received higher mean scores for frozen soup than for chilled soup in PE casings. Frozen PE soup also received higher sensory scores for several sensory characteristics than did frozen C-300 soup (Table 9). Based on results of the trained taste panel, PE casings could be used for frozen storage of soup.

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Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

Microbial quality of chilled and frozen chili and soup in C-300 and PE casings was of excellent quality after 30 ± 4 days storage. Packaging products at above pasteurization temperatures (≥82°C), cooling product to ≤7°C in less than two hours and storing chilled product at a lower chilled temperature of -1° ±1°C, contributed to the microbial safety of kettle-cooked foods. Reheating the product in the casings prevented recontamination of the product. Reheating the products to ≥74°C also ensured that any microorganisms presents would be killed during reheating.

Results of the present study suggest that for precooked foods packaged in PE casings, frozen storage retained product quality better than chilled storage. For products packaged in C-300 casings few significant differences were noted for chilled versus frozen storage. The C-300 casing could be used for product storage in either a cook/chill or cook/freeze foodservice system.

Recommendations for Future Research

Consumer and trained panelists detected few significant differences between chili samples. Due to the nature of the chili with the meat, sauce and strong spices, changes in product quality could be difficult to detect. Perhaps testing

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testing a product with a milder flavor would make it easier to detect changes in sensory quality due to storage or packaging.

Products in PE casings were reheated in water at a temperature of 71°-82°C, to prevent holes in the PE casings, while products in C-300 casings were reheated in water at 90°-100°C. The difference in water temperature resulted in a longer heating time for chili and soup in PE casings. Differences in sensory quality of products in C-300 and PE casings could be due to differences in the time and temperature of the reheating process.

It was difficult to control the water temperature in the steam jacketed kettles used for reheating the chili and soup. Use of a thermostatically controlled water bath may be desirable to have greater control over the final product temperature. All casings of product were reheated to a minimum temperature of 74^{C}, but some products in casings were at 77°-82°C when removed from the kettle. The trained taste panel did rate the temperature of frozen PE chili significantly lower than either chilled PE chili or frozen C-300 chili. This could be due to a difference in product temperature when removing the casings from the reheating medium. Or there could be a difference in heat retention for chili in PE casings. The trained taste panel rated the temperature of chilled PE soup significantly lower than chilled C-300 soup or frozen PE soup. Again this could be due to the difference in water temperature for reheating soup i

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soup in C-300 and PE casings.

The difference in oxygen permeability between the C-300 and PE casing could have resulted in differences in product quality due to oxidative rancidity. A physical measure of oxidative rancidity could be determined by using TBA values. TBA values could then be related to off-flavors detected by the consumer taste panelists.

The results of the trained taste panel did not agree with the results of the consumer taste panel (Table 5). Trained taste panelists rated frozen PE soup significantly higher than frozen C-300 soup. One reason for the difference in results of the trained taste panel and consumer panel evaluation of soup could be due to the longer hot-holding period during the consumer taste panels. The consumer panels were conducted over a period of three to four hours, while the trained taste panels were conducted for one to one-and-one-half hours. Sensory quality of both chili samples or both soup samples at a given consumer panel could have deteriorated due to the long hot-holding period. Glew and Armstrong (1981) cited the long hot-holding period of foods in the conventional foodservice system as one reason for poor sensory quality of foods served in the conventional foodservice system. Perhaps conducting consumer panels at locations where more consumer panelists would be available to taste the samples in a shorter time period would be useful in future research.

The PE casing is cheaper than the C-300 casing and could be

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could be used in a cook/freeze foodservice system. Based on results of the consumer panels, chilled chili or chilled soup in PE casings would not be preferred when compared to chilled chili or soup in C-300 casings (Table 5). However, from an operational standpoint the PE casings is not very practical for a cook/chill or cook/freeze foodservice operation. The PE casing was not as strong as the C-300 casing and required more careful handling during cooling, storage and reheating. Products in PE casings, especially the chili, required much longer reheating times. Thus, the author recommends the C-300 casing for use in either cook/chill or cook/freeze foodservice systems.

APPENDIX

Table A-]

Ingredie

Beef, gr
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Table A-1. Standardized recipe for chili con carne used at University Hospital, Cleveland, Ohio.

Expected Yield: 303 liters
Total Weight: 394.92 kg

Chili Con Carne

Ingredients	% Weight		Instructions
Beef, ground, 20% fat[a]	17.23	1.	Place ground beef, onion and chili powder in steam kettle and saute until browned (approximately 90 minutes).
onions, minced	6.89		
chili powder	0.29		
Tomatoes, canned	39.54	2.	Add tomatoes, salt and pepper to meat and cook about 60 minutes (crush tomatoes by hand before adding).
salt	0.57		
black pepper	0.02		
Bean, kidney	34.89	3.	Drain kidney beans. Discard the liquid.
Sugar, granulated	0.57	4.	Add kidney beans and sugar to above mixture. Cook for 2 hours. Skim off any grease that rises to the top of kettle before serving.
Total	100.00		

[a]In the first batch of chili, 40% of ground beef was frozen and was initially browned for 45 minutes.

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Table A-2. Standardized recipe for vegetarian vegetable soup used at University Hospital, Cleveland, Ohio.

Expected Yield: 303 liters
Total Weight: 367.47 kg

Vegetarian Vegetable Soup

Ingredients	% Weight	Instructions
water	63.20	1.Add water to kettle, using automatic water fill.
tomato juice	11.36	2.Set agitator on speed 2 1/2. Add all ingredients except celery, cabbage, corn, peas, and rice. Cook at 88°C for 2 hours.
tomatoes, whole	6.29	
tomato puree	3.21	
carr, diced 6mm	2.47	
onions, diced 6mm	1.97	
baby lima beans, frozen	0.99	
potatoes, diced 6mm	0.99	
margarine	0.49	
wax beans, frozen	0.49	
green beans, frozen	0.49	
salt	0.45	
sugar, granulated	0.15	
thyme, ground	0.01	
marjoram	0.01	
celery, diced 6mm	2.96	3. Add celery[a]. Cook for 30 minutes.
cabbage, coarsely chopped	1.97	4. Add cabbage, corn, peas and rice and simmer until rice is cooked (about 30 mins.). Taste soup, add more salt[b], if needed.
corn, frozen	0.99	
peas, frozen	0.99	
rice, long grain	0.49	
total	100.00	5. Bring temperature to 82°C. Set to cool hold.
		6. Set agitator speed to 4 1/2 and pump.

[a]In first batch of soup, one half of celery was added in step 3. The remaining celery was obtained from the ingredient room and added during step 4.

[b]In first batch of soup, an additional 0.03% salt was added because the cook tasted the soup and decided it needed more salt.

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Table A-3. Ballot for the pilot consumer taste panel.

Consumer Taste Panel
Preference Test

The two samples you have been given are prepared from the same recipe. Only the method of storage before reheating the sample is different.

Please taste the samples and decide which one you prefer. Retaste the samples until you reach a decision.

Mark the appropriate line below.

________ I prefer sample #65.

________ I prefer sample #27.

________ I have no preference.

Please list reasons why you prefer one sample over the other, or why you have no preference.

Thank you for your participation in our study.

Table A

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2/20/8 MSU Unic
2/21/8 MSU
2/21/ Bur Hil Ret Cer
4/5/ MS
4/10 MS

ble A-4 Location and comparisons for consumer taste panels to compare quality of chili and soup held chilled and frozen for 30 days in C-300 and PE casings.

te/ Location	Time	Product	Planned Comparison	Main Effect Studied
/17/84 MSU Dairy[a] Store	11:30AM to 2:30PM	Chili	Chilled C-300 vs Chilled PE	Packaging
		Soup	Chilled C-300 vs Frozen C-300	Storage
/19/84 University Methodist Church[b]	11:45AM to 12:15PM	Chili	Chilled C-300 vs Frozen C-300	Storage
		Soup	Frozen C-300 vs Frozen PE	Packaging
/20/84 MSU Union[c,d]	12:00PM to 12:15PM	Chili	Frozen C-300 vs Frozen PE	Packaging
		Soup	Chilled PE vs Frozen PE	Storage
/21/84 MSU Dairy	11:30AM to 2:30PM	Chili	Chilled C-300 vs Frozen C-300	Storage
		Soup	Chilled PE vs Chilled C-300	Packaging
/21/84 Burcham Hills[e,f] Retirement Center	5:00PM to 6:30PM	Chili	Chilled C-300 vs Chilled PE	Packaging
		Soup	Chilled C-300 vs Frozen C-300	Storage
/5/84 MSU Dairy[g]	11:30AM to 2:30PM	Chili	Chilled PE vs Frozen PE	Storage
		Soup	Chilled C-300 vs Frozen C-300	Storage
/10/84 MSU Dairy[g]	11:30AM to 2:30PM	Chili	Frozen C-300 vs Frozen PE	Packaging
		Soup	Chilled PE vs Frozen PE	Storage

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Table A-4. Location and comparisons for consumer taste panels to compare quality of chili and soup held chilled and frozen for 30 days in C-300 and PE casings.

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[a]Located in Anthony Hall, Farm Lane, MSU, East Lansing, MI.
[b]Located at 1120 S. Harrison Rd., East Lansing, MI.
[c]Located on West Circle Drive, MSU, East Lansing, MI.
[d]Results of this panel were not included in the study. The chili was not served to the panelists, because a small leak in the casing allowed water from the reheating process to enter the casing. The temperature of the soup served to the panelists should have been $\geq 60^{o}C$ but was only 43-49^{o}C.
[e]Located on Burcham Drive, East Lansing, MI.
[f]Results of the panel were not included in the study because the sample was too small to be included in the statistical analysis.
[g]Chili and soup used for these panels were from the second batch of product produced on 03/07/84. For all other consumer panels, chili and soup were from the first batch of products produced on 01/17/84.

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Table A-5. Ballot for consumer taste panel to compare chilled and frozen chili and soup in C-300 or PE casings.

Date:__________

CONSUMER TASTE PANEL
PREFERENCE TEST

Please fill in the following information:

AGE________

SEX_______

The four samples you have been given are prepared from the same soup or chili recipe. Only the method of storage before reheating is different.

Please taste the soup or chili samples and decide which one you prefer. Retaste the samples until you reach a decision. If you taste chili or soup first, please drink water before tasting the other samples (soup or chili).

Mark the appropriate line below. CHILI

________ I prefer sample #38.

________ I prefer sample #48.

________ I have no preference.

Please list reasons why you prefer one chili over the other, or why you have no preference.

Mark the appropriate line below. SOUP

________ I prefer sample #83.

________ I prefer sample #26.

________ I have no preference.

Please list reasons why you prefer one soup over the other, or why you have no preference.

Thank you for your participation in our study.

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Table A-6. Quantitative descriptive analysis (QDA): preliminary analysis of sensory characteristics.

QUANTITATIVE DESCRIPTIVE ANALYSIS

PRODUCT: ____________________ DATE: ___________

PRELIMINARY ANALYSIS: Taste the product and write down the five or six most prominent sensory characteristics that you can distinguish. Include APPEARANCE, ODOR, TASTE, AND MOUTHFEEL characteristics.

1. ____

2. ____

3. ____

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6. ____

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Table A-7. Trained taste panel: ballot for chili.

PRODUCT CODE #__________

QUANTITATIVE DESCRIPTIVE ANALYSIS

PRODUCT: Chili Date: ________

PANELIST: ____________________________

Please judge the sample for intensity of each of the indicated quality factors.

Place a slash (/) on the line at the appropriate location to indicate your rating of product quality.

FACTOR

Factor		
1. Appearance	orange	reddish-brown
2. Aroma	absent or weak	present or strong
3. Texture	thin and mushy	chunky and thick
4. Integrity of beans	broken up or not intact	whole or intact
5. Temperature	cold	hot
6. Spicy	bland	overpowering
7. Beany flavor	mild or strong	moderate
8. Meaty flavor	mild or strong	moderate
9. Greasiness	present	absent
10. Aftertaste	objectionable or strong	not objectionable
11. Overall Acceptability	dislike very much	like very much

THANK YOU FOR YOUR ASSISTANCE

Table A-

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Table A-8. Trained taste panel: ballot for vegetarian vegetable soup.

PRODUCT CODE #________

QUANTITATIVE DESCRIPTIVE ANALYSIS

PRODUCT: Vegetarian Vegetable Soup DATE:__________

PANELIST: ______________________________

Please judge the sample for intensity of each of the indicated quality factors.

Place a slash (/) on the line at the appropriate location to indicate your rating of product quality.

FACTOR		
1. Aroma	absent	strong
2. Degree of separation of broth (wateriness)	little	much
3. Consistency of broth	watery	thick
4. Color of broth	pale	red-orange
5. Color of Vegetables	dull	bright & contrasting
6. Integrity of Vegetables	broken-up	intact
7. Temperature	cold or lukewarm	hot and steamy
8. Flavor of broth	bland	strong
9. Texture of vegetables	mushy	crunchy
10. Greasiness	too much	too little or none
11. Aftertaste	objectionable or strong	not objectionable
12. Overall Acceptability	dislike very much	like very much

THANK YOU FOR YOUR ASSISTANCE

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Table A-9. ABC Laboratories: Microbial analyses[a], of the first batch[b] of chilled and frozen chili and soup stored for 30 days in C-300 and PE casings.

Product	Total (Aerobic) Plate Count (CFU/gm)	Total Coli-forms (MPN)	Fecal Coli-forms (MPN)	*E. Coli*[c] (MPN)	Salmo-nella[d] (+or-)	*S. Aureus*[e] (CFU/gm)	*C. Perfrin-gens*[f] (CFU/gm)
CHILI							
Chilled C-300	<100	9	<3	--[g]	--	<3	<10
Frozen C-300	<100	<3	--	--	--	<3	<10
Chilled PE	<100	<3	--	--	--	<3	<10
Frozen PE	<100	<3	--	--	--	<3	<10
SOUP							
Chilled C-300	<100	<3	--	--	--	<3	<10
Frozen C-300	50,000	<3	--	--	--	<3	<10
Chilled PE	*[h]	*	*	*	*	*	*
Frozen PE	1,000	4	<3	--	--	<3	<10

[a]Analyses performed by A.B.C. Research, Gainsville, Florida.
[b]Products from the first batch were produced on 01/18/84 and had been stored chilled and frozen for 25 days before shipment to the laboratory for analysis.
[c]*Escherichia coli*.
[d]Results of anlaysis for Salmonella were reported as positive (+) or negative (-) for presence of Salmonella in a 30 gm sample of product.
[e]*Staphylococus aureus*.
[f]*Clostridium perfringens*.
[g]Indicates that the result was negative.
[h]Chilled PE soup was omitted because the shipping container was not large enough to accommodate all eight samples.

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[g]Indi

able A-10. ABC Laboratories: Microbial analyses[a], of the second batch[b] of chilled and frozen chili and soup stored for 30 days in C-300 and PE casings.

Product	Total (Aerobic) Plate Count (CFU/gm)	Total Coli-forms (MPN)	Fecal Coli-forms (MPN)	*E. Coli*[c] (MPN)	Salmo-nella[d] (+or-)	*S. Aureus*[e] (CFU/gm)	*C. Perfrin-gens*[f] (CFU/gm)
CHILI							
Chilled C-300	3,300	9	4	<3	--[g]	<3	<10
Frozen C-300	300	<3	--	--	--	<3	<10
Chilled PE	400	<3	--	--	--	<3	<10
Frozen PE	300	<3	--	--	--	<3	<10
SOUP							
Chilled C-300	300	<3	--	--	--	<3	<10
Frozen C-300	100	<3	--	--	--	<3	<10
Chilled PE	800	<3	--	--	--	<3	<10
Frozen PE	100	<3	--	--	--	<3	<10

[a]Analyses performed by A.B.C. Research, Gainsville, Florida.
[b]Products from the second batch were produced on 03/07/84 and had been stored chilled and frozen for 29 days before shipment to the laboratory for analysis.
[c]*Escherichia coli*.
[d]Results of analysis for Salmonella were reported as positive (+) or negative (-) for presence of Salmonella in a 30 gm sample of product.
[e]*Staphylococus aureus*.
[f]*Clostridium perfringens*.
[g]Indicates that the result was negative.

Table A-1[illegible]

Product
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Table A-11. MSU Labs: Aerobic plate counts (APC)[a,b] for chilled and frozen chili and soup stored for 30 days in C-300 and PE casings.

Product	APC[a] Batch 1 (CFU/gm)[c]	APC[a] Batch 2 (CFU/gm)
CHILI		
Chilled C-300	10	-
Frozen C-300	60	35
Chilled PE	-[d]	300
Frozen PE	-	10
SOUP		
Chilled C-300	-	10
Frozen C-300	-	10,000
Chilled PE	-	50,000
Frozen PE	-	100

[a]Completed at Michigan State University using method by Elliot et al., 1978.
[b]Products were analyzed before reheating and serving to panelists (Figure 1). Chili and soup from the first batch of products had been stored for 25 days, while chili and soup from the second batch of products had been stored for 24 days prior to microbial analysis at MSU.
[c]Colony Forming Units per gram of product in the 25 gram sample.
[d]Indicates no growth on the 10^{-1} dilution. Growth on a plate from a lower dilution was considered contamination and was not reported when no growth occurred on the 10^{-1} dilution.

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Table A-12. Sex and product preference of consumer panelists for chilled and frozen chili in C-300 or PE casing.

Panel Location	Product Preferred	Responses by Sex[a]		
		Male	Female	Total
	CHILI			
Univ. Methodist Church 2/19	Chilled C-300	19 (49)[b]	20 (51)[b]	39 (50)[c]
	Frozen C-300	14 (61)	9 (39)	23 (29)
	N.P.[d]	12 (75)	4 (25)	16 (21)
	Total	45 (58)	33 (42)	78 (100)
[Chilled C-300 preferred][e]				
	CHILI			
Dairy Store 4/5	Chilled PE	9 (53)	8 (47)	17 (24)
	Frozen PE	18 (53)	16 (47)	34 (48)
	N.P.	12 (60)	8 (40)	20 (28)
[Frozen PE preferred]	Total	39 (55)	32 (45)	71 (100)
	CHILI			
Dairy Store 2/17	Chilled C-300	12 (50)	12 (50)	24 (51)
	Chilled PE	8 (44)	10 (56)	18 (38)
	N.P.	3 (60)	2 (40)	5 (11)
[No difference]	Total	23 (49)	24 (51)	47 (100)
	CHILI			
Dairy Store 4/10	Frozen C-300	18 (62)	11 (38)	29 (45)
	Frozen PE	11 (50)	11 (50)	22 (34)
	N.P.	9 (64)	5 (36)	14 (22)
[No difference]	Total	38 (58)	27 (42)	65 (100)

[a]Number of males and females that preferred that product.
[b]Of the panelists who preferred that product, the percent (%) males and females that preferred that product.
[c]Indicates the total number or percent (%) of panelists who preferred that product.
[d]N.P. = No preference.
[e][ ] = Outcome of the sequential analysis using the Decision Chart (Bross, 1952).

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[e] [

Table A-13. Sex and product preference of consumer panelists for chilled and frozen soup in C-300 or PE casing.

Panel Location	Product Preferred	Responses by Sex[a] Male	Female	Total
	SOUP			
Dairy Store 2/17/84	Chilled C-300	25 (52)[b]	23 (48)[b]	48 (56)[c]
	Frozen C-300	13 (48)	14 (52)	27 (32)
	N.P.[d]	7 (70)	3 (30)	10 (12)
[No difference][e]	Total	45 (53)	40 (47)	85 (100)
	SOUP			
Dairy Store 4/10/84	Chilled PE	7 (44)	9 (56)	16 (27)
	Frozen PE	18 (56)	14 (44)	32 (54)
	N.P.	7 (64)	4 (36)	11 (19)
[Frozen PE preferred]	Total	32 (54)	27 (46)	59 (100)
	SOUP			
Dairy Store 2/21/84	Chilled C-300	31 (74)	11 (26)	42 (60)
	Chilled PE	10 (67)	5 (33)	15 (21)
	N.P.	5 (39)	8 (61)	13 (19)
[Chilled 300 preferred]	Total	46 (66)	24 (34)	70 (100)
	SOUP			
Univ. Church 2/19/84	Frozen C-300	22 (47)	25 (53)	47 (60)
	Frozen PE	8 (73)	3 (27)	11 (14)
	N.P.	14 (70)	6 (30)	20 (26)
[Frozen 300 preferred]	Total	44 (56)	34 (44)	78 (100)

[a]Number of males and females that preferred that product.
[b]Of the panelists who preferred that product, the percent (%) males and females that preferred that product.
[c]Indicates the total number or percent (%) of panelists who preferred that product.
[d]N.P. = No preference.
[e][ ] = Outcome of the sequential analysis using the Decision Chart (Bross, 1952).

Table A

AGE (yr
< 20
20-29
30-39
40-49
50-59
≥ 60

[a] One
[b] TWO
[c] THRE
[d] FOUR
[e] FIVE

Table A-14. Age and sex of consumer taste panelists by panel location.

AGE (yrs.)	Panel Location: ONE[a]		TWO[b]		THREE[c]		FOUR[d]		FIVE[e]	
Sex	M	F	M	F	M	F	M	F	M	F
< 20	1	3	18	6	4	1	2	4	0	2
20-29	32	30	5	5	24	17	21	24	21	17
30-39	9	6	7	10	19	5	10	4	12	3
40-49	3	3	11	17	3	1	5	3	3	4
50-59	0	0	6	1	0	1	2	4	2	2
≥ 60	2	0	4	2	0	0	1	0	1	2
Total	44	42	51	41	50	25	41	39	39	30

[a]One = Dairy Store 02/17/84
[b]TWO = University Methodist Church 02/19/84
[c]THREE= Dairy Store 02/21/84
[d]FOUR = Dairy Store 04/05/84
[e]FIVE = Dairy Store 04/10/84

(a)

CHILI
CHILLE
C-300

(b)

CHILI
CHILI
C-300

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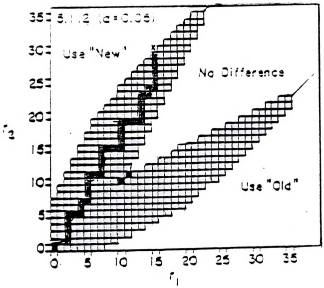
[b]Lo

DECISION CHART

(a)

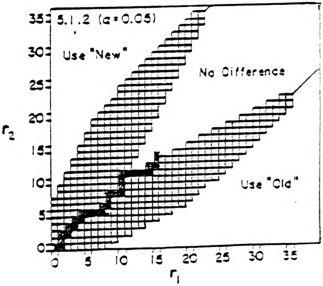
CHILI
CHILLED
C-300



CHILI
FROZEN
C-300

(b)

CHILI
CHILLED
C-300



CHILI
FROZEN
C-300

Figure A-1. Consumer panelists responses [a,b] to preference test for chilled C-300 chili versus frozen C-300 chili.

[a]Location of panel for (a) University Methodist Church, 2/19/84, N=83.
[b]Location of panel for (b) MSU Dairy Store, 2/21/84, N=69.

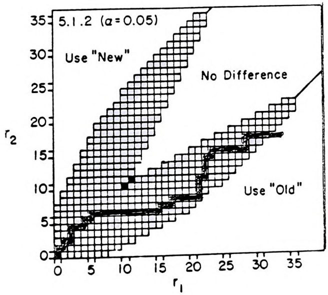
CHILI
CHILLED
PE

Figur

[a]Loca

DECISION CHART

CHILI
CHILLED
PE



CHILI
FROZEN
PE

Figure A-2. Consumer panelists responses[a] to preference test for chilled PE chili versus frozen PE chili.

[a]Location of panel: MSU Dairy Store, 4/5/84, N=71.

(a)

CHILI
CHILLED
C-300

(b)

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CHILI
C-300

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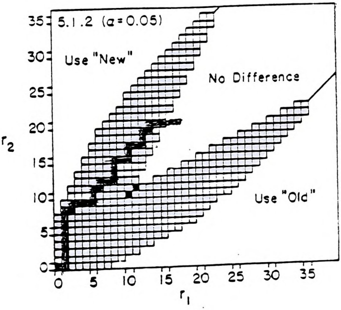
DECISION CHART

(a)

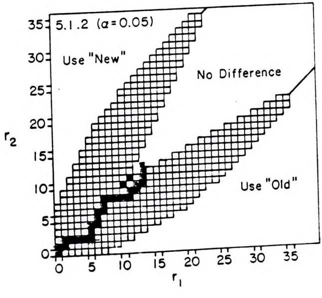
CHILI
CHILLED
C-300



CHILI
CHILLED
PE

(b)

CHILI
CHILLED
C-300



CHILI
CHILLED
PE

Figure A-3. Consumer panelists responses[a,b] to preference test for chilled C-300 chili versus chilled PE chili.

[a]Location of panel: (a) MSU Dairy Store, 2/17/84, N=48.
[b]Location of panel: (b) Burcham Hills Retirement Center, 2/21/84, N = 36.

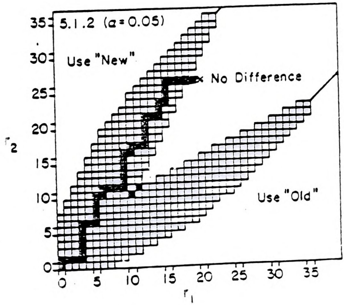
CHILI
FROZEN
C-300

Figur

[a]Loca

DECISION CHART

CHILI
FROZEN
C-300



CHILI
FROZEN
PE

Figure A-4. Consumer panelists responses[a] to preference test for frozen C-300 chili versus frozen PE chili.

[a]Location of panel: MSU Dairy Store, 4/10/84, N=65.

(a)

SOUP
CHILLED
C-300

(b)

SOUP
CHIL
C-30

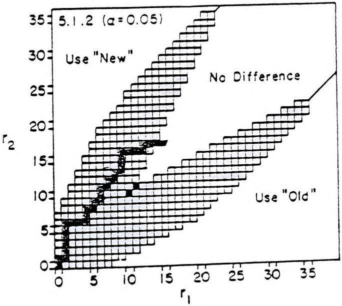
Fi

a
b

DECISION CHART

(a)

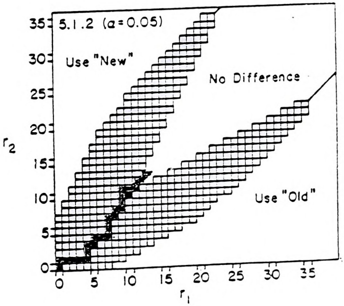
SOUP
CHILLED
C-300



SOUP
FROZEN
C-300

(b)

SOUP
CHILLED
C-300



SOUP
FROZEN
C-300

Figure A-5. Consumer panelists responses[a,b] to preference test for chilled C-300 soup versus frozen C-300 soup.

[a]Location of panel: (a) MSU Dairy Store, 2/17/84, N=86.
[b]Location of panel: (b) MSU Dairy Store, 4/5/84, N=60.

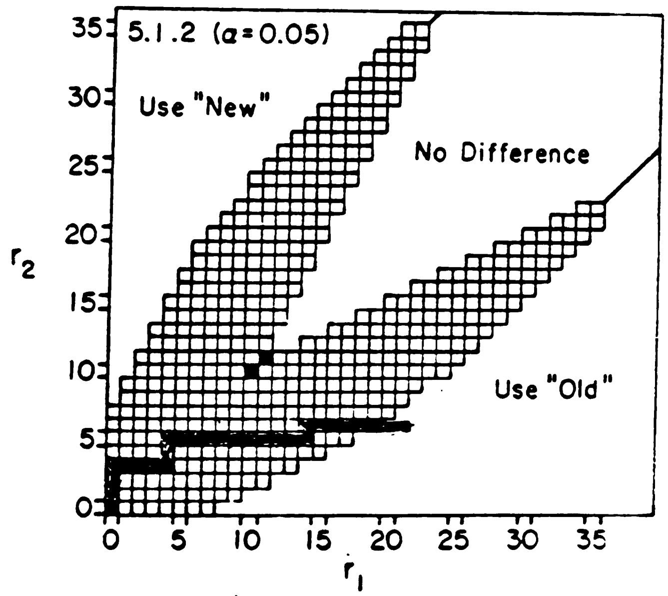
SOUP
CHILLED
PE

Figur

[a]Loca

DECISION CHART

SOUP
CHILLED
PE



SOUP
FROZEN
PE

Figure A-6. Consumer panelists responses[a] to preference test for chilled PE soup versus frozen PE soup.

[a]Location of panel: MSU Dairy Store, 4/10/84, N=59.

(a)

SOUP
CHILLE
PE

(b)

SOUP
FROZ
C-3(

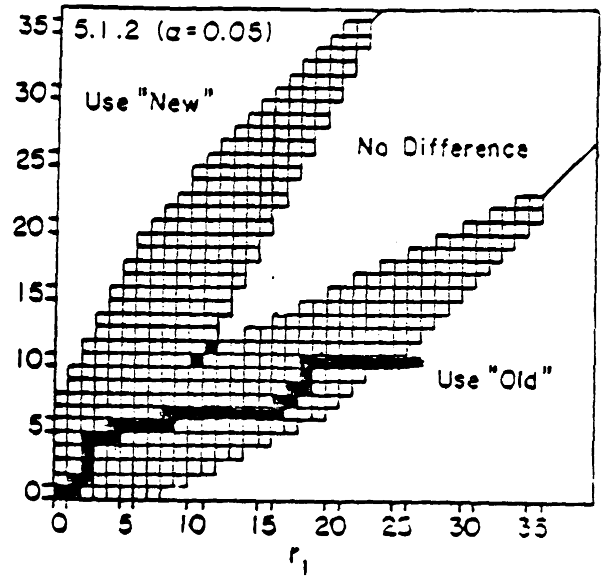
Fi

a I
b I
N=

DECISION CHART

(a)

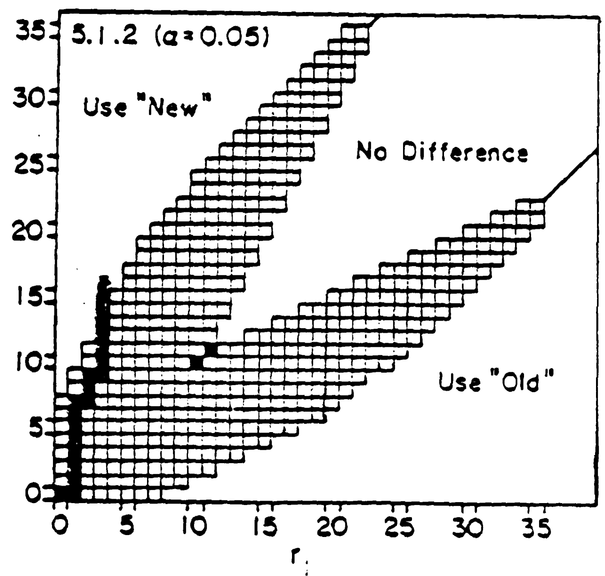
SOUP
CHILLED
PE



SOUP
CHILLED
C-300

(b)

SOUP
FROZEN
C-300



SOUP
FROZEN
PE

Figure A-7. Consumer panelists responses[a,b] to preference test for (a) chilled C-300 soup versus chilled PE soup and (b) frozen C-300 soup versus frozen PE soup.

[a]Location of panel: (a) MSU Dairy Store, 2/21/84, N=73.
[b]Location of panel: (b) University Methodist Church, 2/19/84, N=85.

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LIST OF REFERENCES

Amerine, M.A., Pangborn, R.M., and Roessler, E.B. 1965. Principles of Sensory Evaluation of Food. Academic Press, New York.

Andres, C. 1977. Package/system approach cuts production cost, 30%. Food Processing 38(9):34-35.

Banwart, G.J. 1981. Basic Food Microbiology. AVI Publishing Co., Inc., Wesport, Connecticut.

Bieler, A.C. and Howe, M.A. 1980. Process for packaging, cooling, and storing food items. U.S. Pat. 4,218,486. Aug. 19, 1980.

Bauman, H.E. 1974. The HACCP concept and microbiological hazard categories. Food Tech. 28(9):30-34,74.

Bjorkman, A. and Delphin, K. 1966. Sweden's Nacka hospital system centralizes preparation and distribution. Cornell Hotel and Rest. Admin. Q.7:84-87.

Bobeng, B.J. and David, B.D. 1978a. HACCP models for quality control of entree production in hospital foodservice systems. I. Development of hazard analysis critical control point models. J. Am. Dietet. A. 73:524-529.

Bobeng, B.J. and David, B.D. 1978b. HACCP models for quality control of entree production in hospital foodservice systems. II. Quality assessment of beef loaves utilizing HACCP models. J. Am. Dietet. A. 73:530-535.

Bross, I. 1952. Sequential medical plans. Biometrics 8:188-205.

Bryan, F.L. and McKinley, T.W. 1979. Hazard analysis and control of roast beef preparation in foodservice establishments. J. of Food Prot. 42(1):4-18.

Bryan, F.L. 1980. Foodborne diseases in the United States associated with meat and poultry. J. of Food Prot. 43(2):140-150.

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Bunch, W.L., Matthews, M.E., Marth, E.H. 1976. Hospital chill foodservice systems: acceptability and microbiological characteristics of beef-soy loaves when processed according to system procedures. J. of Food Sci. 41:1273-1276.

Cardello, A.V. and Maller, O. 1982. Acceptability of water, selected beverages and foods as a function of serving temperature. J. of Food Sci. 47(5):1549-1552.

Cichy, R.F. 1983. Sensory evaluation as a quality assurance tool in a commissary foodservice system. Dairy and Food Sanitation. 3(8):288-292.

Centers for Disease Control: 1983. Foodborne Disease Outbreaks. Annual Summary 1980.

Cremer, M.L. and Chipley, J.R. 1977. Satellite food-service system assessment in terms of time and temperature conditions and microbiological and sensory quality of spaghetti and chili. J. Food Sci. 42:225-229.

Cremer, M.L. 1983. Sensory quality of spaghetti with meat sauce after varying holding treatment and heating in institutional microwave and convection ovens. J. Food Sci. 48(6):1579-1582.

Cremer, M.L., Yum, T.K., and Banwart, G. 1985. Time, temperature, microbial and sensory quality assessment of chicken and noodles in a hospital foodservice system. J. Food Sci. 50:891.

Cryovac 1984. C-300 casings. Promotional brochure No. R1-933-NSG-CS-5M-582. Cryovac division, W.R. Grace Co., Duncan, SC.

Dahl, C.A., Matthews, M.E., and Marth, E.H. 1980. Cook/chill foodservice system with a microwave oven: aerobic plate counts from beef loaf, potatoes and frozen green beans. Journal of Microwave Power 15(2):95-105.

Elliott, R.P., Clark, D.S., Lewis, K.H., Lundbeck, H., Olson, J.C.Jr., and Simonsen, B. ICMSF. 1978. Microorganisms in Foods 1. Their significance and methods of enumeration. 2nd ed. University of Toronto Press. Toronto, Canada.

F.D.A. 1978. Bacteriological Analytical Manual. 5th ed. U.S. Food and Drug Administration, Washington, D.C.

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Gill, J.L. 1978a. Design and Analysis of Experiments in the Animal and Medical Sciences. Volume I. Iowa State University Press. Ames, Iowa.

Gill, J.L. 1978b. Design and Analysis of Experiments in the Animal and Medical Sciences. Vol. III. Apendices. Iowa State University Press. Ames, Iowa.

Glew, G. (Ed.) 1973. Cook/Freeze Catering an Introduction to its Technology. Applied Science Publishers, Ltd. London, England.

Glew, G. and Armstrong, J.F. 1981. Cost optimization through cook-freeze systems. Journal of Foodservice Systems 1:235-254.

Goddard, R.R. 1980. Flexible plastics packaging. pp 55 to 79. In Developments in Food Packaging. Ed. S.J. Pauling. 1980. Applied Science Publishers. Essex, England.

Griswold, R.M., Campbell, A.M., and Penfield, M.P. 1979. The Experimental Study of Food. 2nd ed. Houghton Mifflin Co. Boston.

IFT Senory Evaluation Division. 1981. Sensory evaluation guide for testing food and beverage products. Food Tech. 35(11):50-59.

Jakobsson, B., and Bengtsson, N. 1972. A quality comparison of frozen and refrigerated cooked sliced beef. 1. Influence of storage and processing variables. J. Food Sci. 37:230-233.

Karel, M. 1975. Protective packaging. pp 399 to 465. In Principles of Food Science. Part II. Physical Principles of Food Preservation. Ed Fennema, O.R. Marcel Dekker, Inc., New York.

Kaud, F.A. 1972. Implementing the chilled food concept, Hospitals 46(15):97-100.

Kossovitsas, C., Navab, M., Chang, C.M., and Livingston, G.E. 1973. A comparison of chilled-holding versus frozen storage on quality and wholesomeness of some prepared foods. J. Food Sci. 38:901-902.

Koteles, R., Personal communication, June 25, 1984.

Kramer, A. 1979. Effects of freezing and frozen storage on nutrient retention of fruits and vegetables. Food Tech. 33(2):58-65.

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Livingston, G.E. and Chang, C.M. 1976. Food Service Systems Analysis, Design and Implementation. Academic Press. New York.

Longree, K. 1972. Quantity Food Sanitation. 2nd ed. Wiley Interscience, John Wiley & Sons, Inc., New York.

Matthews, M.E. 1977. Quality of food in cook/chill foodservice systems: a review, School Foodservice Research Review 1(1):15-19.

McDaniel, M.C., Marchello, J.A. and Tinsley, A.M. 1984. Effect of different packaging treatment on microbiological and sensory evaluation of precooked beef roasts. Journal of Food Protection 47:(1) 23-26.

McGuckian, A. 1969. The A.G.S. food system - chilled pasteurized foods. Cornell Hotel and Rest. Administration Q. 10:87-92, 99.

Millross, J., Hill, M.A. and Glew, G. 1974. Consequences of a switch to cook-freeze. Hospitals 48:118, 124-126.

Nicholanco, S. and Matthews, M.E. 1978. Quality of beef stew in a hospital chill foodservice system. J. Am. dietet. A, 72:31-37.

Nickerson, J.T. and Sinskey, A.J. 1972. Microbiology of Foods and Food Processing. American Elsevier Publishing Co., New York.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., and Bent, D.H. 1975. Statistical Package for the Social Sciences (SPSS). 2nd ed. McGraw-Hill Book Co., New York.

Pauling, S.J. (Ed.). 1980. Developments in Food Packaging. Applied Science Publishers, Ltd. London, England.

Ramey, D. W. 1984. Extended shelf life: refrigerated foods and produce. Speech 38th Annual Meeting: Research and Development Associates for Military Food 7 Packaging Systems, Inc. Chicago, Il. April 3-5, 1984.

Rollin, J. L., and Matthews, M.E. 1977. Cook/chill foodservice systems: temperature histories of a cooked ground beef product during the chilling process. J. of Food Prot. 40(11): 782-784.

Sacharow, S. and Griffin, R.C. 1970. Food Packaging. The AVI Publishing Co., Inc. Westport, connecticut.

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Stone, H., Sidel, J., Oliver, S., Woolsey, A., and Singleton, R.C. 1974. Sensory evaluation by quantitative descriptive analysis. Food Tech. 28(11):24-34.

Tressler, D.K. 1968. Storage of precooked frozen foods. pp 522 to 534. In The Freezing Preservation of Foods. Vol IV. Freezing of precooked and prepared foods. 4th ed. Eds. Tressler, D.K., VanArsdel, W.B., and Copley, M.J. The AVI Publishing Co. Westport, CT.

Tuomi, S., Matthews, M.E. and Marth, E.H. 1974. Behavior of clostridium perfringens in precooked chilled ground beef gravy during cooling, holding, and reheating. J. Milk Food Technol. 37(10):494-498.

Unklesbay, N.F., Maxcy, R.B., Knickrehm, M.E., Stevenson, K.E., Cremer, M.L., and Matthews, M.E. 1977. Foodservice systems: product flow and microbial quality and safety of foods. North Central Reg. Res. Bull 1018. Mo. Argic. Exper. Sta., Columbia, MO.

Whittington, L.R. 1968. Whittington's Dictionary of Plastics. Technomic Publishing Co., Inc. Stamford, Conn.

Zacharias, R. 1979. Chilled meals: sensory quality. pp 409 to 415. In Advances in Catering Technology. Ed. George Glew 1979. Applied Science Publishers LTD. London.

Zallen, E.M., Hitchcock, M.J., and Goertz, G.E. 1975. Chilled foodsystems: effects of chilled holding on quality of beef loaves. J. Am. Dietet. A. 67:552-557.