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I am submitting herewith a thesis written by Zaharah Wahid entitled "Utilization of Carp and Other Skeletal Muscle Tissues in a Puffed Snack Food." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology and Science.

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UTILIZATION OF CARP AND OTHER SKELETAL
MUSCLE TISSUES IN A PUFFED
SNACK FOOD

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ABSTRACT

The research objective of this study was to develop a meat snack product from low-utilized fish in combination with other skeletal muscle tissues, and to determine how different combinations of skeletal muscle tissues would affect the sensory attributes, chemical composition, physical properties and microbial growth of the snack product. Five treatments were formulated from the combinations of meat tissues as follows: 20:10:10, 30:5:5, 30:10:0, 30:0:10 and 40:0:0 percent fish, beef and chicken respectively.

There was no significant effect on the color among treatments of sensory panelists for deep-fried crackers. This showed that the combination of fish with beef and chicken was no different in color than all fish (control) crackers. It appears that cooking reduced differences in color among treatments.

With the exception of treatment 3 (30 percent fish, 5 percent beef and 5 percent chicken), the flavor scores for all treatments were significantly above the slightly desirable flavor level. With the decrease in percentage of beef the flavor score tended to decrease.

Texture scores for all the treatments were not significantly different ($P < 0.05$) from the control treatment. There was significant different ($P < 0.05$) between replicates. The treatments were all scored above slightly acceptable for overall acceptability, except treatment 3 which was moderately acceptable. The overall acceptability of fish crackers was more related to flavor than the other sensory attributes studied.

The non-American panel rated the deep-fried puffed crackers significantly higher for all sensory attributes except texture than the American panel.

Data on Hunter color values showed that the different combination of skeletal muscle tissues did affect the lightness, redness and yellowness of the deep-fried product.

Significant difference ($P < 0.05$) was determined on Instron measurements of texture (crispness). The trend generally indicated that the treatment with the high percentage of beef tended to have higher mean scores.

There was significant effect on the expansion measurements due to treatment. Treatments with beef were observed to have better expansion properties due to the presence of gelatin.

The treatments differed significantly in percentage of moisture, fat, protein, ash, fiber and carbohydrate. Percentage moisture and percentage protein increased with the decrease in fat content of the raw and fried products. The moisture content of fried product was lower than that of raw product while the fat content was very much higher. The percentage ash and percentage fiber remained constant before and after frying.

Coliforms, yeast and mold were not detected in any treatment for both raw and deep-fried products. A low aerobic plate count reflected that the product had good microbial quality.

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CHAPTER I

INTRODUCTION

The value of carp has long been recognized in both Europe and China, where it has been cultivated for hundreds of years (Tamura, 1961). Carp is abundant in the artificial lakes of the Tennessee Valley (Walford, 1945) and widely distributed throughout the United States, especially in the Great Lakes (Ednan, 1940 and Taylor, 1917). This non-traditional fish provides a potential but largely undeveloped food resource of the people of the United States.

Recently with high food prices in general, and particularly of meat, interest has been shown in utilizing fish from Tennessee fresh water in the manufacture of food products.

Currently there are relatively few meat snack foods manufactured. Also only a few snack foods are high in proteins which have an adequate balance of the essential amino acids. Proteins of animal origin are known to provide the essential amino acids while cereal proteins are usually deficient in one or more.

A strong argument for the utilization of the carp is its excellent food value. It is one of the best sources of inexpensive, high quality protein available to us because it has lower caloric content than meat and contains less cholesterol (Taylor, 1917; King, 1973; Sigler, 1949; Stanley, 1960).

Sigler (1949) reported that fresh carp has been used as a protein supplement. The high protein content and the comparatively low cost of carp appear to justify the efforts of many groups to develop a wider

market for it. Therefore, serious consideration and scientific attention is a worthwhile goal in the hope of providing a readily available and cheap food supply.

In order to increase human consumption of carp, especially for those consumers that dislike strong fish flavor, it would be necessary to increase its palatability first. According to King and Flick (1973) the palatability of the product could be improved by adding suitable seasonings or combination with other meat tissues.

However, research and development in the area for processing carp with different combinations of skeletal muscle tissues is needed before carp products can compete with marine fish products. Research on this subject is not available in the literature. Therefore the objective of this study was to investigate different combinations of fish, beef, chicken and tapioca flour as ingredients in the manufacture of a puffed snack food. Sensory, characteristics, physical properties, chemical composition and microbial growth were measured to assess the formulated product.

CHAPTER II

REVIEW OF THE LITERATURE

I. HISTORICAL ASPECTS OF CARP

The scientific name of carp is Cyprinus Carpio. Geographically it is distributed widely in various lakes and rivers in the world. Walford (1945) and Tamura (1961) reported that carp was introduced in the United States in 1877. Its original home was in the rivers of the Black Sea and Aegean Basins, notably the Danube. It was brought to the European continent in the 13th Century, to England in the 16th, and finally to America (Tamura, 1961; and Walford, 1945).

Since its introduction, carp has become widely distributed from coast to coast and in Southern Canada. It is one of the most widely distributed fish in North America. Walford (1945) noted that commercial fishermen took carp from the Great Lakes for the first time in 1880's and now catch over 5,000,000 pounds a year from these lakes. It is also very abundant in the Mississippi River drainage area where sixteen to seventeen million pounds are caught and sold each year (McClane, 1977).

Carp As A Source Of Food

Carp is a valuable food fish in many parts of the world. According to Taylor (1917) and Ednan (1940), when properly prepared and cooked, carp had an excellent flavor. Taylor (1917) further demonstrated an incident that occurred in 1902, when 200 and 24 members of the North American Fish and Game Protective Association and the representatives of the fishing departments of three province of Canada were purposely deceived, being fed carp as red snapper. That the deception was not

discovered was evidence that whatever objectionable quality the meat might have, could be fully overcome by proper method of preparation. The meat of carp is excellent when smoked (Taylor, 1917; Ednan, 1940 and King, 1970).

The carp is often raised for food, especially in Europe and Asia, because it is possible to produce large amounts of fish per acre. It is a food which meets with particular favor among Jewish people who are large consumers of fish. Carp also are popular among American people of Central European birth or ancestry who have an established preference for carp. Carp is further claimed to be a favorite food fish of the Japanese and Chinese, reported by Taylor, 1917; Tamura, 1961 and Ednan, 1940.

Jarvis (1939) mentioned that "fish is turkey" to some Americans. It is the principal dish on Christmas Eve in many Polish households in the Middle West or other localities in this country having a Polish population. According to the same source carp in 'Polish sauce' also was a favorite dish for the Christmas holidays among Germans and immigrants from other Middle European countries.

Species

There are three chief varieties of carp. The scale carp is completely covered with scales. The mirror carp, is so called because of the extraordinary large scales arranged irregularly over the body with interspersed areas that have no scales. The leather carp has none or only a few scales and possesses a thick, soft skin that feels velvety to the touch. The latter variety is the most common carp in the United States. Carp average from one to six pounds and catches of 15 to 20 pounds

are not rare. Weights as high as 55 pounds have been reported in this country and in Europe it grows even larger.

Reasons For Prejudice Against Carp

Reasons for consumers being biased against carp include the following factors. The main reason is the general reputation of the carp. People have been indifferent and have highly condemned the carp as a food fish (Taylor, 1917). As a consequence of this psychological influence, intensive utilization of carp is discriminated against. Pappas (1979) noted that carp is unappealing to many consumers because of its unpleasant name which sounds not only strange but unappetizing. Often its unusual and unattractive appearance causes the hindering block for its popularity as a food fish. Taylor (1917) and Ednan (1940) mentioned that objection to the carp as a food fish in this country has been based largely on its muddy flavor, the fact that it is sometimes coarse, and that there are small bones within the muscle. Other adverse opinions of the carp arise from consumer concepts and also their very conservative buying habits.

II. PRODUCTION AND CONSUMPTION OF CARP

Although carp is the most abundant fish in the fresh waters of the United States, it has never been utilized to the same extent as herring. Carman (1976) reported that carp culture has never reached the importance in the United States that it enjoys elsewhere in the world. In European countries the carp is used for food on a large scale. It is even raised artificially for its meat (Taylor, 1917). According to Tamura (1961) China was the first country to raise carp. Bongstrom (1962) reported that raising of carp is an extremely profitable business.

Ednan (1940), reported that 34,836,000 pounds valued at \$1,051,000, were landed at the ports of Boston, Gloucester and Portland. The principal market for carp in the U.S.A. is in Eastern cities where a considerable portion of the catch is sold alive to consumers. Despite the fact that it is an excellent source of protein, cheap, and abundant, its consumption has never reached its potential.

According to FAO statistics, the Soviet Union is the leading carp producer with Japan ranks second (Table 1). Recent figures from China are not available but it is to be assumed that they raise more carp than any other single country. India and other Asianic nations are also engaged in carp cultivation.

III. CHEMICAL COMPOSITION AND NUTRITIVE VALUE

Table 2 represents the average composition of the edible portion of carp. As the table shows, carp is an excellent source of protein. It contains protein of high biological value comparable with that of egg, milk and meat (Taylor, 1917; Saraiva de Coster, 1956). More recent references have confirmed that the amino acids composition of fish flesh is very similar to that of carcass meat (Ellinger and Boyne, 1965; F.A.O., 1968). This property makes the carp an excellent source of high quality protein with a wide range of the amino acids that the body needs for proper growth and maintenance (Stanley, 1953). Similar findings were also reported by Pottinger and Baldwin (1940, Beach et al. (1943) and Block and Bolling (1945) showing that amino acids of fish and fish products provide protein of the finest nutritive quality, when evaluated on the basis of

Table 1. Carp Catch in Selected Countries and Areas

	1974	1975	1976	1977	1978	1979
	-----Metric Tons-----					
U.S.A.	12,459	11,809	12,364	12,232	12,128	13,624
Japan	--	--	33,249	36,055	36,536	35,308
Soviet Union	91,400	108,697	101,829	110,407	110,096	123,732
Thailand	--	--	826	1,106	1,250	1,325
Israel	--	--	8,700	8,100	8,300	7,620

SOURCE: FAO (1979).

Table 2. Average Composition of the Edible Portion of Carp per 100 g

Components	Quantity	Unit
Water	77.8	%
Protein	18.0	gm
Fat	4.2	gm
Carbohydrate	0	gm
Calcium	50 .0	mg
Phosphorus	253 .0	mg
Iron	0.9	mg
Vitamin A	170 :0	I.U.
Thiamine	0.01	mg
Riboflavin	0.04	mg
Niacin	1.5	mg
Ascorbic Acid	1.0	mg

SOURCE: U.S.D.A. Agr. Handbook #8. Composition of Foods: Raw, Processed, Prepared. Revised 1973.

its content of essential amino acid. Taylor (1917) reported that numerous investigators have ample evidence to show that fish meat is as easily digested as any other meat.

According to Connell and Howgate (1959) although the range of fish species analyzed is very small in relation to the numbers of species exploited as food, it seems in principle highly unlikely that nutritive value of different species will vary significantly. However Connell (1970) noted that protein content varies seasonally in some species of fish and the variation can also be so great that the actual physical properties of the flesh are affected.

Charley (1970) reported that fish with veterbrate of which carp is one, tend to be lower in thiamine, riboflavin and niacin than are red meats. According to Borgstrom (1962) carp appears to be low in threonine and phenylalanine.

A large majority of the carp species fall into the lean category having an average of two percent fat, that is a range of 0.1 to 3.9 percent. It has a lower calorie content than meat and is generally lower in saturated fat (Anon., 1970). A high proportion of the fat is in the form of high quality polysaturated fatty acids which are believed to reduce the level of cholesterol in the blood (Stanley, 1960).

Mineral matter constitutes approximately one percent of the edible portion of fish, and those minerals are comparable to those found in other meats. Carp is an excellent source of phosphorus but low in iron compared to red meats (Charley, 1970). Carp, like meat, is low in calcium. Canned fish is the exception as the fish is processed long enough to solubilize the bones.

Carp provides appreciable quantities of B-complex vitamins. The oils of fish livers are the most important source of vitamin D, the "sunshine" vitamin (Stanley, 1960). However it has a very low vitamin C content.

Table 3 shows a comparison of composition among various foods. The difference between carp meat and beef or mutton is chiefly in the fat. Carp meat contains approximately as much protein as beef and protein is the most expensive element of food.

IV. TAPIOCA STARCH AS A COMPONENT OF SNACK PRODUCTS

Introduction

Of the non-cereal starches, tapioca has ranked first in order of importance in the United States, as compared to the 800,000,000 pounds of corn starch and 20,000,000 pounds of potato starch produced in the United States (Ralph, 1944). It is widely used in the manufacture of food products. Waldt and Kohoe (1959) reported that cassava flour is a suitable binder since it is bland and a good flavor enhancer. Cassava flour has a cohesive quality that is superior to other kinds of starch flours (Namisato, 1974), since its flour has a high water holding capacity and a good binding property due to its higher protein content as compared with the other starches.

Chemistry Of Tapioca Starch

Starch is composed of an organized structure containing both a linear polymer, amylose, and a branched polymer, amylopectin. These two polymers differ in molecular weight and chemical structure. Amylose consists of 200 - 1000 glucopyranose units joined through alpha 1-4 glucosidic

Table 3. Analysis and Food Value of Fish and Other Meats

	Composition				
	Water	Flesh Dry Matter	Protein	Fat	Ash
	%				
Sirloin Steak	60.00	40.0	20	19	1.00
Mutton Leg	61.80	38.2	18.3	19	0.90
Salmon, Fresh	63.60	36.4	21.6	13.4	1.4
Shad	70.62	29.28	18.55	9.48	1.25
Mackerel	64.01	28.38	18.77	8.21	1.4
Halibut	75.42	24.58	18.35	5.18	1.05
Carp	78.43	21.57	19.07	1.26	1.24

Adapted from Taylor (1917).

linkages. The branched polymer, amylopectin, is made up of chains of 1500 or more glucopyranose units linked at alpha 1, 4 but branched at alpha 1-6 linkage. The linear polymer and the longer branches of the non-linear exhibit a pronounced tendency to orient and associate with other linear molecules (Waladt and Kohoe, 1959).

The starch granules in a solution swell progressively as the temperature is raised to between 60° C to 70° C. The temperature at which gelatinization begins is a characteristic of each particular type of starch. When heated above the temperature of gelatinization, the granules undergo an irreversible, sudden rapid swelling and the viscosity of the suspension increases greatly to form a gel. On further increasing of temperature the final phase of the reaction is indicated by a rapid diffusion of starch from some granules and by the rupture of others, which leaves numerous formless sacs. Upon cooling there is further stiffening and gelling of the sol (Waladt and Kohoe, 1959).

The amylose and amylopectin ratio influences the textural properties of the finished products. The waxy type (amylopectin) starches promote puffing and give an extremely light and fragile produce (Lachmann, 1969). A starch system containing 5-20% amylose will usually give the desired properties (Feldberg, 1969).

The ratio of amylose and amylopectin and its relationship to degree of puffing indirectly influence the oil absorption during deep-fat frying. According to Feldberg (1969), as the degree of puffing increases the percent oil absorbed will usually increase.

Thus, tapioca starch is a bland flavored raw material that is particularly adaptable for use in snack products. It is considerably more versatile in its textural possibilities than the cereal flours.

V. PRÉPARATION OF FISH CRACKERS

Mixing

Mixing of the various components is the most critical phase of preparation in preparation of puffed snacked foods. It affects the degree of gelatinization and rheological nature of the dough-like mixture. According to Lachmann (1969), the degree of gelatinization is one of the factors which influence the degree of expansion of the half-products (intermediate) when immersed in the hot oil. However Matz (1970) explained that the extent of puffing and the texture of the fried snack are influenced by the amylose and amylopectin ratio. A well-mixed preparation will give a smooth texture and good expansion. Nonhomogenous mixing will decrease gelatinization and thus the expansion quality will be lowered. The time of mixing varies with ingredients, amount of additives and the type of mixing machine used (Siaw and Idrus, 1979).

Cooking

Cooked starch granules will result in better rupture of starch cells during frying. The degree of gelatinization of starch will depend on the temperature the granules reach during cooking. Partially cooked granules will give poor expansion characteristics because of inadequate gelatinization. Cooking time varies with size or diameter of the roll and ingredients used. Generally 60 - 90 minutes of steaming under ordinary pressure is sufficient to cook the granules to a temperature of 90 - 95° C (Siaw and Idrus, 1979).

Cooling and Chilling

It is important to cool and chill the roll overnight to give a finer texture. This improves the texture and appearance of the sliced-product. A chilling temperature of about 5 - 10° C was found to be acceptable for most rolls (Siaw and Idrus, 1979).

VI. NEED FOR NEW FISH PRODUCTS

Research organizations engaged in fish utilization involving comminuted and minced fish flesh recognized the need of introducing new fish products and the need increase the use of under-utilized fish. A survey conducted by Miller (1974) indicated that there was a strong and growing demand for seafood products and that seafood was considered high-profit frozen items in the United States supermarket chains. Efficient processing is becoming more and more important because it enables the industry to meet demands. The need for application of improved preservation technology for commercial fishery products lends support to this concern (Wesson, et al., 1979).

In recent years machines have become available which are capable of recovering practically all the edible flesh from fish carcasses (Keay and Hardy, 1978). The same authors also mentioned that this new method of fish processing can achieve a 50 percent increase in yield. This can be largely applied to large untapped resources such as carp, thus making an important contribution to maximize fish utilization.

This new product is of special value in third world countries that are facing malnutrition problems. It can be used as a substitute for high cost protein foods for various feeding programs such as school lunches,

hospitals, universities and armed forces. The potential value of this new produce suggests the desirability of expanding research in this area (King et al., 1971).

Recent Fish Product Research

Much effort has been made to develop new products from under-utilized fish. Production of acceptable fish products has made considerable progress over the past several years. Some of these products have emerged in the United States markets, such as sausages made completely from tuna flesh that have been marketed for sometime as "Friday Franks" (Anon., 1950) and "Tuna-Links" (Anon., 1961). The preparation of food from comminuted fish flesh has been practiced in Japan for many years. Arimoto (1962) described a number of fish products. The Japanese are having success with a seafood sausage-type product (Tanikawa, 1963). An awareness of the potential commercial value of fish sausages is also evident in the Netherlands (Schooners, 1950), in Germany (Reuter, 1949), and in Australia (Montgomery, 1963).

There is a growing interest in special products from under-utilized fish flesh in the United States. The development of fish products from low-utilized fish in general and carp in particular, was initiated by the National Marine Fisheries Service in Gloucester, Massachusetts, and in Seattle, Washington in 1964. Some of the products formulated included fish cakes, fish sticks, fish sausage, fish spread and snack items. Martin (1976) noted that fish sticks and portions are in popular demand because of their convenience and tonnage. Commercially prepared fish cakes made from carp were found to have high acceptability by the Mexican population (Del Valle and Gonzalez-Inigo, 1968). Similar products were also developed

and evaluated by King (1973), King et al. (1971), Beach et al. (1973) and Scott and Crossman (1973).

Recent studies at the National Marine Fisheries Service Laboratory evaluated and compared the commercial feasibility of minced fish blocks prepared from six under-utilized ground fish species for quality, acceptability and storage stability. They exhibited organoleptic and stability properties suitable for commercialization.

The concept of mixing combinations of equal portions of ground beef and fish obtained from under-utilized fish is gaining attention. King and Flick (1973) reported that this product is known as "beefish." The same authors mentioned that mixtures of ground beef and Israel carp have enjoyed good acceptability when served as patties. A similar study on a combination of fish and meat was also reported by Korschegan et al. (1978). They found that the product was highly acceptable.

In Indonesia, Malaysia, and other parts of Southeast Asian countries the idea of mixing ground fish with other ingredients such as tapioca flour with the addition of salt to form a completely new product is not new. They are known as 'keropok' in the above countries (Veen, 1953; Yu, et al., 1981). Yu, et al. (1981) reported that this product remains a 'cottage industry.' Offei-Okrauk (1974) developed the same product in Accra, Ghana, and he found that it had high acceptability. This product differs greatly from the usual fish products, not so much in content, but in shape. It can be prepared from a wide range of fish because the flesh is comminuted and can be formed into whatever size and shape is desired by the processor.

Several studies have sought to improve the palatability of the fish product to meet the changing tastes and demands of consumers. Another reason is to make the fullest use of all available raw material and to develop products from fish which are unfamiliar or new to the consumer. Patashnik, et al. (1973) reported that the flavor of the product could be improved by adding suitable seasonings and combining with other skeletal muscle tissues (King and Flick, 1973; King and Carver, 1970; Miyauchi and Steinberg, 1970).

CHAPTER .III

MATERIALS AND METHODS

I. PRELIMINARY FORMULATION AND EXPERIMENTAL DESIGN

The first approach in the development of the fish crackers was to conduct preliminary studies which involved the formulation of two-component blends by varying the ratio of tapioca flour and fish. Sensory trials showed that the ratio of 60% flour: 40% fish had the highest acceptability score. Samples were formulated and prepared as shown in Figure 1 using different proportions of muscle tissue components.

Table 4, page 20, represents the experimental design developed from the preliminary studies. Other meat tissues were incorporated to see if this would improve the flavor and acceptability of fish crackers for those consumers that disliked strong fish flavor.

The effect of the different meat components on physical, chemical, bacteriological and sensory characteristics of the blends were investigated.

II. PREPARATION OF SAMPLES

The ingredients for each formulation were weighed in the specified quantities. The comminuted muscle tissue, salt (0.05%), monosodium glutamate (0.04%), and cold water (0.31%) based on flour basis were mixed using a Kitchen Aid 5-quart mixer with a paddle for about seven minutes on medium speed. When a homogenous emulsion was obtained, tapioca flour (Manihot esculentus) was added to form a dough like mixture. Mixing was continued for seven additional minutes.

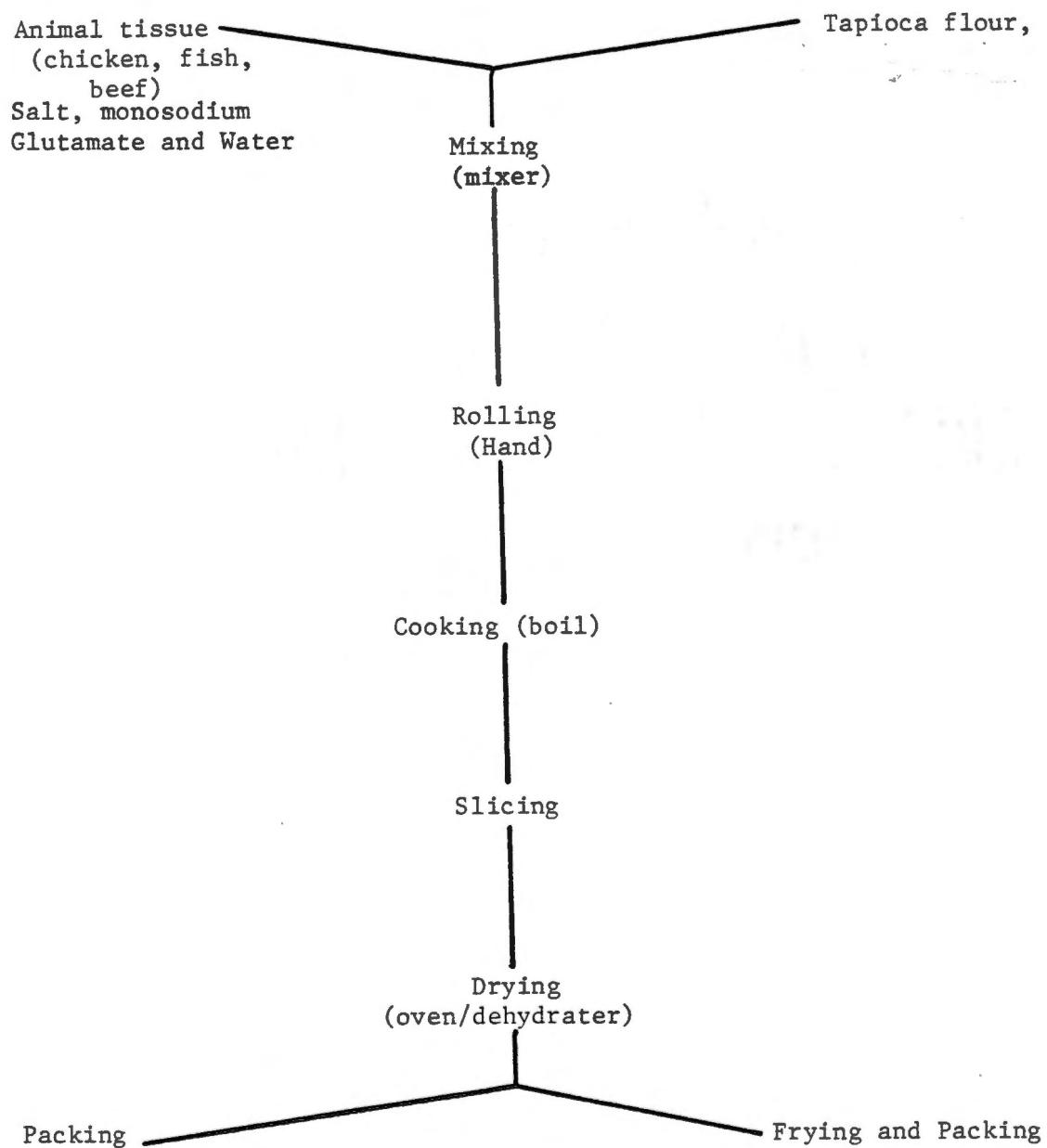


Figure 1. Processing steps for fish crackers.

Table 4. Experimental design.

Treatment	Tapioca Flour	Fish	Beef	Chicken
		%		
1	60	20	10	10
2	60	30	5	5
3	60	30	10	0
4	60	30	0	10
5	60	40	0	0

From this mass, sausage-like rolls weighing about 150 g were made by hand. Each roll measured approximately 17 cm long and 4 cm in diameter. The rolls were immersed in boiling water for 30 minutes to gelatinize the starch. The cooked rolls were then cooled at room temperature and chilled at a temperature of -5° C overnight until firm and ready for slicing.

The rolls were sliced mechanically to a thickness of 3 mm. These thin slices were arranged in rows on 0.02 inch wire-mesh screens. Were dried in a rotatory despatch oven at 180° F for eight hours, and represent the raw product. They were then allowed to cool, and were packed in sealed polyethylene bags they were then put into plastic buckets and stored at -17° C.

III. SOURCES OF CARP, BEEF, CHICKEN AND TAPIOCA FLOUR

Carp (Cyprinus carpio) used in this experiment were caught in Lake Loudon in Knoxville, Tennessee, in October 1982, by Electro-Stunning. The fish were filleted, skinned and manually cut into small pieces and randomly mixed to reduce fish to fish variability. The small bones in the fish flesh were not removed. Prior to freezing the fish flesh was washed throughly with cold water and then put into 5-lb capacity plastic buckets and tightly sealed. They were frozen and stored at -17° C until used.

Frozen mechanically deboned chicken (MDC) was purchased from a local processor. The MDC consisted of flesh from backs, breasts, ribs and pelvic girdle areas of chickens. It was also placed in sealed containers and held at -17° C for use within two weeks of purchase.

Frozen blocks of beef cow trim were also bought from a local processor. The beef trim was cut into smaller pieces using a band saw and coarsely ground in a Hobart Meat grinder ($\frac{1}{2}$ in plate). It was then thoroughly mixed, transferred into sealed containers and held at -17°C for use within two weeks of purchase.

Tapioca flour (Manihot esculentus) was purchased from a wholesaler in North Carolina. The flour was placed in sealed containers and held at room temperature until used.

IV. PREPARATION OF MUSCLE TISSUE

All the frozen muscle tissues were thawed at room temperature until just a few ice crystals remained in the flesh. If brown areas (due to surface oxidation) were present on any of the meat surfaces they were trimmed off. After thawing, the fish and course ground beef were ground through a Hobart food chopper Model H84142 (4 mm plate). All the comminuted muscle tissues were incorporated into the experimental formulation within 24 hours after thawing.

V. METHODS FOR ANALYZING SAMPLES

Sensory Evaluation

Samples of fish crackers were evaluated by untrained sensory panel of 30 - 40 members consisting of faculty and students. Sensory evaluations were made using the standard procedure suggested by I.F.T. (1971). An 8-point hedonic scale (Appendix A) was used to rate color, flavor, texture and overall acceptability (Larmond, 1970). The scale ranged from 1 = extremely undesirable to 8 = extremely desirable for all

the attributes. Sample testing was conducted using individual booths with a red masking light. For color evaluation, panelists visually evaluated a larger representative section of each sample under daylight fluorescent light.

The samples were evaluated after frying in vegetable oil at 195^o C for 5 sec. Five samples representing different treatments were presented to the panelists at each sensory session. Testing was conducted between 9:00 a.m. - 12:30 p.m. and 2:00 p.m. - 3:30 p.m. Samples were coded with three digit numbers in a randomized arrangement to equalize the sample sequence effect on food preference. This experiment was repeated one week later.

Chemical Analyses

Proximate analyses were carried out for both dried (raw) and fried samples. Moisture, protein, fat ash, crude fiber were determined on both replications of the samples. Crude fiber, moisture, protein, and ash were measured according to standard AOAC (1975) procedures, and a chloroform-methanol lipid extraction procedure (Melton et al., 1979) was used to determine the total lipid content in the samples.

Physical Analyses

The expansion of the crackers was determined by the difference in expansion characteristics between puffed and unpuffed crackers. The percentage of expansion was calculated as follows:

$$\% \text{ Area expansion} = \frac{(\text{Area after puffing} - \text{Area before puffing})}{\text{Area before puffing}} \times 100$$

The area of puffing was measured by using a planimeter.

Color was measured on individual pieces of samples as prepared for sensory evaluation with the Hunter Color/Difference Meter (Model D25 D2M, Hunter Associate Laboratory, Fairfax, Virginia). Hunter color values L, "a," and "b" were recorded. The instrument was standardized against a cream colored tile: $L = 79.4$, $"a" = -2.4$, and $"b" = 23.6$. Two replications of each treatments were made and three measurements within each replication were measured.

Texture (crispness) was measured on individual pieces of sample as prepared for sensory evaluation. An Instron Machine (Model 1132) equipped with a 50 kg capacity load cell was used as the testing instrument (Anon; 1970). The Kramer single blade cell was attached to the instrument for compressing the sample. Crosshead speed was 10 cm per minute. Cripiness of the sample is expressed in grams of force required to compress the sample by the single downward action of the blade. Two replications of each treatment were made and three measurements within each replication were made.

Microbiological Analyses

Microbiological analyses were carried out for both raw and deep-fried products. Total plate count, coliform, mold and yeast were determined on both replicates of the sample according to standard procedures (Speck, 1976). Plating media and incubating conditions are listed in Table 5.

Statistical Analysis

The experiment was ordered as randomized complete block with a factorial arrangement of treatments. Data were analyzed by analysis of variance to determine effects of treatments and replication on the

Table 5. Plating Media and Incubation Conditions

Determination	Media employed	Incubation time and temp (° C)
Total plate count	Standard Plate Agar	48 hr. 32°
Coliform count	Violet Red Bile Agar	24 hr. 37°
Yeast and Mold count	Acidified Potato Dextrose Agar	5 da. 21°

characteristics of fish crackers. When significant differences were found by the analysis of variance, Duncan's Multiple Range test was applied to separate means (Duncan, 1955).

CHAPTER IV

RESULTS AND DISCUSSION

I. SENSORY EVALUATION

Analysis of variance for color, texture, flavor and overall acceptability of deep-fried puffed crackers as affected by different combination of skeletal muscle tissues is presented in Table 6. The panel detected no significant differences ($P < 0.05$) in color attributes among all five treatments and also replicates. The mean color score for all treatments just above the slightly desirable color level as depicted in Figure 2. Treatment 5, the control, which contained only 40 percent fish component, received the highest color score while treatment 3 and 4 (30 percent fish, 5 percent beef and 5 percent chicken; 30 percent fish, 10 percent beef and no chicken, respectively) had the lowest color score (Figure 2). These results showed that the combination of fish with beef and chicken was not different in color than the all fish (control) crackers. It appears that cooking reduced differences in color between the treatments. These data suggested that myoglobin denaturation had occurred during cooking.

A significant flavor difference ($P < 0.01$) was observed among the five treatments and two replicates (Table 6). With the exception of treatment 4, the flavor scores for all the treatments were above the slightly desirable level as depicted in Figure 3. Treatment 4, received the lowest flavor score while treatment 3 (30 percent fish, 5 percent beef and 5 percent chicken) had the highest flavor score. Treatment 1 and

Table 6. Analysis of Variance of the Effect of Different Combinations of Skeletal Muscle Tissues on Sensory Attributes of Deep-fried Crackers

Source	DF	Mean Squares			
		Color	Texture	Flavor	Overall Acceptability
Nationality	1	0.05	0.85 [*]	1.23 ^{**}	2.30 ^{**}
Treatment	4	0.09	0.16	0.75 ^{**}	0.79
Replication	1	0.05	0.55 [*]	0.69 [*]	0.77
Nationality x Treatment	4	0.08	0.33	0.16	0.08
Error	9	0.17	0.14	0.13	0.23
Total	19				

^{*}P<0.05

^{**}P<0.01

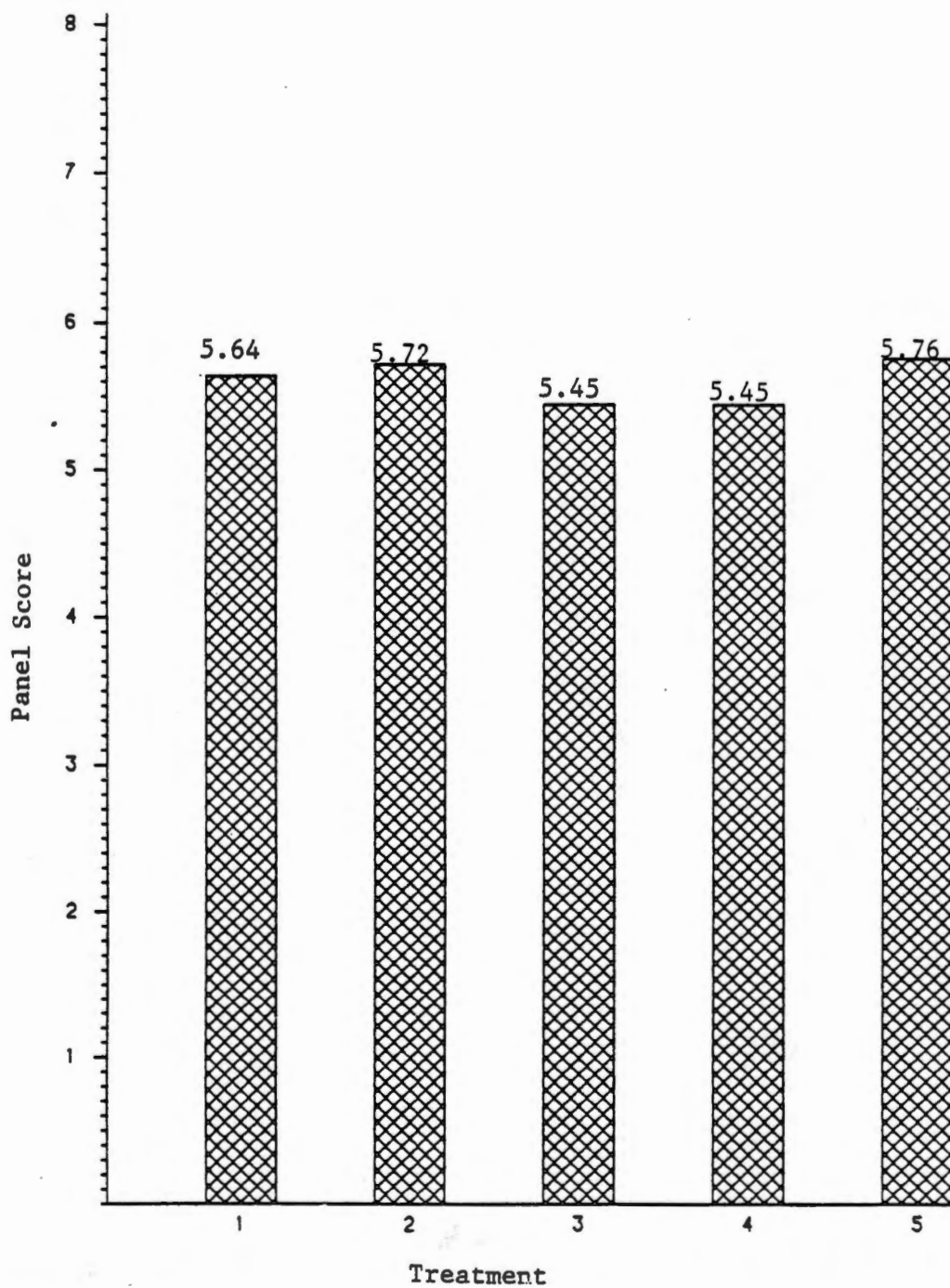


Figure 2. Mean panel scores for different treatments on color of deep-fried crackers

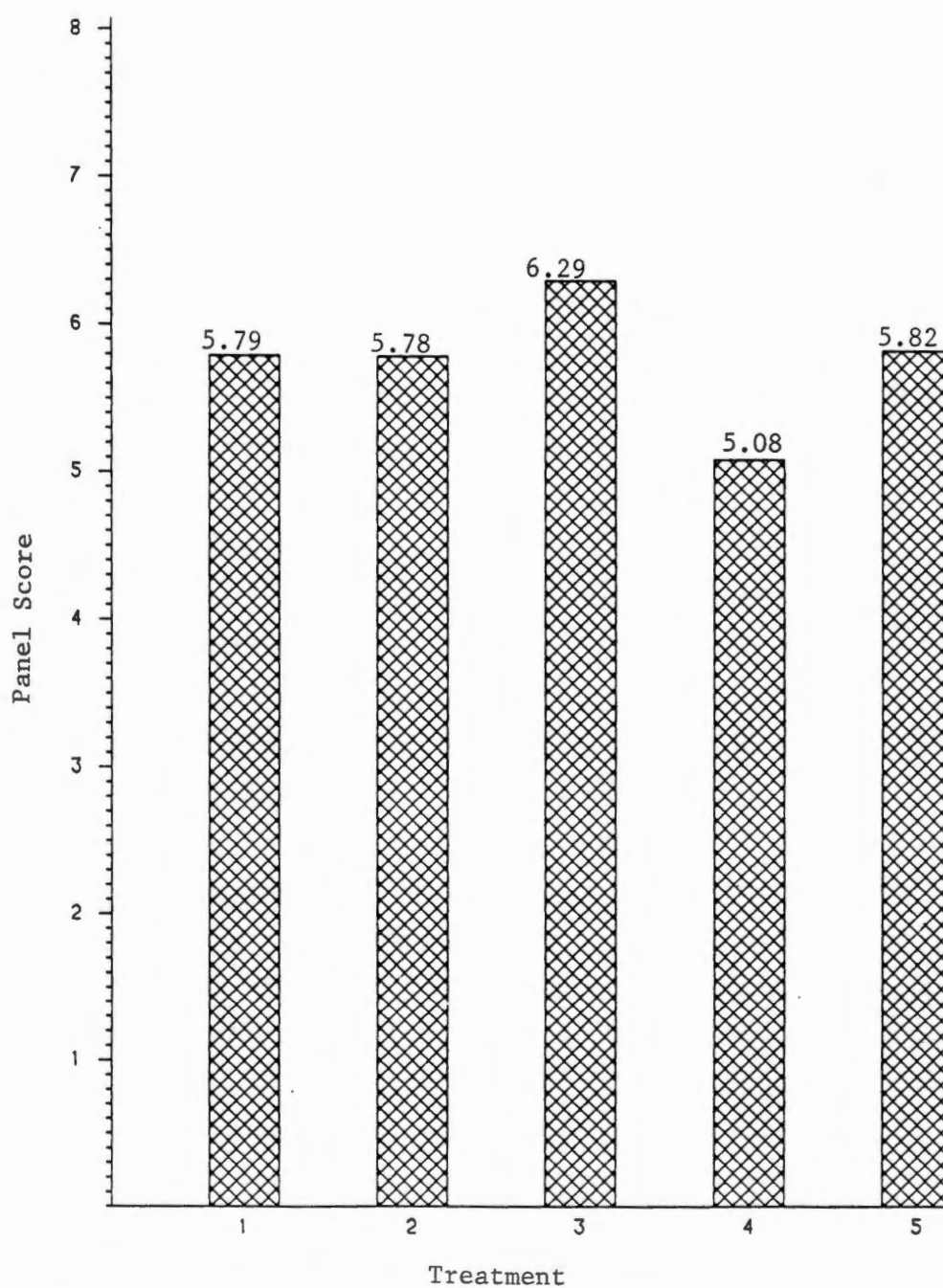


Figure 3. Mean panel scores for different treatments on flavor of deep-fried crackers.

treatment 2 were similar in flavor to treatment 5, the all fish (control) crackers. Treatment 5, control, was scored higher ($P < .001$) than treatment 4. Treatments 1, 2 and 4 had 10 percent, 5 percent and 10 percent chicken component respectively, and were rated lower in flavor by the panelists than treatments 3 and 5 which contained no chicken. With a decrease in percentage of beef the flavor score tended to decrease (Appendix B).

Mean sensory score for texture are shown in Figure 4. No significant differences ($P < 0.05$) existed among treatments and between replicates (Appendix B). Treatment 3 had the highest texture score while treatment 4 received the lowest score (Figure 4).

There were no significant differences ($P < 0.05$) in overall acceptability among the 5 treatments (Table 6). Treatment 4 was scored lower than other treatments 2 and 3 (Figure 5). Treatment 1, 2, 3 and 5 did not differ significantly. Treatment 3 was the most preferred sample (Figure 5).

A significant difference ($P < 0.01$) was found between the two nationalities panel groups in both flavor and overall acceptability (Table 6). The non-American (mostly Asian) panel rated the deep-fried puffed crackers significantly higher for all characteristics, except texture than the American panel as depicted in Figure 6 through Figure 9 and Appendix C. The higher scores by the non-American panel may be attributed to the food being more culturally and traditionally acceptable to those panelists.

A significant ($P < 0.001$) correlation coefficient was found between overall acceptability and flavor ($r = 0.88$). These data revealed

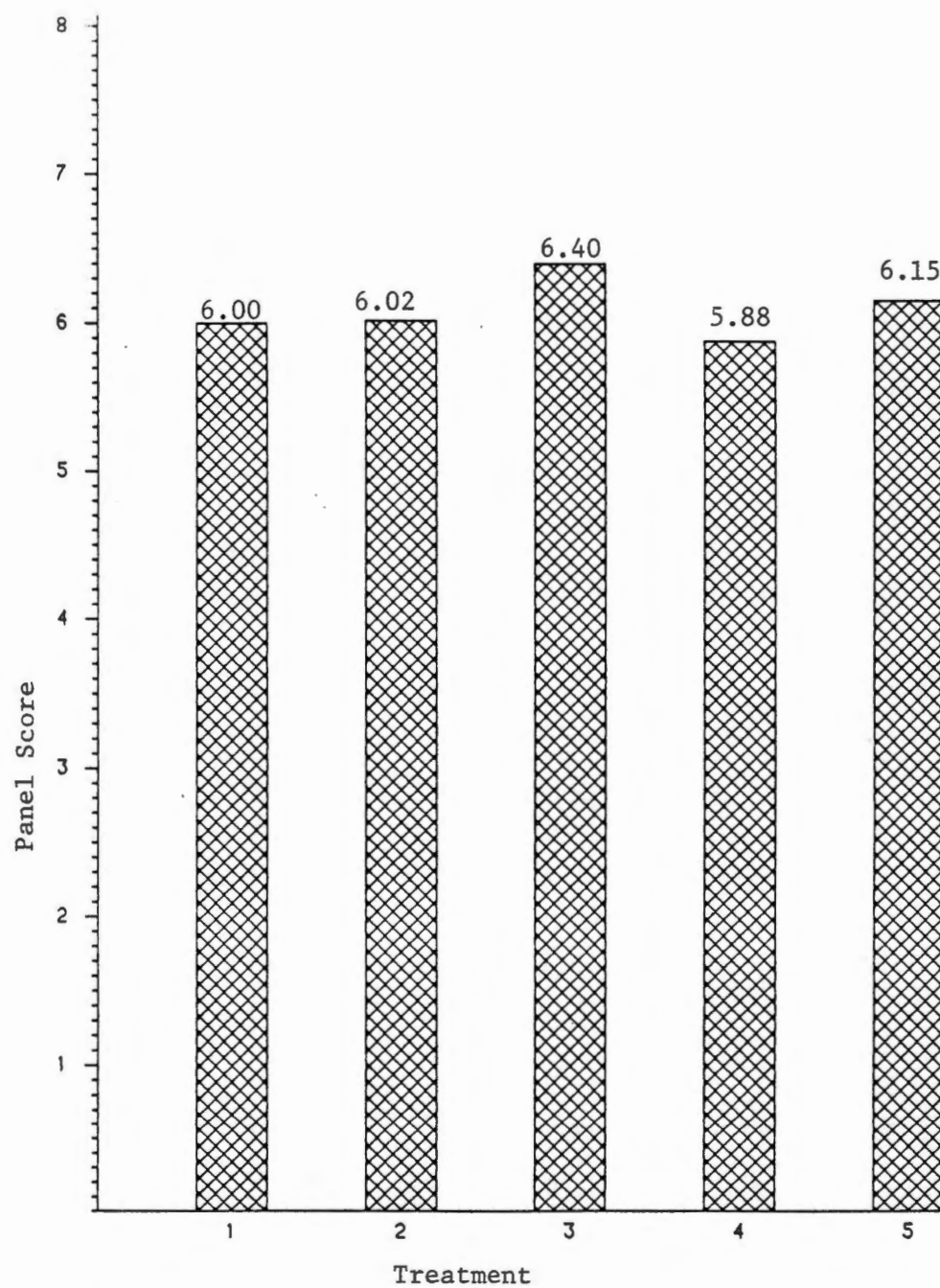


Figure 4. Mean panel scores for different treatments on texture of deep-fried crackers.

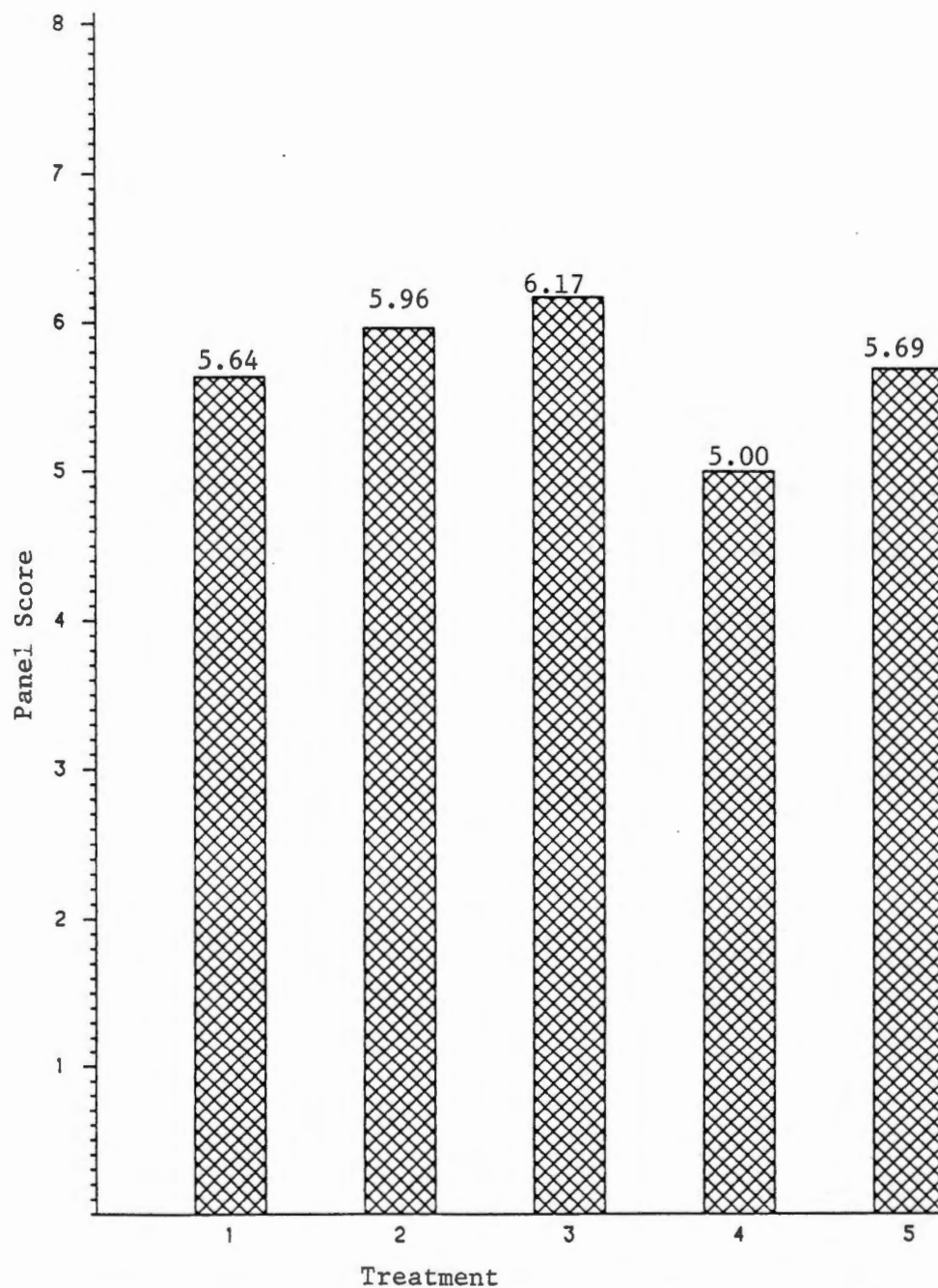


Figure 5. Mean panel scores for different treatments on overall acceptability of deep-fried crackers.

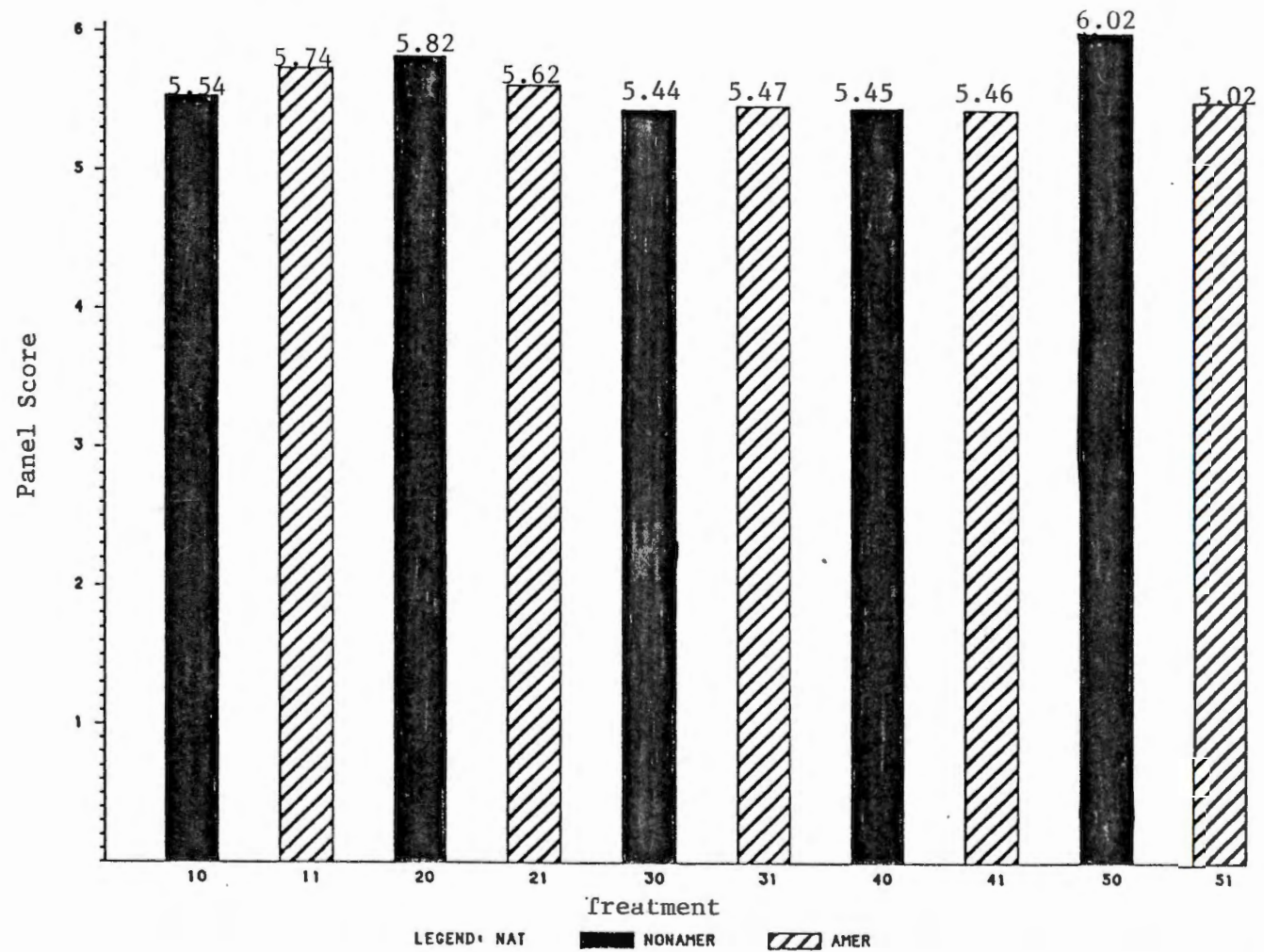


Figure 6. Mean color scores assigned by American and non-American panels to deep-fried crackers.

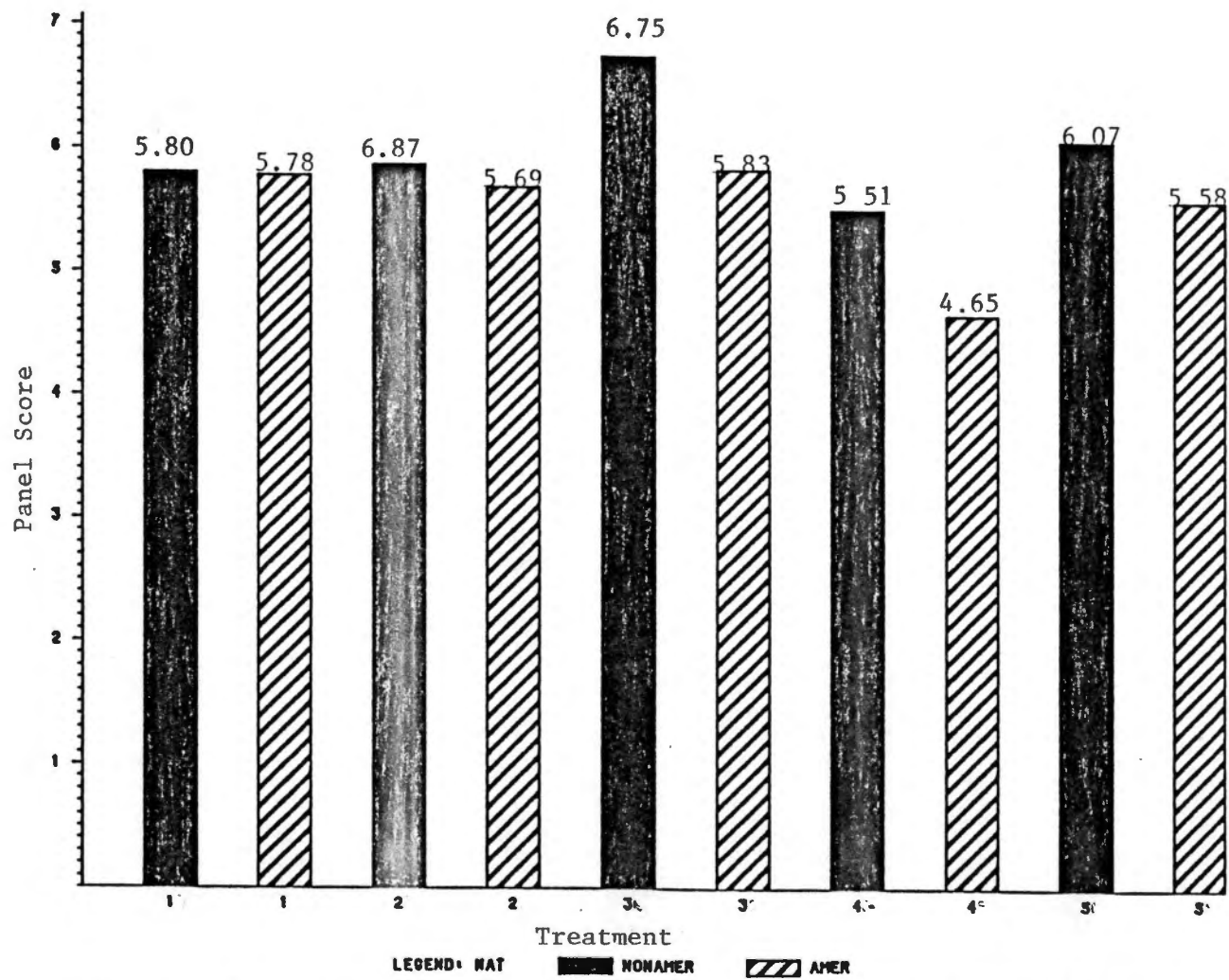


Figure 7. Mean flavor scores assigned by American and non-American panels to deep-fried crackers.

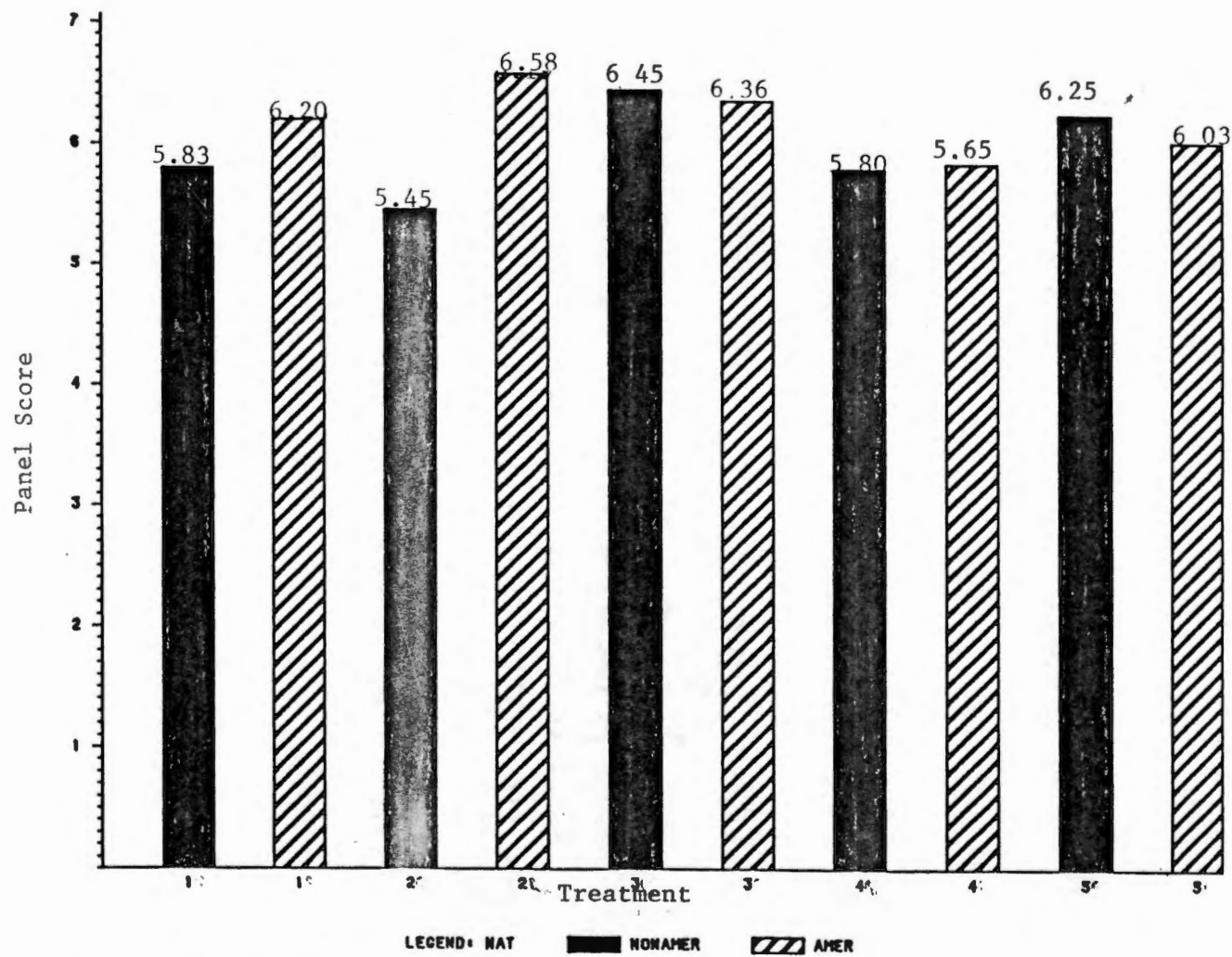


Figure 8. Mean texture scores assigned by American and non-American panels to deep-fried crackers.

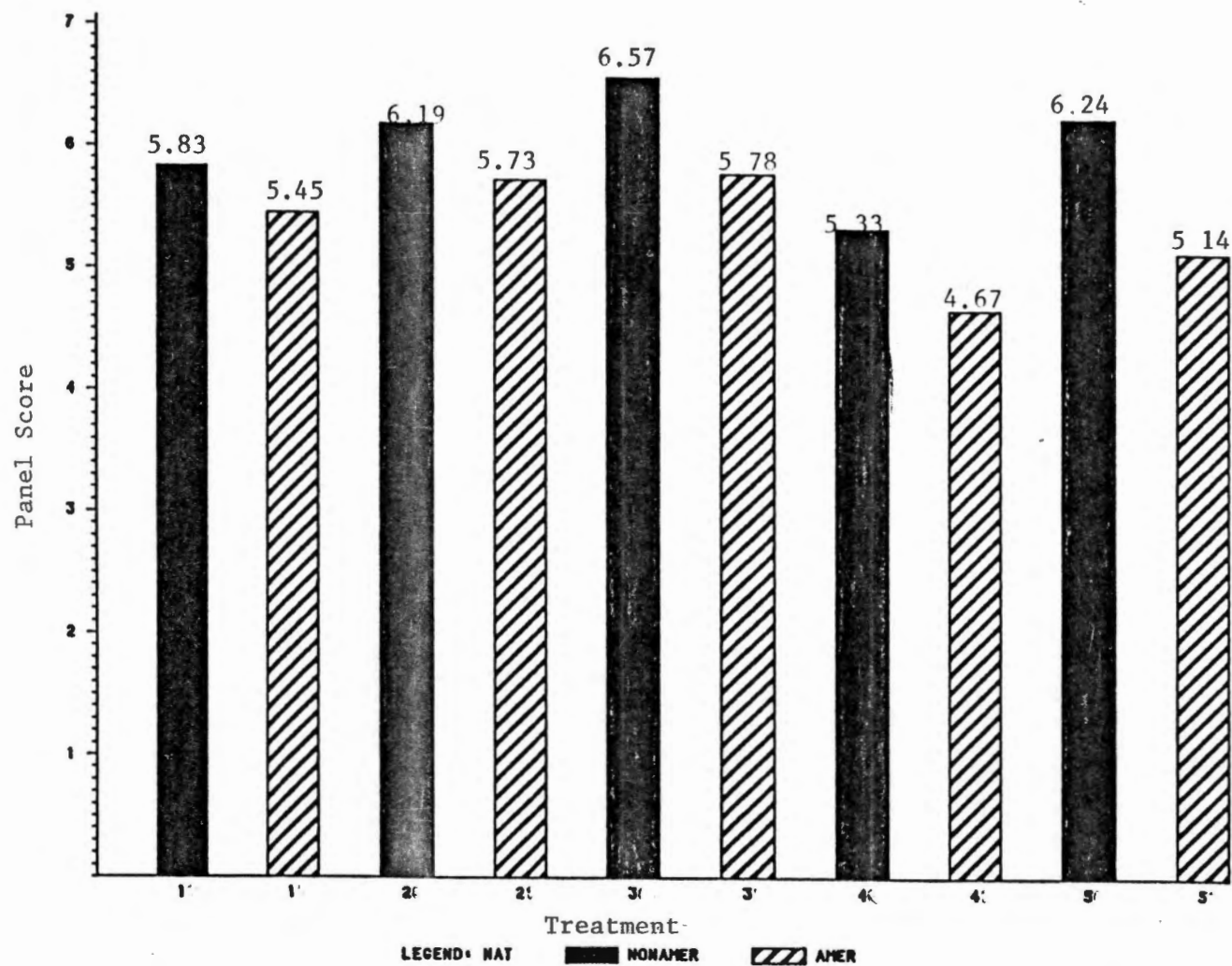


Figure 9. Mean overall acceptability scores assigned by American and non-American panels to deep-fried crackers.

that the overall acceptability of fish crackers was more dependent on its flavor than on its texture. This finding was in agreement with that reported by Rasekh et al. (1970) and Howgate (1977).

II. COLOR MEASUREMENTS

Tables 7 and 8 show the effect of different combinations of skeletal muscle tissues on color of deep-fried puffed crackers as measured on the Hunter instrument. The different combinations of skeletal muscle tissues did significant ($P < 0.001$) affect the color of deep-fried puffed crackers. There was significant difference among the treatments for lightness (L). No significant differences were found in yellowness ("b") or redness ("a") of the color ($P < 0.05$).

There was no general agreement between the objective measurement of color and that determined by the consumer type panel.

III. TEXTURE (CRISPNESS)

Analysis of variance of the effect of different combinations of skeletal muscle tissues on texture (crispness) of deep-fried puffed crackers is presented in Table 9. The Instron measurements of textural quality of the crackers Appendix D showed that significant differences ($P < 0.001$) existed among treatments. The mean texture for treatment 1 and 3 were much higher compared to treatment 5, the control, as depicted in Figure 10. The trend generally indicated that treatments with higher percentage of beef tended to require more force for compression (higher texture mean score). This is probably due to the fact that beef has much higher connective tissue content compared to fish and chicken.

Table 7. Analysis of Variance of the Effect of Different Combinations of Skeletal Muscle Tissues on Hunter L, "a" and "b" Color Values^a of Deep-fried Crackers

Source	DF	Mean Squares		
		L	"a"	"b"
Treatment	4	53.19***	5.38	4.32
Replication	1	133.23***	21.03	5.82
Error	4	3.85	8.16	1.90
Total	9			

P<0.001

Table 8. Means^a for the Effect of Different Combinations of Skeletal Muscle Tissues on Hunter L, "a" and "b" Color Values of Deep-fried Crackers

Treatment ^c	L ^b	"a" ^b	"b" ^b
1 (20:10:10)	50.30 ^{ef}	0.95 ^d	10.45 ^d
2 (30:5:5)	54.19 ^e	1.25 ^d	12.00 ^d
3 (30:10:0)	46.05 ^f	-0.85 ^d	11.42 ^d
4 (30:0:10)	59.84 ^d	3.75 ^d	13.30 ^d
5 (40:0:0)	50.55 ^{abc}	1.35 ^d	9.45 ^d

^aMeans of six determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

^bL = lightness; "a" = redness +, gray 0, green -; "b" = yellowness +, gray 0, blueness -; in Hunter color measurements.

^cTreatments are combinations of fish, beef and chicken, numbers in parentheses represent percentage of each, respectively.

Table 9. Analysis of Variance of Instron (Crispness) of Deep-fried Crackers

Source	DF	Mean Squares
Treatment	4	0.30**
Replication	1	0.002
Error	4	0.002
Total	9	

P<0.001

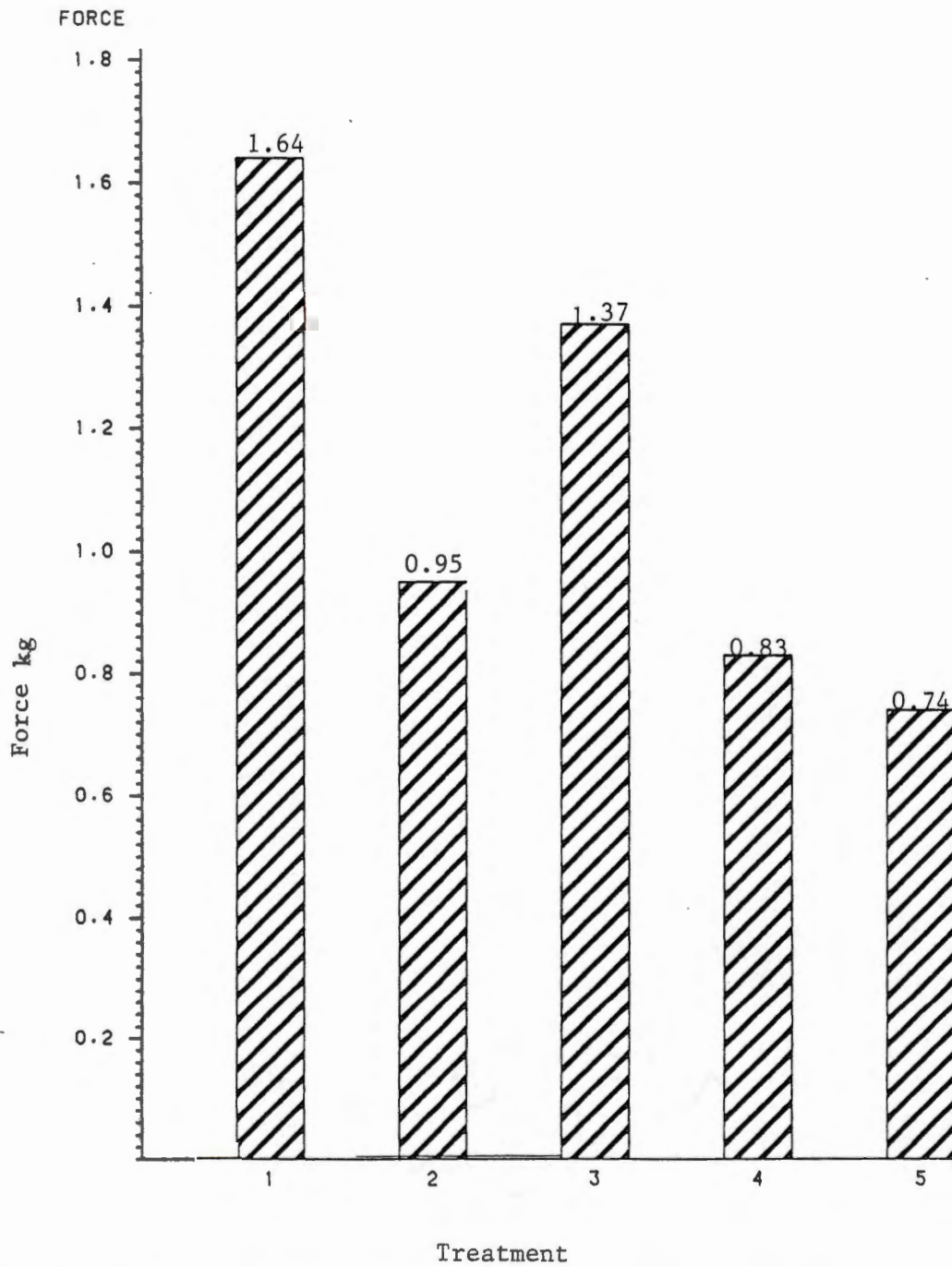


Figure 10. Means for the effect of different treatments on Instron crispness values of deep-fried crackers.

IV. AREA EXPANSION

Table 10 shows the effect of different skeletal muscle tissues on the expansion or puffing of finished fish crackers. There was significant difference among the treatments for puffing effect. Treatment 3 had the highest percent of expansion and treatment 4 had the lowest (Figure 11) and Appendix E. According to Siaw and Idrus (1979) linear expansion greater than 77 percent was ideal in terms of crispness of fish crackers.

The extent of puffing and the texture of the finished product are influenced by the amylose amylopectin ratio. At least 50 percent or more amylopectin (Matz, 1970) and 5-20 percent amylose (Feldbert, 1969) are required for a good quality product. The tapioca flour used in this experiment had more than 50 percent amylopectin and between 17-25 percent amylose so that the compositional requirements were within ideal limits. However the variation in the expansion or puffing values among treatments may be due to the different percentage of skeletal muscle tissue components. The results indicated that treatments with beef components seemed to have better expansion properties compared to those without beef component. As depicted in Figure 11. This is probably due to the presence of gelatin in the beef tissues.

V. CHEMICAL ANALYSIS

Analysis of variance of the effect of different combination of skeletal muscle tissues on percentage of moisture, protein, fat, ash, fiber and carbohydrate in the raw fish crackers is presented in Table 11. There were significant differences ($P < 0.001$) among treatments for the percentage

Table 10. Analysis of Variance for Expansion of Deep-fried Crackers

Source	DF	Mean Squares
Treatment	4	297.7***
Replication	1	0.35
Error	4	0.18
Total	9	

P<0.001

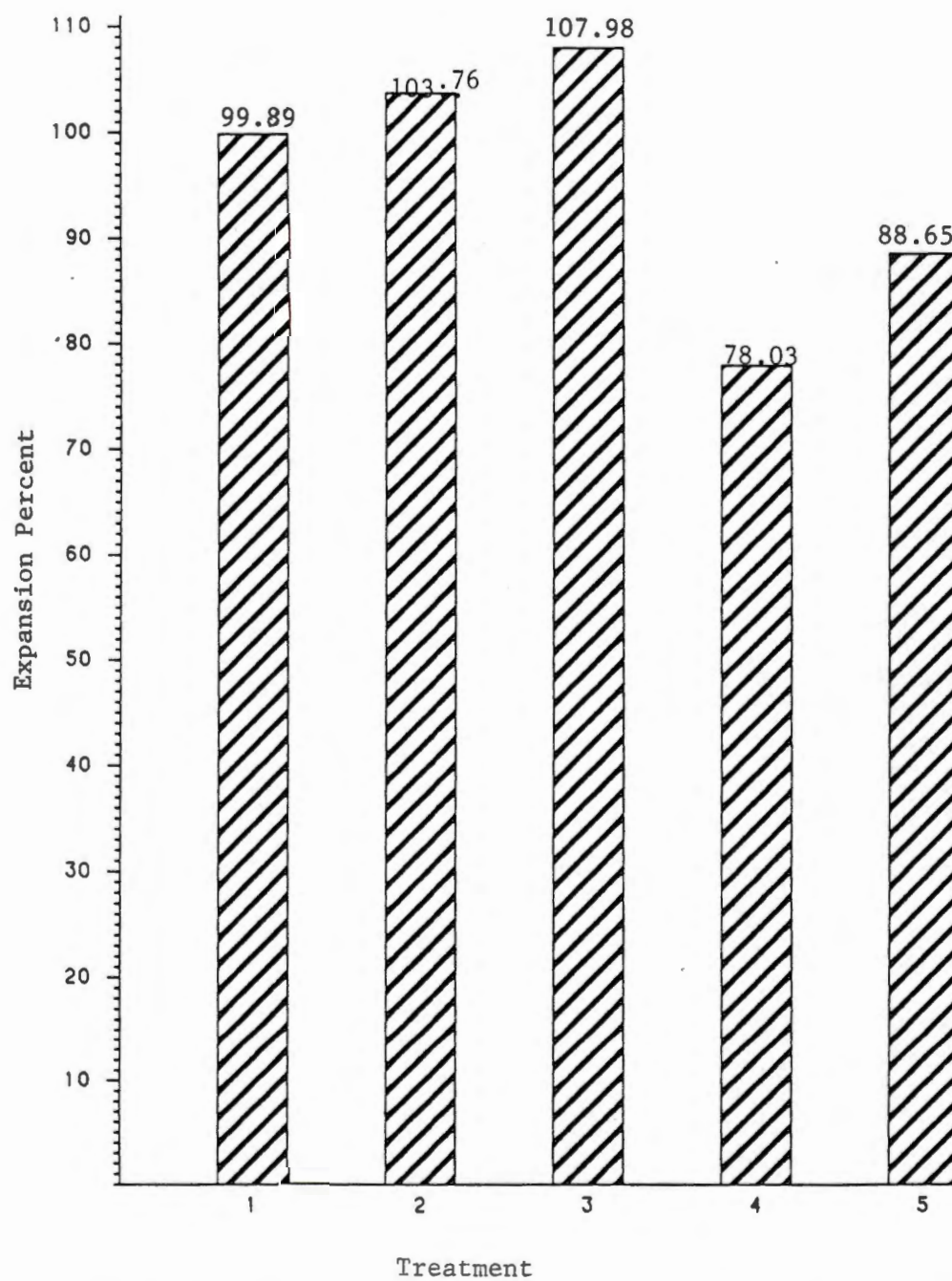


Figure 11. Means for the effect of different treatments on expansion of deep-fried crackers.

Table 11. Analysis of Variance of the Effect of Different Combinations of Skeletal Muscle Tissues on Percentage of Moisture, Protein, Fat, Ash, Fiber and Carbohydrate of Raw Crackers

Source	DF	Mean Squares					Carbohydrate
		Moisture	Protein	Fat	Ash	Fiber	
Treatment	4	0.21 ^{***}	0.028 [*]	0.05 ^{**}	0.04 ^{***}	0.002 ^{***}	0.18 [*]
Replication	1	0.009	0.002	0.002	0.001	0.00001	0.11
Error	4	0.002	0.001	0.001	0.0003	0.00001	0.001
Total	9						

P<0.001

**
P<0.01

*
P<0.05

of moisture, fat, ash and fiber and for protein and carbohydrate ($P < 0.05$). Statistical analyses of the proximate composition revealed that no differences existed between replicates.

Treatment 3 had the highest percent moisture while treatment 1 had the lowest percent moisture (Figure 12 and Appendix F). It should be noted that no consistent trend was apparent for the moisture content among the treatments. However, there was an indication that fat content decreased with an increase in percent moisture.

An increase in protein content was also observed with the decreased in fat content. The average protein was in agreement with that found in the literature. Yu et al. (1981) mentioned that the average protein for fish cracker with ratio of fish to flour 40:60 was 10.58 percent.

There was significant difference ($P < 0.001$) among treatments for the percentage of ash. Treatment 1 had the lowest percentage while treatment 4 had the highest. These results suggested that treatments which contained more fish component tended to have higher percentage of ash (Figure 12).

Differences existed among treatments in fiber content of raw snack foods. Treatments 1 and 5 were significantly different from each other but not treatments 2, 3 and 4, (Appendix F).

A significant difference was also observed in carbohydrate content of raw products among treatments (Table 11). Treatment 3 was significantly lower in carbohydrate than other treatments (Appendix F). This treatment contained no chicken.

Table 12 and Appendix G show the effect of different combinations of skeletal muscle tissues on the proximate composition of deep-fried puffed

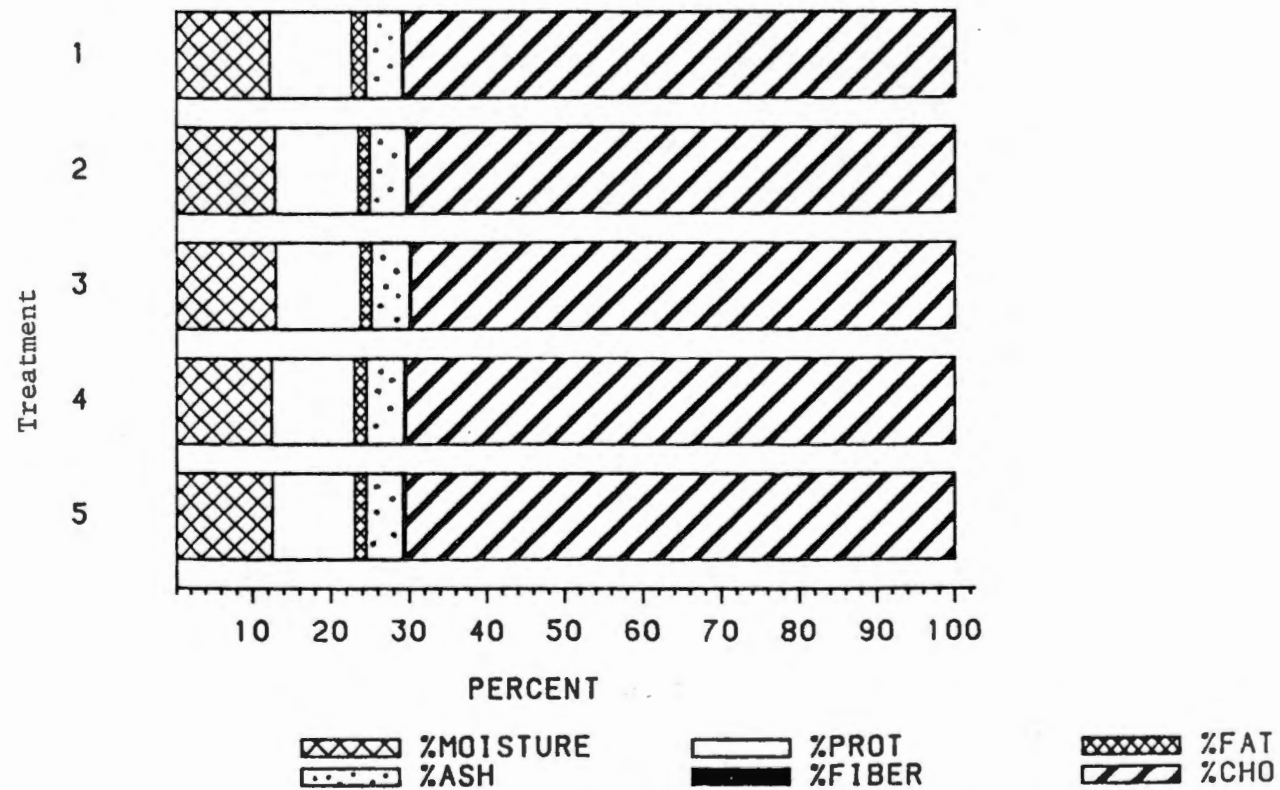


Figure 12. Proximate composition of different treatments for raw crackers.

Table 12. Analysis of Variance of the Effect of Different Combinations of Skeletal Muscle Tissues on Percentage of Moisture, Protein, Fat, Ash, Fiber and Carbohydrate of Deep-fried Crackers

Source	DF	Mean Squares					
		Moisture	Protein	Fat	Ash	Fiber	Carbohy- drate
Treatment	4	0.0039 ^{***}	0.026 ^{***}	6.23 ^{***}	0.029 [*]	0.0015	17.41 ^{***}
Replication	1	0.002	0.002	0.002	0.0003	0.002	0.64
Error	4	0.0001	0.0001	0.0001	0.004	0.001	0.72
Total	9						

* P<0.05

** P<0.01

*** P<0.001

fish crackers. There was significant difference ($P < 0.05$) among the treatments with the exception of percentage of fiber. There was a decrease in percent moisture of the deep-fried compared to the raw fish crackers. The range of moisture for the raw crackers were 12.13 to 12.93, while it was 3.22 to 3.34 percent for the deep-fried puffed crackers. The moisture content was lower than that of the raw samples while the fat content was very much higher. These results were expected since deep-frying tends to cause a relatively high degree of moisture loss with a concomitant uptake of oil.

There was a slight increase in the percentage of protein in the deep-fried puffed crackers. The range of percentage of protein for the raw were 10.43 to 10.73, and 10.66 to 10.96 percent for the deep-fried puffed crackers. There was a large increase in percentage fat after frying. The range of percentage fat for the raw crackers was 1.43 to 1.84, while the percent fat for the deep-fried puffed crackers was 30.77 to 35.25 (Figure 13 and Appendix G).

The significant difference between the treatments for carbohydrate was probably due to moisture loss and increases in fat content during frying.

VI. MICROBIOLOGICAL EVALUATION

Coliforms, yeasts and molds were not detected in any of the five treatments for both uncooked and deep-fried products. The absence of coliforms reflect that the meat used was free from contamination and that clean processing procedures were followed. The absence of yeast and mold growth is due to the low moisture content which did not favor their growth.

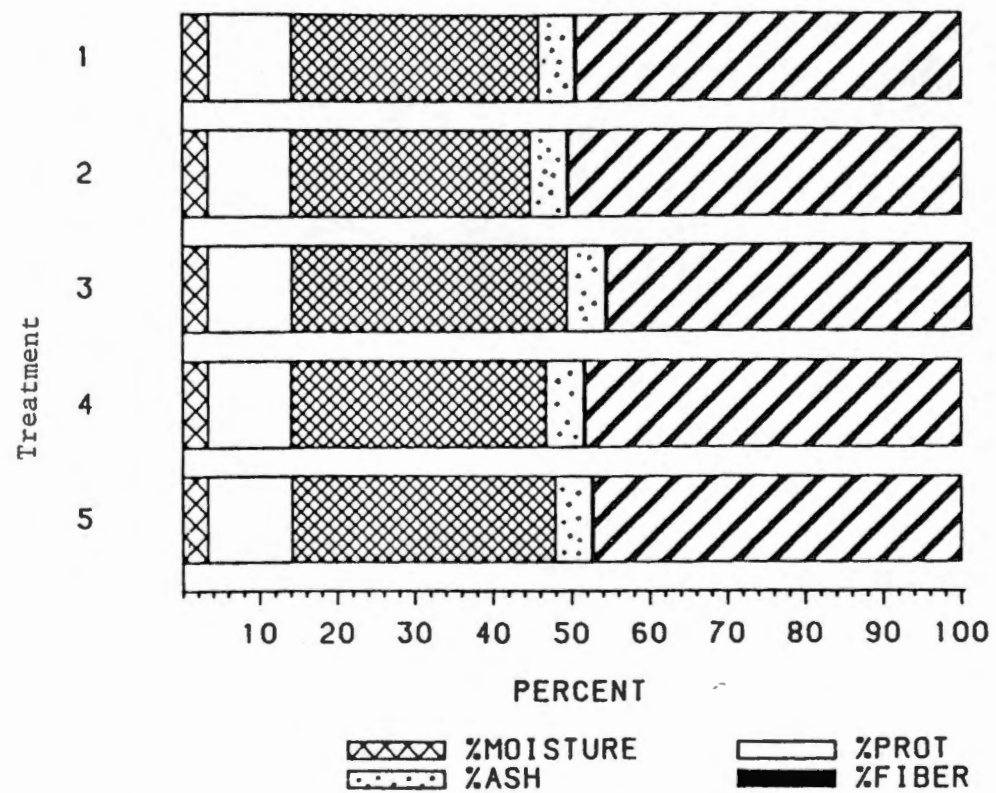


Figure 13. Proximate composition of different treatments for deep-fried crackers.

However, there was bacterial growth in the aerobic plate agar for both raw (Table 13) and deep-fried product (Table 14). Significant treatment differences ($P < 0.001$) and ($P < 0.001$) were found for aerobic plate count in both raw and deep-fried products (Table 15).

In the case of raw crackers treatment 5 (control) had the highest count compared to the others and treatment 3 the lowest (Table 15). In the deep-fried product the aerobic plate count in all treatments was lower than that in the raw product and treatment 4 had the highest count of all treatments (Table 15).

The results indicate that the different tissue components had an effect on the growth of the aerobic plate count, but no consistent trend was apparent among treatments.

The result showed that the plate counts were quite low for both the raw and deep-fried products which could be considered good microbial quality.

Table 13. Analysis of Variance of the Effect of Different Combination of Muscle Tissues on Aerobic Plate Count of Raw Crackers

Source	DF	Mean Squares
Treatment	4	1525350000.0***
Replication	1	810000.0
Error	4	350000.0
Total	9	

P<0.001

Table 14. Analysis of Variance of the Effect of Different Combinations of Muscle Tissues on Aerobic Plate Count of Deep-fried Crackers

Source	DF	Mean Square
Treatment	4	77733.4***
Replication	1	136.90
Error	4	141.4
Total	9	

P<0.001

Table 15. Mean Values for the Effect of Different Combinations of Skeletal Muscle Tissues on Aerobic Plate Count, Coliform, Mold and Yeast of Raw and Deep-fried Crackers

Treatment ^b	Aerobic Plate Count	Coliform	Yeast and Mold
	----- per g -----		
Raw Product:			
1 (20:10:10)	29,000 est ^c	< 1 est	< 1 est
2 (30:5:5)	30,000 ^b	< 1 est	< 1 est
3 (30:10:0)	18,000 ^e	< 1 est	< 1 est
4 (30:0:10)	22,000 ^d	< 1 est	< 1 est
5 (40:0:0)	85,000 ^a	< 1 est	< 1 est
Deep-fried Product:			
1 (20:10:10)	10 est ^c	< 1 est	< 1 est
2 (30:5:5)	320 ^b	< 1 est	< 1 est
3 (30:10:0)	10 est ^c	< 1 est	< 1 est
4 (30:0:10)	400 ^a	< 1 est	< 1 est
5 (40:0:10)	350 ^b	< 1 est	< 1 est

^aMeans of four determinations. Means in column groups followed by the same letter are not significantly different ($P < 0.001$).

^bTreatments are combinations of fish, beef and chicken; numbers in parentheses represent percentage of each meat, respectively.

CHAPTER V

SUMMARY

The purpose of this study was to develop a meat snack product using under-utilized fish in combination with other skeletal meat tissues and to determine the effect of different combinations of skeletal muscle tissues on sensory attributes, chemical composition, physical properties and microbial growth in the fish crackers. Five treatments were formed using the following combinations of meat tissues: 20:10:10, 30:5:5, 30:10:0, 30:0:10 and 40:0:0 percent fish, beef and chicken respectively (Table 4, page 20).

Significant differences ($P < 0.01$) were found between the two nationalities of sensory panelists for both flavor and overall acceptability (Table 6, page 27). The non-American (Asian) panelists rated the deep-fried puffed crackers significantly higher for all sensory attributes except texture than the American panelists.

The panel detected no significant differences ($P < 0.05$) in color among treatments (Table 6). This result showed that the combination of fish with beef and chicken was not different in color than the all fish (control) crackers. It appears that cooking reduced differences in color among the treatments.

Significant differences ($P < 0.01$) were revealed in flavor among all five treatments and replicates (Table 6). With the exception of treatment 3, the flavor scores for all treatments were above the slightly desirable flavor level as depicted in Figure 3, page 29. Treatment 3 had the highest flavor score while treatments 1 and 2 were similar in flavor

to treatment 5 (control). Treatments 1, 2 and 4 which had chicken in them are rated lower in flavor by the panelists. With the decrease in percentage of beef the flavor scores tended to decrease (Table 16, Appendix B). Sensory scores for texture revealed that no significant differences ($P < 0.05$) existed among treatments and replicates. However treatment 3 had the highest texture score while treatment 4 received the lowest texture score (Figure 4, page 31). There was significant difference ($P < 0.05$) between replicates.

There was no significant difference ($P < 0.05$) in overall acceptability among all treatments (Table 6, page 27). Treatments 1, 2, 3, 4 and 5 did not differ significantly in overall acceptability score. However, treatment 3 was the most preferred sample as depicted in Figure 5, page 32.

These sensory data revealed that the overall acceptability of fish crackers was more dependent on its flavor than on its texture. It appears that from a sensory standpoint, carp can successfully be added to a snack product at appreciable levels. With a seasoning blend added, much of the flavor difference attributed to carp could be masked.

Data in Table 7, page 38, on Hunter color values showed that the different combination of skeletal muscle tissues did differ significantly ($P < 0.05$) in their effects on the color of deep-fried puffed fish crackers. It seems that cooking reduced the differences in color among the treatments.

Significant differences ($P > 0.05$) was determined for Instron measurements of texture (crispness) for the deep-fried fish crackers (Table 12, page 48). The mean texture for treatment 1 and 3 was much higher compared to treatment 5 (control). The trend generally indicated that treatments with higher percentage of beef tended to require more force to

fragment them. This probably was due to the fact that beef had much higher connective tissue content compared to fish and chicken.

Data from the puffed expansion measurements revealed no significant difference ($P < 0.05$) among treatment and replicates (Figure 13, page 43). However the variation in the expansion values may be due to the different percentage of skeletal muscle tissues. It seemed that treatments which had beef component tended to have better expansion properties due to the presence of gelatin.

Significant differences ($P < 0.001$) were found among treatments for water, protein, fat, ash, fiber and carbohydrate in the raw fish cracker. Significant difference was also revealed among the treatments with the exception of percentage of fiber for the deep-fried crackers. This was probably due to moisture loss and an increased in fat content during frying.

The moisture content of the fried product was lower than that of raw product while the fat content was very much higher. These results were expected since deep-frying tended to cause a relatively high degree of moisture loss with a concomitant uptake of oil.

Coliforms, yeast and mold were not detected in all treatments for both raw and deep-fried products. However, there was bacterial growth in the standard plate agar for both raw and deep-fried product. No consistent trend was apparent in the aerobic plate count among treatments. The low aerobic plate count reflected that the product had good microbial quality (Table 15).

MANUSCRIPT

LITERATURE CITED

LITERATURE CITED

- Anon. 1961. Fish challenges meat on its own grounds - in tuna-links, a meatless hot dog. *Fishing Gazette*. 78(3):14.
- Anon. 1950. Friday franks. *Fishing Gazette*. 67(2):28.
- Anon. 1970. Instron Universal Testing Instrument. Table Model 1130 Operating Instrument Manual 10-1130-1. Instron Corporation, Canton, MA.
- AOAC. 1975. "Official Methods of Analysis." 12th ed. Association of Official Analytical Chemist, Washington, D.C.
- Arimoto, K. 1962. "Fish as Food. Vol. II. The role of marine and fresh-water foods in the Japanese Diet," Academic Press Inc. New York, NY.
- Beach, B. L., Hitchcock, M. J., and Goertz, G. E. 1973. Children accept fish-based school lunch entrees. *Food Prod. Dev.* 7(9):104.
- Beach, E. F., Munks, B., and Robinson, A. 1943. The amino acid composition of animal tissues protein. *J. Biol. Chem.* 148:431.
- Block, R. J., and Bolling, D. 1945. "The Amino Acid Composition of Proteins and Foods," 1st ed. 396 pp. Charles C. Thomas, Springfield, Illinois.
- Borgstrom, G. 1962. "Fish as Food"; Vol. 2, Academic Press, New York, NY.
- Carman, V. D. 1976. Hunting and fishing in West Tennessee. *Tennessee Sportsman*, 8(1):6.
- Carver, J. H. and King, F. J. 1971. Fish scrap offers high quality protein. *Food Eng.* 43(1):75.
- Charley, H. 1970. "Food Science," The Ronald Press Co., New York, NY.
- Connell, J. J. 1970. "Proteins as Human Food: Properties of Fish Proteins," Ed. Lawrie, R. A. p. 200, AVI Publishing Co., Westport, Conn.
- Connell, J. J., and Howgate, P. F. 1959. Studies on the protein of skeletal muscle. 6. Amino acid composition of cod fibrillar proteins. *Biochem. J.* 71:83.
- Del Valle, F. R., and Gonzalez-Inigo, J. L. 1968. A quick-salting process for fish. *J. Food Technol.* 22:1135.

- Duncan, D. G. 1955. Multiple range and multiple F tests. *Bio Metrics*. 11:1.
- Ednan, N. S. 1940. Economics of the carp. U. S. Dept. of Commerce, Bureau, Washing. Vol. 2, No. 12.
- Ellinger, G. M. and Boyne, A. W. 1965. Nutritive properties of fish proteins. *Brit. J. Nutr.* 19:587.
- FAO. 1968. Amino acids contents of foods and biological data on proteins. Rome: F.A.O.
- FAO. 1979. "Yearbook of Fishery Statistics," Vol. 48.
- Feldberg, C. 1969. Extruded starch-based snacks. *Cereal Sci. Today*. 14(6):211.
- Howgate, P. 1977. Aspects of Fish Texture. In "Sensory Properties of Foods," Eds. Birch, G. G., Brennan J. G. and Parker, K. J, p. 249. Applied Science Publishers Ltd. London.
- IFT. 1971. Author's guidelines for I.F.T. research papers reporting sensory evaluation data. *Food Technol.* 25:254.
- Jarvins, D. N. 1939. The humble carp. U. S. Dept. of Commerce, Bureau, Washington, Vol. 1. No. 12.
- Keay, J. N. and Hardy, A. 1978. Fish as Food. I. The fisheries resource and its utilization. *Process Bio.* 13(7):2.
- King, F. J. 1973. Acceptability of main dishes (entrees) based on mixtures of ground beef with ground fish obtained from under-used sources. *J. Milk Food Technol.* 36:504.
- King, F. J, and Carver, J. H. 1970. How to use nearly all the ocean's food. *Commer. Fish. Rev.* 32(12):12.
- King, F. J., Carver, J. H., and Prewitt, R. 1971. Machines for recovery of fish flesh from bones. *Am. Fish Farmer* 2(11):17.
- King, F. J., and Flick, G. J. 1973. Beefish patties. *Marine Fisheries Rev.* 35(7):31-33.
- Korschegen, B. M., Bladwin, R. E., and Russel, W. D. 1978. Acceptance of summer sausages prepared with beef, pork, and turkey combinations. *Food Prod. Devel.* 12(2):84.
- Lachmann, A. 1969. Snacks and fried products. Noyes Development Corporation, London.
- Larmond, A. 1969. Method for sensory evaluation of food. Canada Rept. Agric., Ottawa.

- Martin, R. E. 1976. Mechanically deboned fish flesh. Food Technol. 39(9):64.
- Matz, S. A. 1970. "Snack Food Technology," AVI Publishing Co., Westport, CT.
- McClane, A. J. 1977. "The Encyclopedia of Fish Cookery, Carp," The Ridge Press. New York, NY.
- Melton, S. L., Moyers, R. E., and Playford, C. G. 1979. Lipids extracted from soy products by different procedures. J. Amer. Oil Chem. Soc. 56(4):489.
- Miller, M. 1974. Introducing new products into seafood markets. Marine Fisheries Rev. 36(10).
- Miyauchi, D. M. and Steinberg, M. 1970. Machine separation of edible flesh from fish. Fishery Industrial Res. 6(4):165.
- Montgomery, W. A. 1963. Fish Preservation Inquiries. Fisheries products, Fish Sausage. Fish. Newslett. 22(5):21.
- Namisato, T. 1974. "The Chemistry and Technology of Marine Products Processing," Japan Overseas Corporation Volunteers, Manila, Philippines.
- Offci-Okraku, G. 1974. Trials in the production of fish crackers. Ghana J. Agric. Sci. 7:139.
- Pappas, L. S. 1979. "Fish Cookery International" 101 Productions, San Francisco, CA.
- Patashnik, M., Kudo, G., and Miyauchi, D. 1973. Smooth, white spread from separated fish flesh forms a base for flavored dips, snack items. Food Prod. Devel. 7:82.
- Pottinger, S. R., and Baldwin, W. H. 1940. The content of certain amino acids in the edible portions of fishery products. Proc. Pacific Sci. Congr., Pacific Sci. Assoc. 6th Congr. 3:453.
- Ralph, W. K. 1944. "Chemistry and Industry of Starch," Academic Press Inc., New York, NY.
- Rasekh, J., Kramer, A., and Finch, R. 1970. Objective evaluation of canned tuna sensory quality. J. Food Sci. 35:417.
- Reuter, A. P. 1949. Progress in the production of fish sausage, Fish Res. Board of Canada, Ottawa, Prog. Rept. No. 51:1.
- Saraiva de Coster. 1956. Protein and amino acids in nutrition. Proc. Inter-African Conf. 2.
- Schooners, J. G. 1950. Fish sausages have a future. Prog. Rept. No. 72. Fisheries Res. Board of Canada, Ottawa.

- Scott, W. B. and Crossman, E. J. 1973. Freshwater fisheries of Canada. Bull. 184. Fisheries Res. Board of Canada, Ottawa.
- Siaw, C. L. and Idrus, A. Z. 1979. Application of intermediate technology in the processing of fish crackers in Malaysia. MARDI report.
- Sigler, W. F. 1949. Carp as a protein supplement. Farm and Home Sci. 10(2):10.
- Speck, M. L. (ed). 1976. "Compendrium of the Methods for the Micro-biological Examination of Foods," American Public Health Assoc., Washington, DC.
- Stanley, R. P. 1960. Sea-food in armed forces rations. U. S. Fish and Wildlife Service, U. S. Dep.t of the Interior, Washington, DC, 15(1):1.
- Stansby, M. E. 1953. Composition of certain species of fresh-water fish. I. Introduction: The determination of the variation of composition of fish. Food Research 19:231.
- Tamura, T. 1961. "Fish as Food. Vol. I. Carp Cultivation in Japan," Academic Press Inc., New York, NY.
- Tanikawa, E. 1963. Fish sausage and ham industry in Japan. Advances in Food Research, Vol. 12. Academic Press Inc., New York, NY.
- Taylor, H. F. 1917. The Carp: A valuable food resource. U. S. Comm. Fish and Fisheries; Commissioners Rept., No. 31.
- USDA. 1963. Composition of foods. Agricultural Handbook No. 8, USDA, Washington, DC.
- Veen, A. G. 1953. Fish preservation in Southeast Asia. Advances in Food Research, 4:209.
- Waladt, L. and Kohoe, D. 1959. Starch chemistry for food technologists. Food Technol. 13:104.
- Walford, L. A. 1945. Fishery resources of the USA. U. S. Fish and Wildlife Service, Washington, DC 7:7.
- Wesson, J. B., Lindsay, R. C., and Stuijber, D. C. 1979. Discrimination of fish and seafood quality by consumer populations. J. Food Sci. 44:878.
- Yu, S. Y., Michell, J. R., and Abdullah, A. 1981. Production and acceptability testing of fish crackers ('keropok') prepared by the extrusion method. J. Fd Technol. 16:51.

APPENDICES

APPENDIX A

Name: _____ EVALUATION OF PUFFED FISH CRACKER

Date: _____

Nationality: _____

Do you like fish? Yes ____ No ____

Instructions:

You will be given 5 samples of puffed fish cracker. For each sample presented evaluate for color, texture (e.g. crispiness) flavor and overall acceptability. For overall acceptability, take into consideration all the attributes e.g. color, crispiness, flavor etc. Sniff and taste the sample and indicate your feeling about the sample using the scales below designed for each attribute.

Please rinse your mouth with water between samples. Cups are provided for expectoration. An honest expression of your feeling will be valuable to this research

Sample Code	Color	Texture	Flavor	Overall Acceptability	Specify which attributes you like or dislike and why. Comments.

KEY:

Color	Texture	Flavor	Overall Acceptability
8. Extremely desirable	8. Extremely desirable	8. Extremely desirable	8. Extremely desirable
7. Very desirable	7. Very desirable	7. Very desirable	7. Very desirable
6. Moderately desirable	6. Moderately desirable	6. Moderately desirable	6. Moderately desirable
5. Slightly desirable	5. Slightly desirable	5. Slightly desirable	5. Slightly desirable
4. Slightly undesirable	4. Slightly undesirable	4. Slightly undesirable	4. Slightly undesirable
3. Moderately undesirable	3. Moderately undesirable	3. Moderately undesirable	3. Moderately undesirable
2. Very undesirable	2. Very undesirable	2. Very undesirable	2. Very undesirable
1. Extremely undesirable	1. Extremely undesirable	1. Extremely undesirable	1. Extremely undesirable

APPENDIX B

Table 16. Means^a for the Effect of Different Combinations of Skeletal Muscle Tissues on Sensory Attributes of Deep-fried Crackers

Treatment ^b	Color	Texture	Flavor	Overall Acceptability
-----score ^c -----				
1 (20:10:10)	5.64 ^d	6.00 ^d	5.79 ^d	4.65 ^d
2 (30:5:5)	5.72 ^d	6.02 ^d	5.78 ^d	5.96 ^d
3 (30:10:0)	5.45 ^d	6.40 ^d	6.29 ^d	6.17 ^d
4 (40:0:10)	5.45 ^d	5.88 ^d	5.08 ^e	5.00 ^d
5 (40:0:0)	5.76 ^d	6.15 ^d	5.82 ^d	5.69 ^d

^aMeans of four observations; means in each column followed by the same letter are not significantly different ($P < 0.05$).

^bNumbers in parentheses represent percentage of fish, beef and chicken, respectively.

^cColor, texture, flavor and overall acceptability scored on 8 point scale; 8 = extremely desirable; 1 = extremely undesirable.

APPENDIX C

Table 17. Taste Panel Scores^a Assigned by American and non-American Panels to Deep-fried Crackers

Variable	Non-American	American
Color	5.65 ^b	5.55 ^b
Texture	5.88 ^c	6.30 ^b
Flavor	6.00 ^b	5.50 ^c
Overall Acceptability	6.03 ^b	5.35 ^c

^a Means of 4 observations. Means in each row followed by the same letter are not significantly different ($P < 0.05$).

APPENDIX D

Table 18. Means for the Effect of Different Combinations of Skeletal Muscle Tissues on Instron (crispness) Values of Deep-fried Crackers

Treatment ^a	Mean force ^b kg
1 (20:10:10)	1.64 ^c
2 (30:15:5)	0.95 ^e
3 (30:10:0)	1.37 ^d
4 (30:0:10)	0.83 ^f
5 (40:0:0)	0.74 ^f

^aTreatments are combination of fish, beef and chicken; see Table 16, page 67, for explanation.

^bMeans of six observations. Means in a column followed by the same letter are not significantly different ($P < 0.05$).

APPENDIX E

Table 19. Means for the Effect of Different Combinations of Skeletal Muscle Tissues on Expansion of Deep-fried Crackers

Treatment ^a	Expansion ^b
	----%----
1 (20:10:10)	99.89 ^e
2 (30:5:5)	103.76 ^d
3 (30:10:0)	107.98 ^c
4 (30:0:10)	78.03 ^f
5 (40:0:0)	88.65 ^g

^aSee Table 16, page 67, for explanation.

^bMeans of three observations; means in each column followed by the same letter are not significantly different ($P < 0.05$).

APPENDIX F

Table 20. Mean Values^a for Percentage of Moisture, Protein, Fat, Ash, Fiber and Carbohydrate of Raw Crackers

Treatment ^b	Percent					
	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate ^c
1 (20:10:10)	12.13 ^g	10.43 ^g	1.84 ^d	4.49 ^c	0.23 ^d	70.88 ^{de}
2 (30:5:5)	12.78 ^e	10.65 ^{de}	1.47 ^{fg}	4.57 ^e	0.27 ^e	70.26 ^e
3 (30:10:0)	12.93 ^d	10.73 ^d	1.40 ^g	4.79 ^d	0.29 ^{de}	69.86 ^f
4 (30:0:10)	12.34 ^f	10.51 ^f	1.61 ^e	4.81 ^d	0.28 ^e	70.45 ^d
5 (40:0:0)	12.45 ^f	10.58 ^{ef}	1.52 ^d	4.58 ^e	0.31 ^d	70.56 ^d

^a Means of four determinations; means in each column followed by the same letter are not significantly different ($P < 0.05$).

^b See Table 16, page 67, for explanation.

^c Means calculated by difference.

APPENDIX G

Table 21. Mean Values^a for Percentage of Moisture, Protein, Fat, Ash, Fiber and Carbohydrate of Deep-fried Crackers

Treatment ^b	Percent					
	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate ^c
1 (20:10:10)	3.34 ^d	10.84 ^e	31.64 ^g	4.56 ^e	0.22 ^h	49.44 ^d
2 (30:5:5)	3.29 ^f	10.73 ^g	30.77 ^h	4.57 ^e	0.25 ^g	50.33 ^d
3 (30:10:0)	3.22 ^h	10.96 ^d	35.25 ^d	4.77 ^d	0.27 ^f	46.81 ^e
4 (30:0:10)	3.31 ^e	10.66 ^h	32.75 ^f	4.80 ^d	0.28 ^e	48.13 ^d
5 (40:0:0)	3.28 ^g	10.81 ^f	33.80 ^e	4.57 ^e	0.29 ^d	47.25 ^f

^aMeans of four determinations; means in each column followed by the same letter are not significantly different ($P < 0.05$).

^bSee Table 16, page 67, for explanation.

^cMeans calculated by difference.

VITA

Zaharah Wahid was born in Melaka, Malaysia, on October 25, 1954. She graduated from Cedar Girls' High School in 1971. Upon graduating from the Mara Institute of Technology, Shah Alam, Malaysia in June, 1977, she worked as a technical assistant in the Defense Research Center, Kuala Lumpur, Malaysia. In June 1979, she was offered a scholarship from the Malaysian Government to pursue further studies.

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