PREFLAVORING LIVE CHANNEL CATFISH

by

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INTRODUCTION

Economists predict seeing channel catfish production increasing before the end of the century. As this production expands, a responsive marketing system needs to be developed and expanded. This expansion should focus on the tastes and preferences of the consumer (Nichols and Lacewell, 1971). Currently consumer demand for catfish has been in the institutional market; now the home market needs to be developed (Greenfield, 1971). Greenfield further states that catfish is a bland-flavored fish and it does potentially have a broader appeal than in its traditional southern-midwestern market. However, it has to sell as a premium fish; selling to those people who think catfish is worth more than codfish or unidentified fish block product. Farm-raised catfish cannot afford to be equal in quality to other products--it must be better (Ayers, 1971). And it must be better in flavor, through not only production but post-harvest treatment as well.

Previous work at Kansas State University (KSU) with channel catfish has shown that fish flavor is influenced by the pond conditions and the fish diet (Maligalig et al., 1973). Subsequent work has shown that odor and cooked flavor of the fish kept in tanks containing solutions of odoriferous compounds such as 2-pentanone and dimethyl sulfide (Maligalig, 1974) or flavoring materials such as onion juice or liquid smoke flavoring are reminiscent of that added compound. Reese (1972), citing KSU work, states that the chemical compound or the flavoring material induces flavors that survive a plain cooking method, steaming.

Preliminary probes at KSU also indicated the feasibility of "preflavoring" fish before processing by holding them live in water containing a desirable flavorant. One desirable flavorant could be a liquid smoke concentrate if it

would meet two criteria: to yield a lightly smoke-flavored catfish that may be prepared by different cooking methods, and to retain its identity during storage of the preflavored catfish. Purpose of this study was to assess through sensory evaluation the retention and flavor effects of a commercially available smoke-type preflavoring in channel catfish held in refrigerated and frozen storage before cooking. The underlying objective of the preflavoring approach was not to mask undesirable flavor but rather to present an excellent source of protein along with a desirable flavor.

The three cooking methods selected for use were steaming, a plain method utilizing the microwave oven; pan-frying a breaded dressed fish (the conventional home method); and deep-fat frying a breaded dressed fish (the conventional restaurant method).

Examination of the fish samples was conducted with a four-member flavor panel trained in descriptive flavor analysis and oriented to channel catfish flavor.

REVIEW OF LITERATURE

Smoke-flavored Fish

No reports of using liquid smoke to flavor live fish were found. Preserving fish by smoke treatment is a time honored process resulting in well accepted products. Recently Boggess et al. (1973), in a study of processing smoked channel catfish, found by sensory panel evaluation that smoked catfish compared favorably in acceptability with smoked haddock and chubs. They commented that catfish is a popular menu item in the southern parts of the United States and is usually prepared by deep-fat or pan-frying rather than broiling or baking. Vaisey et al. (1971) wrote that as consumers seek more variety in food textures and flavors, interest in smoked fish has been renewed.

Lightly smoked products, with the smoky and salty tastes well-blended, can enjoy appreciable status among meat sources. Of conventional smoking, the chief purpose is to impart flavor. In recent years the trend toward ever lighter and milder smoked products has continued with the result that smoke serves more as a condiment than preservative (Cutting, 1962).

Smoking has also been used to mask fish off-flavors. Iredale and Rigby (1972) investigated the efficacy of two smoking processes in masking muddy odor and flavor in rainbow trout: one process resulted in a high concentration of smoke; the other, a concentration present in conventionally smoked, dressed fish. Muddiness was masked by both processes, and effectiveness appeared to be related to intensity of smokiness.

Fish Flavor

Fish flavor has not been studied as much as other food flavors. Fish are perishable and therefore difficult to work with. Because of perishability, they are rarely eaten in a truly fresh state. Most consumers eat fish after it has passed through some kind of icing, refrigeration, heat processing, drying or freezing.

Fish have little or no fish odor as taken from the water (Potter, 1973). Yet virtually all fish and fish products from the market place have a fishy odor which is evidence of some deterioration. Two factors may be involved: bacteria and phospholipids.

Although the flesh of healthy live fish is sterile, surface slime and digestive tracts of live fish harbor large numbers of many types of bacteria. When the fish are killed the bacteria rapidly attack all tissues. Moreover, since these bacteria are accustomed to rather low water temperatures, they continue to grow even under refrigeration. When caught, fish struggle and use up most of the muscle glycogen so that there is little post-mortem production

of lactic acid to retard bacterial growth.

Associated with the fat of fish are phospholipids rich in trimethylamine (TMA) precursors. TMA, which has a strong old-fish odor, is split from phospholipids by bacteria and fish enzymes. The offensiveness of the old-fish odor from TMA is augmented by odorous products of fat degradation, such as oxidized and rancid characteristics.

Jones (1961) indicates sources of flavor changes as time span between point of capture and processing and actual consumption, variations in treatment, and inherent differences between species. Other factors affecting the fish flavor are feed, age, sexual development, season and varieties within species (Tarr, 1966).

Many types of odors and flavors occur in fish. Descriptive material on seafish flavor, developed by Shewan and co-workers (1953), became the basis for their taste panel evaluations of quality. In describing progressively deteriorating fish, the loss of raw odors followed the disappearance of "fresh, seaweedy odors". This neutral odor preceded odors of progressive deterioration until "nauseating, putrid, faecal odors" were reported for spoiled fish. Further work showed that many components of the raw fish odor influenced the overall flavor of the cooked fish.

Stansby and Jellinek (1964) compiled terminology for commonly encountered flavors and odors in fish and fishery products. Their sequence from fresh to spoilage was summarized as follows: natural species odor and flavor; green; sweet, amine-like; early oxidation; and putrid or spoiled. Earlier, Stansby (1962) had pointed to the ambiguity of the term "fishy", which has been used especially for dairy and poultry products.

Effects of Freezing and Freezer Storage on Fish and Fish Flavor

Fish commonly is preserved by freezing, which can bring about changes in

odor, flavor and texture. Such changes are dependent upon conditions of the raw material and the handling and processing techniques employed before, during and after freezing. Freezing can result in excellent or poor quality, depending upon how quickly the freezing is done after the fish is caught and upon freezing and storage temperature (Potter, 1973). He recommends gutting and freezing within two hours. Burgess et al. (1967) emphasize storage temperature and initial freshness; "stale fish spoils more rapidly during cold storage".

When fish die, chemical and physical changes occur that affect quality in the fresh state and their suitability for subsequent freezing and frozen storage (Slavin, 1968). Before freezing, naturally occurring enzymes in fish muscle cause autolysis. Without chill storage before freezing, flavor loss may occur through autolytic cleavage of flavorous compounds (Jones, 1969).

Freezing causes the free water present in muscle to form ice crystals, bringing about substantial chemical and physical changes. Zaitsev (1965) states that as water crystallizes, salt levels in the remaining moisture associated with proteins in the tissues become progressively concentrated, lowering the freezing point of the tissues. Maximum ice crystal formation occurs between -0.8 and -5° C, resulting in a very slow freezing rate at this point (Dyer and Dingle, 1961). After this point, moisture in the cells is lessened, and denaturation of proteins may occur.

Protein denaturation has been related to the tough texture of frozen fish and fishery products. Connell (1969) cited Reay in noting that textural deterioration and protein denaturation were associated with decreased protein extractability or solubility in frozen-stored fish. Dyer and Fraser (1959) proposed that the loss of protein solubility could be attributed to cleavage

of the lipo-protein complex followed by lipid hydrolysis and/or formation of insoluble complexes of free fatty acids and proteins. Anderson and Steinberg (1964) and Bull and Breese's work (1967) support the theory.

Rapid freezing of fish results in smaller ice crystals than are formed by slow freezing. Large ice crystals may rupture the cells, causing increased drip formation from thawing (Borgstrom, 1968). Greater protein denaturation also was found in slow-frozen fish (Reay cited by Dyer, 1951). The period of maximum ice crystal formation was passed more rapidly during rapid-freezing than during slow-freezing. Love (1958, 1962), however, found that proteins of fish frozen at intermediate rates were less extractable than when fish were frozen at rapid or slow rates. He suggested that relative toughness should always be evaluated by a taste panel, because textural characteristics of frozen fish may be affected by factors other than protein denaturation (1956).

Rigor Mortis in Fish

The process of rigor mortis has been described as an increasing toughness and resiliency of fish muscle which spontaneously ends. After resolution the muscles soften gradually until they become flabby and inedible unless processed forthwith (Zaitsev, 1965). Love (1968) has attributed this process to the decomposition of energy-supplying organic acids in muscle. When a certain critical level is reached, the muscle fully contracts. In this stage, rigor mortis, the fish muscle is tough and the cells are dry. After resolution of rigor mortis, the muscles relax and the tissues become moist again.

The duration and intensity of the post-mortem and rigor mortis stages are variable and dependent upon the conditions. The start and duration of rigor mortis depend upon the species and method of catch. It sets in more quickly in an exhausted than in a strong or vigorous fish. The later rigor mortis begins, the longer it lasts (Zaitsev, 1965).

Zaitsev found that the cause of rigor mortis is a change in the pH attributed to an accumulation of lactic and phosphoric acids in the blood. A swelling of the muscle tissue proteins has been correlated with the pH change, as well as a subsequent coagulation of the muscle plasm proteins, myosin and myogen, containing insoluble myosin fibrin and myogen fibrin.

Various workers have suggested different optimum times for the freezing of fish. Nikkila and Linko (1954) observed that freezing during rigor mortis rendered proteins more prone to denaturation during subsequent thawing than fish frozen after the resolution of rigor. They suggested that fish be frozen after the resolution of rigor. Contrary to this, Love (1962) found fish frozen before the onset of rigor suffered less protein damage during subsequent storage. Connell (1964) noted that differences in protein extractability between pre- and post-rigor frozen fish may exist before storage; storage may induce no further effects. Considering these findings, Banks (1965) suggested more research on controlling the onset and duration of rigor in fish.

It appears, however, that control should begin with the method of catch and handling conditions prior to processing. Boggess et al. (1971) reported that storage behavior is influenced substantially by characteristics of fresh fish and practices employed in processing and handling the product.

Factors That Influence the Flavor of Freshwater Fish

Water source. Baldwin et al. (1961) studied the flavor of three species of fish (walleye, northern pike and carp) from four freshwater sources: a cold, deep lake; a shallow, mixed water lake; and flowages above and below industrial plant effluents. Sampling was made during four seasons of the year. Fish from below the effluent had the lowest scores in flavor while highest scores were given to fish from lakes. Among species studied, walleye had highest scores while carp had lowest scores. For carp, descriptive terms for

aroma and flavor included "musty" and "fishy".

Baldwin and co-workers (1970) conducted further work on the palatability of carp, flathead catfish and freshwater drum from different sites on the Mississippi River. At certain times of the year, flavors of those three species were affected adversely by river pollution. Extent of flavor damage was related to species and proximity to pollution source. Fish from sites close to the source were given lower flavor scores. Freshwater drum was more susceptible to environmental flavor changes than flathead catfish or carp. Fish aroma, to a lesser degree, also was affected adversely by polluted water. Scores for aroma of polluted water were not significantly correlated with palatability scores. It was noted the judges needed additional experience in determining aroma of polluted water.

Size. In regard to size and body area, Baldwin et al. (1961) found no correlation with flavor scores. For northern pike, larger fish, within a source for a season, scored higher than smaller fish. Within a season and location for carp, however, smaller fish scored higher in aroma and flavor than larger ones. For walleye, no correlations were found.

A further study by Baldwin and co-workers (1969) was on the relationship of size and body area to the aroma and flavor in three freshwater fish: carp, flathead catfish and freshwater drum. Preference for large or small fish was not consistent. Flavor and aroma of small carp (3 lb 1 oz) was less preferred than large carp (8 lb 5 oz), contradicting previous findings for Baldwin et al. (1961). Higher flavor scores were given to small flathead catfish (1 lb 4 oz) than to large flathead catfish (23 lb 3 oz). Less clear-cut differences were found for freshwater drum. The same study also investigated different sites of fish (anterior, middle and posterior) for flavor differences. No significant differences were found for each sex and species except anterior portions of

male carp were scored significantly higher in aroma than the posterior. The researchers suggested further study of positional differences in flavor and aroma by conducted in relation to sex and species.

Maligalig et al. (1973) found in channel catfish slight flavor differences in different sites of the same cooked fish. Anterior portions (belly and top) were similar, but different from the posterior portions which usually had more total flavor. Dorsal and ventral sides of the tail had similar flavors.

Preparation procedure. In a study on the relationship between preparation procedure and flavor and aroma, Baldwin et al. (1962) found no consistent trend for the influence of skin and bone. In a comparison between frying and baking, fried fish scored significantly higher than baked samples. It was concluded fried fish seemed more familiar and, therefore, more acceptable. However, unusual flavor characteristics were present irrespective of cooking method.

The cooking of fish has received little consideration from scientific workers. The number of basically different methods of cooking fish are few and relatively simple. Baker (1943) noted fish are easy to cook; no great skill is required to produce a palatable, cooked product although great skill may be exercised in enhancing its flavor and succulence. Steaming is often used, for odors can be distinguished more readily by this method (Dyer et al., 1964). Baldwin and co-workers (1962) surmised frying is the conventional method and Connell and Howgate (1971) noted frying for presentation in a restaurant is a pleasant way of serving fish. Frying is preferred over other cookery methods such as baking or steaming for several reasons. Frying is believed to mask "off-flavors" (Connell and Howgate, 1971); frying covers many of the deficiencies of cold storage (Dyer et al., 1964); and, the batter has a flavor influence in fish by acting as a flavor seal to arrest the escape of delicate flavors (Rietz and Wanderstock, 1965).

Deep-fat fried foods in restaurants may be popular because few consumers can successfully reproduce them at home (Thorner, 1973). That quality of a golden brown and crisp crust on deep-fat fried foods is appealing and flavorful particularly for seafoods.

EXPERIMENTAL PROCEDURE

Materials and Methods

Two-year old channel catfish were stocked in two plastic-lined ponds described by Tiemeier and Deyoe (1973) in May, 1974, and given Z-58 feed (Table 9, Appendix).

Water was carefully monitored for development of off-odors and algae growth. On July 16 after a spell of hot weather, off-odor in the ponds was observed. To prevent off-flavor development, the pond was drained, fish removed, pond swept clean and fish restocked after filling with fresh water. On July 23, a test fish did not have off-flavor.

Fish were seined from the ponds as needed, one day beforehand and conditioned by holding them live without feed in a 150 gallon metal tank with an aerator and filled with water of 58 to 60° F. Gradual conditioning allowed the fish to become acclimatized to the cooler water and to recover from the stress of seining. Fish were conditioned to prevent shock from their transfer from the warm pond water to the cooler water available in Bushnell Hall laboratories.

Fish were then transported to Bushnell Hall, KSU, and held without feed at least two days in 150 gallon holding tanks with aerators, filled with dechlorinated tap water at 58 to 61° F. Grizzell et al. (1969) suggested not feeding fish the day before harvest because the digestive tract of fish should be empty when they are handled or hauled in non-aerated water.

Liquid smoke had been chosen as the preflavoring because smoke-flavored

fish are traditionally acceptable to consumers and are commercially available. The concentrate is a hardwood smoke mixture, is stable to refrigeration and freezing, and is readily mixable with water (Table 10, Appendix).

Fish, (no more than 8 per aquarium), were treated or preflavored by holding them live for 30 minutes in an aerated aquarium containing 20 gallons of dechlorinated tap water and 3 concentrations of a given weight of the flavorant. This study used 10 g to produce a 125 parts per million (ppm) solution, 19 g to produce 250 ppm and 38 g to produce 500 ppm (Table 11, Appendix). Maligalig (1974) found that 30 minutes in a tank of 500 ppm yielded a moderate to strong smoky flavor.

Immediately after preflavoring fish were dressed (killed by stunning, skinned, beheaded and eviscerated). All dressed fish were weighed (see Tables 2 - 8), labelled and wrapped in heavy duty aluminum foil. Fish were either stored in refrigerated or frozen storage before cooking by steaming, pan-frying, or deep-fat frying.

Fish not to be frozen were transported on ice to the food research laboratory at Justin Hall, KSU, where they were stored in a home refrigerator maintained at 0 to 6° C (32 to 40° F) and used exclusively for this project for 20 weeks.

Fish for freezing were transported on ice to the meat science laboratory, Weber Hall, KSU. The foil-wrapped fish were vacuum-sealed in 3 mm Iolon (Dupont) film and blast frozen within 2 hours after death. They were stored in a walk-in freezer maintained at -20° C (4° F) in the meat science laboratory.

One day prior to flavor examination, freezer stored fish were transported in a Styrofoam™ carrier to Justin Hall. Samples to be fried were allowed to thaw overnight in the refrigerator; samples to be steamed were placed in the freezing compartment of the same refrigerator. Fish were rinsed again in

distilled deionized water after thawing to remove bloody exudate.

Cooking Methods

Control fish were steamed in covered Pyrex^{TM} (1 $\frac{1}{2}$ qt casseroles) in an Amana Radarange (type approval oven ME 605, Model RR 2.) Steaming enabled the odors to be distinguished more readily as found by Dyer et al. (1964). Cooking time was roughly determined according to the dressed weight:

Less than 150 g	4.0 minutes
150 - 175 g	4.5 minutes
175 - 200 g	5.0 minutes
200 - 225 g	5.5 minutes
225 - 275 g	6.0 minutes
275 - 350 g	6.5 minutes
350 - 425 g	7.0 minutes

Frozen fish to be steamed were first given an additional 45 seconds per side. Normally fish were steamed in the casserole without turning.

For the pan-fried fish the whole dressed fish were breaded and battered (Table 12, Appendix). They were fried in a cast-iron skillet (9" diameter) over a thermostatically controlled flame in 200 g of $^{(K)}$Wesson$^{(R)}$Oil, preheated to 190° C (375° F). Weight again was used to determine the frying time based on recommendations of the A.H.E.A. Handbook of Food Preparation (1971):

Less than 225 g	20 minutes
225 - 350 g	25 minutes
350 - 425 g	30 minutes

Fish were turned halfway through the cooking time to brown both sides.

For deep-fat frying the same procedure for breading and battering was followed as for pan-frying (Table 12, Appendix). Fish were lowered into a deep-fat fryer containing 2000 g of unused preheated $^{(K)}$Wesson$^{(R)}$ Oil. The

same frying temperature and times as for pan-frying were used. Summary of examinations is given in Table 1 while the experimental schedule is detailed in Table 13, Appendix.

Table 1 - Summary of examinations

A. Refrigerated Storage Samples

Days in Refrigerator	Smoke ppm	No. of Replications S[a]	P	D
0-1	125	2	2	0
	250	3	3	2
	500	4	4	0
3	125	2	2	0
	250	2	2	0
	500	1	1	0

B. Frozen Storage Samples

Weeks in Freezer	Smoke ppm	No. of Replications S[a]	P	D
2	0	3	3	1
	125	1	1	0
	250	1	1	1
	500	1	1	0
6	0	3	3	1
	125	1	1	0
	250	1	1	1
	500	1	1	0
8+	0	3	3	0
	125	1	1	0
	250	1	1	0
	500	1	1	0

[a]S - Steamed; P - Pan-fried; D - Deep-fat fried.

Flavor Examinations

Flavor examinations included orientation sessions to (1) develop standard techniques to examine samples; (2) acquaint the panel with channel catfish flavor; and (3) determine terminology to describe the flavor.

Standard techniques were developed for examining steamed fish and fried fish. The flavor examinations were conducted by the author, the project leader and two other trained tasters in a quiet, well-lighted, and relatively odor-free laboratory.

Panel members used the *flavor profile method*. This method involves an analysis of aroma, flavor by mouth, including feeling sensations when food substances are taken into the mouth and swallowed and aftertaste. It also focuses on the whole flavor of the product, putting into perspective all the flavor components of the sample product.

The profile method includes five basic concepts: (1) perceptible aroma and flavor characteristics; (2) their respective intensities; (3) order in which the characteristics are perceived; (4) aftertaste; and (5) overall impressions of the aroma and flavor. Within the first concept of the aroma and flavor the panel members are trained to use the same descriptive words for like factors.

Intensity denotes the strength of the aroma or flavor characteristics. Since the inception of the *flavor profile method*, intensity has been rated as:

0 not present

)(just recognizable or threshold

1 slight

2 moderate

3 strong (Caul, 1957).

This panel did not use "0" as they were not looking for any absence of flavor or aroma; they did use "$\frac{1}{2}$" to show that something was present above recognition threshold. The symbols "+" and "-" were sometimes added to the intensity rating for comparison with that session's first sample or to indicate a range. For instance, 1+ would indicate a level between 1 and 2, but closer to 1.

The order in which factors, notes or characteristics are perceived can play an important role in the flavor of a food. It could be undesirable to have an unpleasant odor or flavor be first or last in a product. This concept is considered in a profile by listing the notes in chronological order. For this study, notes were recorded by the panel in the order perceived; however, to facilitate data interpretation all tables list categories of notes not necessarily in their perceived order.

In some instances, there may be some lingering flavor after swallowing. It could be important to determine if the aftertaste is pleasant or not. Ordinarily an intensity rating is not assigned to aftertaste. For this study aftertaste and duration of aftertaste were observed.

The overall (including everything) impression is defined as amplitude which is a parameter of both aroma and flavor. This study did not employ the term as such; however, the term "seasoned" was applied late in the program especially to freezer stored, fried fish.

The panel was divided into pairs. Each pair was given a cooked fish to individually examine first for the aroma, then for the flavor. All panelists sniffed their sample as it was served, writing their findings on blank panel sheets; then examined flavor. For flavor examinations panelists ate a sample approximately $\frac{1}{2}$ by $\frac{1}{2}$ in, recording flavor factors and then repeating the procedure several times. Deionized, distilled water at room temperature was used as a mouth rinse. For two samples of the same treatment, the panel rested 10 minutes, then exchanged samples so that each sample was examined by the full panel, following the same procedure. This procedure was followed when control and treated fish were examined at the same session. Later in the study only 2 persons were available to examine the frozen stored fish and experimental probes on the deep-fat fried fish.

For the steamed samples, each panelist sniffed the aroma emanating from the partially uncovered casserole 2 or 3 times. The cover was replaced for a short while between times.

For the flavor examination, one member of a pair of panelists scraped off the silvery subdermal layer covering the outer surface of the fish, separated that whole side from the skeleton, and served the other taster(s) small lateral sections, taken midway between the anterior and posterior ends. Heated china plates and warmed stainless steel flatware were used. Samples were cut from dorsal to ventral, approximately $\frac{1}{2}$ to $\frac{1}{2}$ in wide.

For the fried samples, one fish was placed on a heated china plate with first fried surface up. Panelists sniffed this top side; then the fish was turned over and bottom side was sniffed. The fish was flipped over a second time so that the original side was up and then was laid open after a sharp knife had run the length of the backbone. Samples for tasting were taken from the same area as for steaming. These same procedures were followed for the deep-fat fried fish.

For the frozen fish, untreated fish were examined separately as controls for preflavored fish. The untreated fish served as an everpresent reference for channel catfish flavor and could indicate if any inferior characteristics such as earthy, muddy, or old-fish flavor were present. The panelists were not told beforehand which fish was the control, although usually they could deduce this information from their findings.

Fish under refrigeration were examined at two storage periods: (1) considered market fresh, that is, 0-1 day in refrigerated storage; and (2) edible although not fresh, 3 days. Fisk kept in frozen storage were examined at the end of approximately 2 weeks $\pm$ 2 days, 6 weeks $\pm$ 2 days, and periods between 8 to 10 weeks $\pm$ 2 days.

Panel members became acquainted with catfish flavor by examining fresh channel catfish. Later they examined smoke-flavored catfish to become familiar with the treated fish. After closed sessions in which each panel member recorded her aroma and flavor findings, an open session was conducted. Each panel member reported her findings and discussion followed until agreement was reached. Terminology which resulted incorporated that of Maligalig et al. (1973) and some new terms:

Cornmeal: having the aromatic of the cereal grain and often the mouthfeel of "grittiness".

Dry tongue: a feeling factor described as dryness of the tongue; often found in the smoky flavor fish or in aftertaste.

Earthy: a damp-earth aromatic related to muddy.

Fish identity (fish id): recognizable fish character in contrast to e.g., poultry or meat.

Fish: There are several distinctions of the characteristic. They include fresh fish (from fresh not salt water) and old which implies an old note related to trimethylamine. In between are neutral, a quality neither old nor fresh; and stale, a lesser quality that is not yet old.

Flaky: for cooked fish, the state at which the muscle tissue comes off in flat, thin layers.

Fried: an impression of browned batter cooked in oil.

Meaty: a note characteristic of flesh food, having no fish or poultry connotation; also includes brothy: the aroma and flavor similar to stew.

Mouth satisfying (MS): a sensation of having eaten but without any particular lingering flavor. It may be similar to the sensation received from monosodium glutamate.

Note: perceptible aroma or flavor factor.

Oily: the aromatic of heated oil.

Poultry: reminiscent of stewed poultry especially chicken.

Pond water: note reminiscent of fairly still water with some vegetation growing around it; sometimes specified as grassy pond, green water, and old pond water.

Salty: a basic taste factor associated with sodium chloride and the juices of steamed channel catfish.

Seasoned: a blended or full flavor especially in comparison to the control.

Smoky: a note reminiscent of fresh smoke from a wood fire.

Sticky teeth: a feeling factor as from eating tacky food, and having the back teeth adhere slightly.

Sweet: a basic taste factor and odor note associated with good quality channel catfish.

Sweet feel: afterfeel suggesting sweetness below taste threshold.

Woody: a note reminiscent of a dead campfire.

Woodsy-grassy: a note reminiscent of a forest or vegetation; sometimes specified as woodsy-vegetation or sweet green. Perhaps also related is apple-y, having the note reminiscent of the fruit.

RESULTS AND DISCUSSION

Orientation Sessions on Steamed Channel Catfish

Through orientation sessions the trained panel described the aroma of fresh channel catfish, steamed, as having recognizable fish identity plus freshwater fish and sweet characters. The flavor presented the same aromatic notes with just recognizable sweet and salty tastes and occasional indications of meaty and poultry character notes (Table 2). Aftertaste was usually described as mouth satisfying. Preflavored fresh fish, steamed, readily exhibited the added smoky character in aroma, flavor and aftertaste.

Steamed Fish from Refrigerated Storage:

Preflavored fish refrigerated 0-1 day before steaming all had some fresh fish and smoky aroma and flavor (Table 3). The intensity of smoky aroma and flavor for fish preflavored with the 3 concentrations of 125 ppm, 250 ppm and 500 ppm was similar. Smoky was reported in the aftertaste when the smoky note in flavor had been found at an upper level of the slight intensity range; vide

Table 2 - Profiles of steamed and pan-fried fish from refrigerated storage; orientation sessions

	Steamed 1 day						Pan-fried 1 day					
Concentration (ppm)	0				250		0				250	
Dressed weight (g)	179	217	172	210	233	259	218	263	222	250	231	199
Aroma:												
Fish id		)([a]	)(	)(		)(	)(	)(	)(	)(	)(	)(
Fish: fresh	1	1	1	1-	)(	1	)(+	1-				
Sweet	1	)(	1	1-						1		
Meaty									1-	1-		
Fried							1	1+	1	1	1	1
Oily									1			
Cornmeal							1	1	1	1	1	1
Smoky: fresh					1+	1-					1+	1
Flavor:												
Fish id	)(	)(	)(	)(	)(							)(
Fish: fresh	1	1	1	1-	1-	1	1-	1-	1	1-	1-	
Sweet	1	)(+	)(	)(+	)(+	1	1	1	1	1	1	1
Salty	)(	)(	)(	)(	)(	)(	)(	)(	)(	)(	)(	)(
Meaty	1		1						1			
Poultry	1					½				½		
Fried							1	1-	1-	1-	1-	1
Cornmeal							1	1		1	1	1
Smoky: fresh					2	1-					1	1
Aftertaste:												
MS		x	x		x	x		x		x	x	x
Meaty												
Sweet feel												
Smoky					x	x					x	x

[a]Key to symbols: p. 48.

Table 3 - Profiles of preflavored steamed fish from refrigerated storage

	Steamed													
	0-1 day									3 days				
Concentration (ppm)	125		250			500				125		250		500
Dressed weight (g)	159	131	218	221	170	262	198	144	160	221	196	218	192	211
Aroma:														
Fish id	1[a]				½				1	1-	)(			1
Fish: fresh		)(	1	1			1-	1-		1		)(	½	
Sweet	)(		1			1				1		1		
Meaty		)(									1	1	1-	
Smoky: fresh	1	)(	1+	1+	1+	1+	1+	1-	1+	1	)(+	1+	1	1
Flavor:														
Fish id						½	1	)(	)(	1	)(			1+
Fish: fresh	)(	)(		1	1	1-						1-	1-	
Sweet		)(	1			)(		1	1			½		)(
Salty	)(	)(				)(		)(			)(	)(	)(	)(
Meaty		1	1			1	)(	2		)(	1	)(		)(
Poultry												1-	½	
Smoky: fresh	1	)(	1	1+	1	1+	1+	1	½	1	)(	1	1	2
Aftertaste:														
MS		x			x						x			
Meaty			x		x	x	x	x						
Sweet feel										x		x	x	
Smoky				x		x	x	x				x		x

[a]Key to symbols: p. 48.

500 ppm. In the flavor, only fish identity was perceived at 500 ppm while at the 2 lower concentrations freshwater fish character was found.

Preflavored fish refrigerated 3 days had similar aroma and flavor notes to those refrigerated 0-1 day, so the smoky flavoring endured for the 3 day storage period and fish notes did not change in their quality.

Orientation Sessions on Pan-fried Channel Catfish

Orientation sessions, conducted on fresh channel catfish refrigerated for 0-1 day before being pan-fried, highlighted differences attributable to cooking method (Table 2). Pan-frying breaded fish provided character notes in aroma and flavor described as fried and cornmeal. Those notes dominated the freshwater fish and sweet aromatics in aroma and the fish identity in flavor. They probably contributed to sweet taste as well. Fresh fish preflavored at 250 ppm and refrigerated and prepared like the controls, were recognizably smoky in aroma and flavor; otherwise, they were similar to controls.

The aroma reported for pan-fried fish and deep-fat fried fish (q.v.) was observed in two stages: from the intact fish which emitted fried, oily and cornmeal notes; and after the fish had been opened, when other notes could be detected.

Pan-fried Fish from Refrigerated Storage

In the aromas of pan-fried fish preflavored at the 3 levels and refrigerated for 0-1 day (Table 4) the fish identity characteristics were considerably less noticeable than those of the orientation controls. The oily note redolent of frying oil was more prominent. As the concentration of smoke preflavoring increased, the smoky note increased, although none was stronger than slight. There was some indication that the added smoke reduced the strength of the cornmeal aromatic while leaving the fried character intact.

Flavor intensity of the smoky note paralleled the preflavoring concentra-

Table 4 - Profiles of preflavored pan-fried fish from refrigerated storage

	Pan-fried													
	0-1 day									3 days				
Concentration (ppm)	125		250			500				125		250		500
Dressed weight (g)	191	142	180	208	335	319	271	212	195	195	203	198	185	261
Aroma:														
Fish id							)([a]		)(			)(	)(	)(
Fish: fresh			1								½			
Sweet		1			)(	)(	1	1	½		1	1+	1	
Meaty											1-			
Fried		1	1	1+	1	1+	1	1	1	1+		1	1	1
Oily	)(		1	)(	1			)(			1+	)(		
Cornmeal	1	1+						)(	)(	1+	1+	1	1	
Smoky: fresh	)(+	1-	½-1	1	1+	1	)(	1	1+	)(	)(	1	1	1
Flavor:														
Fish id		)(+											)(	)(
Fish: fresh			1		)(	)(+		)(+	)(		)(	)(		
Sweet	)(		1	)(	)(									
Salty	)(		1	)(	)(		)(	)(	)(	)(		)(	)(	)(
Meaty		)(					1			1	)(			1+
Poultry												1+		
Fried	1	)(	1			1	1	1	1	1	1	1+	1	
Cornmeal	1				1+		1	)(	)(	1			1	1
Smoky: fresh	)(	1-	1	1+	½	1-	1	1	1	)(	)(	1	1	½
Aftertaste:														
MS		x									x	x		
Meaty			x				x			x			x	x
Sweet feel	x												x	
Smoky			x	x	x	x		x	x					

[a]Key to symbols: p. 48.

tion levels; fish character flavor was more prominent than in the aroma but less than that found in the orientation control fish.

The major finding after 3 days' refrigerated storage was the decline in smoky character note in the aroma and especially flavor. Absence of smokiness in the aftertaste of all preflavoring levels is particularly indicative. The decrease is not attributed solely to the 3-day refrigerated storage, because similarly stored fish cooked by steaming apparently retained their respective levels of smokiness. Rather, the decrease might be attributed to the combined effects of aging under refrigeration plus the breading and pan-frying treatment.

Steamed Fish from Frozen Storage

In the frozen fish cooked by steaming, no fresh fish aroma was detected even at 2 weeks (Table 5). Fish identity was strongest at 6 weeks in the control fish aromas. At 8+ weeks an old-fish aromatic was found in 2 of the 3 controls.

Meaty and poultry notes were found in the aromas of control fish at 6 weeks but only meaty notes were present at 8+ weeks. This may indicate aging of fish.

Fish identity aroma was strongest at 2 weeks but no fresh fish notes were found for any frozen fish. Fish identity remained through 6 weeks of storage. At 8+ weeks an old-fish character note was found at 125 ppm but at 250 ppm and 500 ppm only fish identity was reported.

Throughout the storage period the smoky note was found in the aroma of preflavored fish. At the 2- and 6- week storage intervals, smoky intensity increased with concentration. After 8+ weeks of frozen storage, intensity of smoky aroma decreased at 250 and 500 ppm from levels observed at 6 weeks. Even though the level of smoky decreased at 8+ weeks it apparently was sufficient to cover the off-note, old-fish. This is supported by Iredale and Rigby

Table 5 - Profiles of control and preflavored steamed fish from frozen storage

	Steamed																	
	2 weeks						6 weeks						8+ weeks					
Concentration (ppm)	0			125	250	500	0			125	250	500	0			125	250	500
Dressed weight (g)	242	197	189	255	200	239	294	303	237	276	271	259	277	336	349	247	298	291
Aroma:																		
Fish id	)(a	)(	)(+	)(	1	1	)(	1	1	)(	)(	1			)(		½	)(
Fish: fresh																		
neutral																		
stale																		
old													1+	1-		1		
Sweet	)(			1-													)(	
Meaty			)(				1	1	1	1	1+	1		1	1+		1	1
Poultry							1+	1	2-									
Smoky: fresh				)(+	1+	2-					1	2				1	)(+	
woody										1								1
Others:	grassy pond	green water	grassy pond	pond water									old pond water	apple-y				

Table 5 - concluded

	Steamed																	
	2 weeks						6 weeks						8+ weeks					
Concentration (ppm)	0			125	250	500	0			125	250	500	0			125	250	500
Dressed weight (g)	242	197	189	255	200	239	294	303	237	276	271	259	277	336	349	247	298	291
Flavor:																		
Fish id	1+	1+	1	1+	1	)(	)(	)(	)(	)(		1				)(		)(
Fish: fresh															½			
neutral													1				1-	
stale							)(+				1			1-				
old																		
Sweet	1-	1	1	)(+	1+		1+	1		1		1-		)(	)(		)(	)(
Salty	)(	)(	)(					)(	)(							)(		
Meaty		1	1		1	1	1	1	1+	1	1+		1	1	1	1	1	1
Poultry																		
Smoky: fresh				)(	1	1				½		1				1	1-	.1
woody											½							
Others:																		
Seasoned										x	x	x						
Aftertaste:																		
MS	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fish id	x	x	x													x		
Meaty								x	x									
Dry tongue				x		x				x	x							
Sweet								x										
Smoky					x					x		x				x	x	x

[a]Key to symbols: p. 48.

(1972) who in a study of masking of muddiness of fish found the effectiveness of the masking apparently related to the intensity of the smokiness. The aroma of untreated fish also had notes described as "grassy-pond", "green-water", "old pond water" or "apple-y". These appeared at 2 and 8+ weeks of storage. In one instance, 125 ppm at 2 weeks, an off-note appeared described as "pond water". The other preflavored fish may have contained off-notes but, as suggested by Iredale and Rigby, these notes apparently were covered by the smoky flavoring.

Fresh fish flavor was not found in frozen fish. Maligalig (1971) found the fresh character disappeared after 2 weeks of storage. Fish identity was stronger at 2 weeks than at 6 weeks and had virtually disappeared at 8+ weeks. In one control fish at 6 weeks, an old-fish note was detected. At 8+ weeks old off-notes detected in the aroma were also present in the flavor of the controls. Maligalig (1971) found total flavor decreased progressively until the sixth week when a suppressed flavor was described by her panel as "sat-upon" (practically nil, expected to be off soon). This may relate to the present study's description of the fish aromatic and flavor as neutral. Her panel found at 8+ weeks indications the fish were spoiling.

Meaty character survived throughout the frozen storage but a poultry note found in aroma was not detected in flavor. Significance of meaty and poultry character notes is not known.

The preflavored fish had less fish identity at 2 weeks than the unflavored controls; the intensity was inverse to smoky concentration. But at 8+ weeks, only one preflavored fish (250 ppm) had an off-note, described as stale fish flavor.

For 125 ppm the intensity of the smoky flavor increased with storage time. At 250 ppm the smoky remained at the same level. At 6 weeks the smoky flavor

in the 250 ppm fish was described as woody. That same fish had emitted a stale fish character. Perhaps the off-note altered the smoke identity or perhaps the slight alteration in character signified instability of the smoky flavoring. The smoke character of fish flavored at 500 ppm held at the same flavor intensity throughout the storage period. A new description "seasoned" appeared at 6 weeks. The flavor of steamed fish apparently was enhanced by the presence of the smoke flavorant. This approximates Cutting's (1962) view of smoke-cured fish, that the smoke serves more as a condiment to impart an agreeable flavor than as a preservative.

In the aftertaste, the sensation of mouth satisfaction was present in all fish. As storage time lengthened, smoky appeared more often in the aftertaste. Fish identity was present in the aftertaste at 2 weeks but only appeared once more, in the aftertaste of fish flavored at 125 ppm stored for 8+ weeks.

During frozen storage, the smoky character in the aroma and flavor endured and was not broken apart except possibly once or twice as inferred from the slight alteration to the woody character. The important finding is that it remained recognizable as smoke.

Pan-fried Fish from Frozen Storage

As in the refrigerated fish, fried character notes appeared in and dominated aromas of the intact pan-fried fish. After the fish were opened other factors could be identified (Table 6). Throughout the storage period some fish identity was found in the control fish aromas. As in the steamed control fish, fresh fish character had disappeared at the 2-week interval. At 6 weeks, old-fish notes appeared which had not been detected in similarly stored steamed fish. At the 8+-week interval, stale and old-fish notes were found in the pan-fried controls as in the steamed controls.

Table 6 - Profiles of control and preflavored pan-fried fish from frozen storage

	Pan-fried																	
	2 weeks						6 weeks						8+ weeks					
Concentration (ppm)	0			125	250	500	0			125	250	500	0			125	250	500
Dressed weight (g)	235	249	185	219	247	191	223	236	167	193	221	184	198	286	231	219	295	239
Aroma:																		
Fish id	)([a]	1-	1	)(+		)(	)(		)(	½	1	1		)(				)(
Fish: fresh																		
neutral																		
stale														1				
old							1-	)(	)(				1		½		½	
Sweet						1+		1				1						
Meaty							)(	1									½-1	
Poultry	1+	1						½	)(									
Fried	1	1+	1	1	2	1+	1+	1	1+	1+		1	1+	1	1	1	1	1
Oily	1	1	1	1+			1					½	½	1	)(	½	1	1
Cornmeal	1		1	1		1	1-	1	)(	)(	1	1	1	1+		1	1	
Smoky: fresh				1-	1+	1+				X-½		X-1				)(	1	)(
woody											X-1+							
Others:				woodsy grassy	woodsy vegetation								sweet green			smoky fish		

Table 6 - concluded

	Pan-fried																	
	2 weeks						6 weeks						8+ weeks					
Concentration (ppm)	0			125	250	500	0			125	250	500	0			125	250	500
Dressed weight (g)	235	249	185	219	247	191	223	236	167	193	221	184	198	286	231	219	295	239
Flavor:																		
Fish id	)(	1-	)(				)(	1		1-			)(			)(		)(
Fish: fresh																		
neutral								1						1				1
stale										)(					1	1	1+	
old							1						1+					
Sweet					1		)(	)(		)(		)(				)(	)(	
Salty	)(	)(	)(			)(	)(				)(						)(	)(
Meaty		1	1		1	1	1		1	½	)(	1	1	½			1	
Poultry		1						½					)(					
Fried	1	1	1	1	2		1	1	1		)(	1	1	1	1-		1	1
Cornmeal				1		1	1	1	½	1	1	1	½	1		½		
Smoky: fresh				1	1	½						1						1+
woody											1					)(		
Others:																		
Seasoned										x	x	x						x
Aftertaste:																		
MS	x	x	x	x	x		x	x	x	x		x		x	x	x	x	x
Fish id															x			
Meaty																		
Dry tongue		x	x	x	x	x			x		x							
Sweet																		
Smoky						x					x					x	x	x

[a]Key to symbols: p. 48.

In the aroma, the panel also found notes of sweet, poultry, and meaty but no sure reason accounts for their presence. The poultry character, as in the refrigerated pan-fried fish, may be related to the egg in the batter. Or, there may have been the development of a poultry-like note. At 6 weeks both the steamed and pan-fried control fish had poultry notes. At 8+ weeks, an off-note, "sweet-green", was found in a control. In the steamed fish stored the same time, several off-notes, e.g., "old pond water" and "apple-y", had been found. Possibly all fish had a similar off-note, varying in intensity at the time of treatment which was between July 17-29, 1974, the period when ponds developed an off-aroma as cited in Experimental Procedure (p.10).

Fried or cornmeal character flavor notes were dominate in preflavored pan-fried fish; however, other flavor notes could be detected. Fish character aroma in the preflavored fish was strongest at 6 weeks, but no fresh fish character was detected in any of the preflavored fish. Only one pan-fried preflavored fish had any off-fish aroma, the preflavored fish at 250 ppm and stored for 8+ weeks. A similar finding has been cited for the steamed series.

The smoky note in the aroma at 2 weeks was perceived at slight intensity. At 6 weeks the strength had decreased to approximately the threshold level. The smoky character in one fish, preflavored at 250 ppm and stored for 6 weeks, changed to the woody note (Cf. steamed series, 6-week aroma for 125 ppm, Table 5). After 8+ weeks of storage, fish preflavored at 125 ppm and 500 ppm had smoky aroma at a just recognizable level while fish preflavored at 250 ppm had smoky aroma at a slight level. Some off-notes described at "woodsy-grassy" and "woodsy vegetation" were detected at 2 weeks. Steamed fish, both controls and treated, also had off-notes at 2 weeks and 8+ weeks. These off-notes may have been present at the time of treatment in varying intensity as all fish for a given concentration were preflavored at one time. It is possible that

the smoke flavoring masked some of these notes in some fish.

In the flavor of the pan-fried controls, as in the steamed fish, fish identity was always found, but not fresh fish flavor, even at 2 weeks' frozen storage. Off-fish flavor, such as neutral, stale and old, first appeared at 6 weeks in the control fish.

No fish character of any kind was detected in the flavor of the preflavored fish frozen at 2 weeks. Some fish identity was perceived in fish frozen for 6 weeks. A stale flavor also was detected in the 125 ppm preflavored fish at 6 weeks, while an old-fish flavor had been found in the corresponding control. This, perhaps, indicates the smoke flavoring helped to cover the old-fish making it less undesirable. For those fish frozen 8+ weeks the possible old-fish notes of the preflavored fish were modified by the smoke flavoring and perceived as stale for 125 ppm and 250 ppm, and neutral for 500 ppm.

Some meaty notes occurred in fish where there was no indication of fish character of any kind. This may be an indication of flavor development as the fish aged. Meaty aromatics seemed more prominent during aging of fish in the steamed frozen series. As in the control fish, fried identity was present in all preflavored frozen fish.

Smoky flavor survived throughout the storage period as it had in the steamed frozen fish. Apparently the smoky flavor was not strong enough to be detected at all levels, e.g., at 125 ppm for 6 weeks and 250 ppm for 8+ weeks. Character of the smoky flavor had changed to "woody" at 250 ppm for 6 weeks and at 125 ppm for 8+ weeks. Since the smoky flavor was not found for 250 ppm at 8+ weeks, the change may be indicative of a coming disappearance or breaking down of the smoke flavoring.

As in the steamed fish the 6-week pan-fried preflavored fish acquired a seasoned flavor which the control fish lacked. One of the longer stored

preflavored fish, 500 ppm for 8+ weeks, had the "seasoned" effect.

The most consistently reported note in aftertaste was mouth satisfaction. In fish frozen 2 weeks, the dry tongue feeling appeared in some controls and preflavored fish. This sensation usually was associated with the presence of smoky flavor. Its presence in the controls may be related to the textural changes to be discussed later. Smoky appeared once in the aftertaste at 2 weeks and 6 weeks, but was present at all three concentrations at 8+ weeks. The absence of smoky flavor had been reported for 250 ppm at 8+ weeks. Since it was found in the aftertaste, smoky may have appeared so late in the flavor that it was not detected until the fish was swallowed. Or, since these fish were thawed before pan-frying, the fish fluids containing the smoke components may have moved toward the surface and been absorbed by the breading. Although the amount of drip dormed during thawing was not measured, little appeared to be formed. Zaitsev (1965) reported when absolutely fresh fish are frozen, stored and thawed under optimum conditions, their histological structure differs only slightly from fresh fish and little drip is formed upon thawing.

Deep-fat Fried Fish from Refrigerated and Frozen Storage

Some exploratory probes were made on fish cooked by deep-fat frying from refrigerated and frozen storage. Fish for deep-fat frying were preflavored at 250 ppm and stored for 1 day in the refrigerator and 2 and 6 weeks in the freezer after blast freezing. Frozen control fish were provided for the preflavored fish stored 2 and 6 weeks.

Refrigerator stored fish that were deep-fat fried had aroma profiles similar to the 0-1 day refrigerated 250 ppm preflavored pan-fried fish (Table 6). Characteristics of fish identity, fried, cornmeal and smoky found in the pan-fried fish also appeared in the deep-fat fried fish and at approximately the same levels (Table 7).

Table 7 - Profiles of deep-fat fried fish from refrigerated and frozen storage

	Deep-fat fried					
	1 day		2 weeks		6 weeks	
Concentration (ppm)	250		0	250	0	250
Dressed weight (g)	231	324	390	384	300	298
Aroma:						
Fish id	1[a]	1	1-	-	)(	)(
Fish: fresh						
neutral						
stale						
old						
Earthy					)(	
Sweet						
Meaty		1				
Poultry						
Fried	1	1	1	1	1	1
Oily				1-		
Cornmeal	1	1	1			
Smoky: fresh	1	1		1		1
woody						
Flavor:						
Fish id			1		)(	1
Fish: fresh	1-	1				
neutral						
stale						
old			)(			
Earthy					1	
Sweet	1	½	)(	)(	)(	)(
Salty		)(	)(	)(		)(
Meaty		1	1-	1	1	
Poultry						
Fried	1	1	)(	1	1	1
Cornmeal		1	)(	)(		
Smoky: fresh	1	1		1+		1
woody						
Others:						
Seasoned				x		x
Aftertaste:						
MS	x	x	x	x	x	x
Fish id				x	x	
Earthy					x	
Meaty						
Sweet feel	x	x				
Dry tongue			x			
Smoky	x	x		x		x

[a]Key to symbols: p. 48.

The same is true of the flavor properties of the deep-fat fried and pan-fried preflavored (250 ppm) fish refrigerated before preparation. The major difference was in the texture of the breading. The deep-fat fried fish had a crisp, crunchy crust which the pan-fried fish lacked, and perhaps, a sweeter taste.

In the aftertaste, smoky and mouth satisfaction appeared in the deep-fat fried fish, as in the pan-fried fish. There was a sweet feel in the aftertaste which may be related to either the smoky character or the fried batter.

There were similarities in notes for fish frozen 2 weeks and cooked by either pan-frying or deep-fat frying. In the control aromas, fish identity and the fried characters appeared at the same slight range. In the preflavored fish, the smoky aromatic was detected at the same level, slight.

The panel found about the same flavor factors in the deep-fat fried frozen series as in the pan-fried frozen series of fish. Two differences were noted: texture of the batter as cited above; and the seasoned character not reported for preflavored pan-fried fish until 6 weeks' frozen storage. The deep-fat fried fish were examined after many of the pan-fried frozen fish had been examined. The panel was probably acquainted, therefore, with the seasoned character and detected in both 2-week and 6-week preflavored fish that quality, flavor totality, lacking in the control fish.

In the aftertaste of the deep-fat fried fish, fish identity and smoky character were noted. The fish identity may have been present because the deep-fat fried fish were more mature than the pan-fried fish and, hence, more fish identity was present to begin with.

At 6 weeks, contrary to pan-fried fish there was no indication of any off-fish aroma in the deep-fat fried fish. The smoky aroma also remained true in contrast to the pan-fried fish. However, a note described as earthy was

found in the control fish. Some of the pan-fried fish from 2-week and 8+-week frozen storage had off-notes in aroma described as "woodsy-grassy", "woodsy-vegetation", and "sweet-green". Since fish were all frozen within a 2-week time period (July 17-29, 1974) these notes may be predecessors of the earthy note. Support for this suggestion is found in Maligalig's work (1971).

As stated under Experimental Procedure (p. 10), off-odor was observed in the ponds on July 16. The ponds were cleaned and fish replaced. A week later, one fish was checked and no off-flavors found (Table 8). Maligalig (1971) found off-notes in stored frozen fish which had been purged of off-notes before being frozen. Presence of the earthy note in aroma, flavor and aftertaste of the 6-week frozen control (Table 7) suggests that aging under frozen conditions allowed a latent level of earthiness to become detectable, along with other results of aging. Burgess et al. (1967) found that stale fish do not improve with freezing.

Aftertaste of control fish presented the earthy character along with mouth satisfaction and fish identity. For the preflavored fish, the smoky character was found together with mouth satisfaction.

It is conceivable that both fish had earthy character. If so the smoky flavor may have helped to mask the off-note in the preflavored fish. Overall, the effects of deep-fat frying were similar to those of pan-frying, with the smoky flavor surviving and contributing to the "seasoned" quality. The major difference between the deep-fat fried and pan-fried fish was the crunchy texture.

Other Observations

While specific textural observations were not made, the panel did comment on the texture. In the refrigerated stored fish, contrary to expectation, the panel noted that the flesh was not "flaky", although it was moist and tender. In cooking fish, doneness is sometimes assessed when the myomeres separate

Table 8 - Profile of fish examined on July 23 for detection of any off-aroma or flavor notes, steamed

Dressed weight (g)	227
Aroma:	
Fish id	
Fish: fresh	1+[a]
Sweet	1
Meaty	
Flavor:	
Fish id	1+
Fish: fresh	
Sweet	1-
Salty	)(
Meaty	1
Poultry	
Aftertaste:	
MS	x
Meaty	

[a]Key to symbols: p. 48.

readily and give rise to flakes of cooked flesh (Charley, 1970). Instead the texture of the refrigerated stored fish was described as "chunks" of fish. Also, one panelist reported a sensation described as "sticky teeth". This may have been derived from the fish fluids.

After 2 weeks of frozen storage, flaky texture was found in all fish. The flesh remained moist and tender. At 6 weeks and 8+ weeks, however, the texture was similar to that of refrigerated stored fish, like a "chunk" instead of a "flake". Also the fish flesh had become dry and tough by 8+ weeks. In the last storage period, the flesh was elastic and not moist until after considerable chewing had released the "juice"; then the sensation of "sticky teeth" was reported. This may be related to the "gumminess" reported by Boggess et al. (1971) for catfish skinned and held in commercial storage.

Another factor which contributes to the texture may be the state after death when the fish were stored. During rigor mortis the fish muscle is tough and cells are dry (Love, 1968). After rigor the muscle relaxes and the tissues

are moist. Since the onset and duration of rigor are dependent upon a variety of pre-mortem conditions (Zaitsev, 1965), the fish may or may not have been in rigor upon freezing. If frozen in rigor, tough and dry fish would be expected, but if frozen out of rigor, the textural (and flavor) changes found in fish after 6 weeks of frozen storage indicate the perishability of fish.

Weight of each dressed fish was recorded to determine if weight and, therefore, maturity had any relation to intensities of smoky and meaty character notes. Scanning of these data showed no relation between the weight and these notes (Table 14, Appendix).

Another observation made by the panel was that, for all fish, fish character and smoky character seemed stronger when the cooked fish had cooled to room temperature. At times an old-fish flavor was found in the cool fish, but not in a hot one.

SUMMATION AND FURTHER RECOMMENDATIONS

The retention and flavor effects of a commerically available smoke-type flavoring in channel catfish held in refrigerated and frozen storage before being cooked by steaming in a covered glass casserole, pan-frying or deep-fat frying were evaluated.

Preflavored steamed and pan-fried fish had freshwater fish character along with smoky note in both aroma and flavor after 0-1 day and 3 days of refrigerated storage.

Preflavored fish refrigerated 3 days before steaming did not show any striking aroma and flavor differences from day-old counterparts. This finding means that the smoky flavoring endured throughout the storage period and the fish notes did not change in their quality.

In pan-fried fish refrigerated 3 days there was some decline from 0-1 day

in smoky character note in aroma and especially flavor with absence of smokiness in aftertaste.

In frozen fish cooked by steaming, smoky character endured throughout the storage period. While there was some development of off-fish aromas and flavors the smoke tended to cover or attentuate those notes. The smoke flavoring appeared to break apart once or twice as inferred from the "woody" note. However, it remained recognizable as smoke and favorably enhanced the flavor of the fish giving them a "seasoned" effect.

For frozen fish, pan-fried, smoky endured for the storage period and covered some off-notes detected in control fish. Those notes included the off-fish notes and the off-notes of "woodsy-grassy" and "pond water".

Fish cooked by deep-fat frying were similar to pan-fried fish with the smoky flavor surviving and contributing to the "seasoned" effect. The deep-fat frying method contributed crunchy texture not found in pan-fried fish.

From other observations made by the panel, texture became dry and tough with frozen storage.

Generally the smoky flavoring endured through refrigeration and frozen storage and maintained its true identity. It apparently masked, although this was not intended, undesirable aromas and flavors which developed during prolonged frozen storage.

Preflavored frozen fish, and perhaps preflavored refrigerated fish to some degree, had more total flavor as well as seasoned flavor, than did untreated fish.

Several recommendations can be made for further studies. These include investigation of different concentrations and exposure times to smoke flavoring and to other flavorings; density of fish in a tank and intensity of flavoring; and relation of aeration of the water to the volatilization of the

flavoring, if any.

As Banks (1965) suggested, more research on the effect of rigor mortis in fish might be another area. Other studies might center on the state of excitability in the fish and the uptake of flavoring.

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APPENDIX

0 = not present

)(= just recognizable, threshold

$\frac{1}{2}$ = more than)(, but less than 1

1 = slight intensity

2 = moderate intensity

+,- = comparative

Figure 1 - Key to symbols used for taste panel examinations

Table 9 - Composition of feed formula Z-58 (30% protein) for channel catfish (Tiemeier and Deyoe, 1973)

Ingredients	Pounds
Soybean meal	516.8
Meat and bone meal	304.4
Distillers dried grains with solubles	100.0
Fat	29.0
Wheat midds	385.0
Ground sorghum	22.6
Ground wheat	460.6
Premix A	161.6
Premix B	20.0
Total pounds	2000.0

Premix A

Ingredients	Pounds
Dicalcium phosphate	83.2
Salt	7.8
Ground limestone	9.4
Blood meal	61.2
Total pounds	161.6

Premix B

Ingredients	Grams
Vitamin A (10,000 IU/gram)	200
Vitamin D (15,000 IU/gram)	20
Vitamin B_{12} (20 mg/lb)	228
B-complex (1233)[a]	228
Methionine	3542
Ground grain	4862
Total grams	9080

[a]Contains perpound: 8 g riboflavin; 14.72 g d-pantothenic acid; 24 g niacin; and 80 g choline chloride.

Table 10 - Specifications of liquid smoke flavoring (Sair, 1974)

Griffith's "Natural Concentrated Liquid Smoke Flavor: SF-12"
(Griffith Laboratories, 1415 West 37th Street, Chicago, IL 60609)

A natural hardwood smoke flavor.

Analytical range:

Total solids, %	3.0-3.6
Total acidity as acetic acid, %	8.0-9.5
Color value (10% solution in water) 525 B Fisher Photometer II	16-24
Flavor	Equivalent to Standard
Price packed 55 lb drum	$.60/lb.

Table 11 - Calculation of ppm of smoke flavoring for aquarium used

20 gallons = 76 liters

$1 : 1x10^6 :: X : 76{,}000$

$\therefore$ 1 ppm = 0.076 grams
125 ppm = 9.4 grams*
250 ppm = 18.8 grams
500 ppm = 37.6 grams

1 : 0.076 :: X : 10

$\therefore$ 10 g = 132 ppm = \$0.013 = 1.3 ¢
19 g = 250 ppm = 0.025 = 2.5 ¢
38 g = 500 ppm = 0.05 = 5.0 ¢

60¢/lb = 0.13¢/gm

1 ppm requires:	2.7	lb/acre foot
	0.0038	gm/gallon
	0.0284	gm/cu ft
	0.00000623	lb/cu ft or

1 ppm = 3.8 gm/1000 gallons
10 ppm = 38.0 gm/1000 gallons
100 ppm = 380.0 gm/1000 gallons

120 ppm = 1 lb/1000 gallons = 60¢

*This project used the following weights for a 20 gallon aquarium:
125 ppm = 10 grams
250 ppm = 19 grams
500 ppm = 38 grams

Table 12 - Ingredients and procedure for breading and batter used for pan-fried and deep-fat fried fish (Adapted from Kansas State University, 1966)

Ingredient	Weight (g)
Cornmeal, fine yellow	40.0
Flour	40.0
Whole egg	48.0
Whole milk	48.0
Salt	1.5
Black pepper	0.1

Procedure: Combine cornmeal and flour in a shallow plate.
Beat egg slightly and blend with milk, salt, pepper in another shallow plate.
Wipe fish as dry as possible with paper toweling.
Roll fish in cornmeal; dip into egg and again roll in cornmeal.
Care should be taken to have all parts completely covered.
Let fish set for approximately one minute to dry the coating.
Then pan-fry or deep-fat fry in preheated oil.

Products used:

Oil: Wesson® pure vegetable oil
cottonseed oil
specially processed soybean oil
(Hunt-Wesson Foods, Inc., Fullerton CA 92634)

Cornmeal: Quaker enriched degerminated yellow cornmeal
degerminated yellow cornmeal
niacin
iron
thiamine
riboflavin
(The Quaker Oats Company, Chicago IL 60654)

Table 13 - Schedule for killing fish and date of flavor examinations

Kill date	Conc. of flavor[a]	Storage method[b]	Number of days	Cooking method[c]	Flavor exam.
Jul 2	250	R	1	D	Jul 3 *
Jul 9	250	R	0	S	Jul 9
	250	R	0	P	Jul 9
	250	R	3	S	Jul 11
	250	R	3	P	Jul 11
Jul 10	500	R	0	S	Jul 10
	500	R	0	P	Jul 10
Jul 15	250	R	1	S	Jul 16
	250	R	1	P	Jul 16
Jul 17	500	R	0	S	Jul 17
	500	R	0	P	Jul 17
	250	R	1	S	Jul 18
	250	R	1	P	Jul 18
	250	F	12	S	Jul 29
	0	F	12	S	Jul 29
	250	F	14	P	Jul 31
	0	F	14	P	Jul 31
	250	F	40	S	Aug 26*
	0	F	40	S	Aug 26*
	250	F	41	P	Aug 27*
	0	F	41	P	Aug 27*
Jul 18	500	R	1	S	Jul 19
	500	R	1	P	Jul 19
	500	F	14	S	Aug 1
	0	F	14	S	Aug 1
	500	F	15	P	Aug 2
	0	F	15	P	Aug 2
	500	F	41	S	Aug 28*
	0	F	41	S	Aug 28*
	500	F	42	P	Aug 29*
	0	F	42	P	Aug 29*
Jul 22	125	R	1	S	Jul 23
	125	R	1	P	Jul 23
	125	R	3	S	Jul 25
	125	R	3	P	Jul 25
Jul 23	500	R	1	S	Jul 24
	500	R	1	P	Jul 24
	500	R	3	S	Jul 26
	500	R	3	P	Jul 26

Table 13 - concluded

	500	F	71	S	Oct 2 *
	0	F	71	S	Oct 2 *
	500	F	78	P	Oct 9 *
	0	F	78	P	Oct 9 *
Jul 24	125	F	12	S	Aug 5 *
	0	F	12	S	Aug 5 *
	125	F	14	P	Aug 7 *
	0	F	14	P	Aug 7 *
	125	F	41	S	Sep 3 *
	0	F	41	S	Sep 3 *
	125	F	42	P	Sep 4 *
	0	F	42	P	Sep 4 *
Jul 29	125	F	57	S	Sep 24*
	0	F	57	S	Sep 24*
	125	F	58	P	Sep 25*
	0	F	58	P	Sep 25*
	250	F	64	S	Oct 3 *
	0	F	64	S	Oct 3 *
	250	F	72	P	Oct 8 *
	0	F	72	P	Oct 8 *
Aug 2	250	F	42	D	Sep 13*
	0	F	42	D	Sep 13*
Aug 5	125	R	1	S	Aug 6 *
	125	R	1	P	Aug 6 *
	125	R	3	S	Aug 8 *
	125	R	3	P	Aug 8 *
Aug 6	250	R	3	S	Aug 9 *
	250	R	3	P	Aug 9 *
Sep 19	250	R	1	D	Sep 20*
	250	F	15	D	Oct 4 *
	0	F	15	D	Oct 4 *

[a]Concentration of flavoring: 0 = no flavoring; 125 = 125 ppm; 250 = 250 ppm; 500 = 500 ppm.

[b]Storage method: R = refrigeration; F = frozen.

[c]Cooking method: S = steaming; P = pan-frying; D = deep-fat frying.

* two member panel.

Table 14 - Comparison of dressed weights of preflavored fish to meaty flavor intensity and smoky flavor intensity

Concentration (ppm)	Dressed weight (g)	Meaty flavor[a]	Smoky flavor[a]	Storage method[b]	Cooking method[c]
125	131	1	)(	R:0-1	S
	142	)(	1-	R:0-1	P
	159	0	1	R:0-1	S
	191	0	)(+	R:0-1	P
	193	½	0	F:6	P
	195	1	)(	R:3	P
	196	1	)(+	R:3	S
125	203	)(	)(	R:3	P
	219	0	1	F:2	P
	219	0	)(	F:8+	P
	221	)(	1	R:3	S
	247	1	1	F:8+	S
	255	0	)(	F:2	S
	276	1	½	F:6	S
250	170	0	1	R:0-1	S
	180	0	1	R:0-1	P
	185	0	1	R:3	P
	192	0	1	R:3	S
	198	0	1	R:3	P
250	200	1	1	F:2	S
	208	0	1+	R:0-1	P
	218	1	1	R:0-1	S
	218	)(	1	R:3	S
	221	0	1+	R:0-1	S
	221	)(	1	F;6	P
	231	0	1	R:0-1	D
	247	1	1	F:2	P
	271	1+	½	F:6	S
	295	1	0	F:8+	P
	298	0	1	F:6	D
	298	1	1-	F:8+	S
250	324	1	1	R:0-1	D
	335	0	½	R:0-1	P
	384	1	1+	F:2	D
500	144	1	1	R:0-1	S
	160	0	½	R:0-1	S
	184	1	1	F:6	P
	191	1	½	F:2	P
	195	0	1	R:0-1	P
	198	)(	1+	R:0-1	S

Table 14 - concluded

500	211	)(	2	R:3	S
	212	0	1	R:0-1	P
	239	1	1	F:2	S
	239	0	1+	F:8+	P
	259	0	1	F:6	S
	261	1+	½	R:3	P
	262	1	1+	R:0-1	S
	271	1	1	R:0-1	P
	291	1	1	F:8+	S
500	319	0	1-	R:0-1	P

[a]Key to symbols: see p. 48.

[b]Storage method: R = refrigeration (0-1 day, 3 days)
F = frozen (2 weeks, 6 weeks, 8+ weeks)

[c]Cooking method: S = steaming
P = pan-frying
D = deep-fat frying

SUPPLEMENT

The following literature reviews the role of fish as a food source, its flavor chemistry and off-flavors, and the regulations for the smoke-processing of fish. It is intended to supplement the material found in the review of literature.

Fish as Food

The approximate chemical composition of both seafish and freshwater fish is similar to that of other animal sources. The principal constituents are water, 66-84 percent, protein, 15-24 percent, fat 0.1-22 percent, and minerals, 0.8-2 percent (Jacquot, 1961; Tarr, 1969). The protein is complete like other animal protein but contains little connective tissue which results in the flakiness and tenderness of the muscle (Bowers, 1972).

Fat content varies from species to species; lean fishes, such as cod, contain less than 1 percent fat, while fatty fishes, such as salmon, have more than 20 percent (Tarr, 1969). Fat content often is inversely proportioned to the water content and together they comprise approximately 80 percent of the total weight (Bowers, 1972). However, one should not classify fishes only on the basis of their fat content. Studies conducted by Thurston et al. (1959) and by Stansby and Hall (1967) indicate various factors will affect the lipid content: feeding, locality, size, age and season.

Role as protein food source

Recently many individuals have become aware of the protein situation, especially in the wake of rising meat prices and short supplies. While the United States and other advanced nations enjoy the luxury of over-nutrition, many sections of under-developed nations are nearly all ill fed. Estimates are one-half of the world's population is starved or semi-starved and badly lacking in fresh protein. Much of the cause of social unrest, slow economic development,

administrative malfunctioning, and other problems of the developing world may lie in protein malnutrition. If so, fish protein may contribute greatly toward solving these problems (Chapman, 1966).

Cost of gathering animal protein from the sea has been significantly lower than on land. On a world-wide basis it costs half as much to gather a ton of protein from fish than from beef (Brown, 1973). Consequently, fish can be used for supplementation of diets based on cereal and low in protein (Borgstrom, 1962). Also because of lower fat content, some fish may be included in a diet without increasing significantly the amount of total fat.

Fish consumption has risen in the past century. In 1850, the total world catch of fish and shellfish was between 1.5 and 2.0 million tons (Chapman, 1966). For 1969, the Food and Agriculture Organization of the United Nations reported a world fish population of 56.2 million tons (FAO, 1970). Within the United States, the production of fish was 2.5 million tons. Civilian per capita consumption increased 2 percent from 12.3 pounds to 12.6 pounds in 1973 (Anon., 1974b). However, fish consumption remained less than for other flesh foods: 39.9 lbs for chicken, 64.6 lbs for pork and 109.6 lbs for beef (Lee, 1971).

Low fish consumption can be related to several factors: transport facilities, degree of processing, methods of utilization, the attitude of the consumer, price quotations as compared to meat, religious considerations, labor costs along with the magnitude of the fishing (Reidel, 1961). Processors remain optimistic that the following will raise fish consumption: future trends of high quality, ease of preparation, portion control involving more convenience foods such as pre-breaded cooked fish sticks; more fillets and boneless cuts; and more freezing and prepackaging (Anon., 1974b).

Freshwater fish farming within the United States is beginning to expand. Two main species are cultured: rainbow trout and channel catfish (Brown, 1973).

Catfish and trout are by far the most marketable farmed fish because of the production and development efforts over the last several years (Anon., 1974a). In 1972 total food sales of catfish was about 64 million lbs liveweight or 35 million lbs dressed.

Farm prices for catfish range between 31 and 40 cents per lb for liveweight, 80 and 90 cents for wholesale and 1.09 and 1.39 for retail (Brown, 1973). Catfish is comparable in cost with meat produced from land animals. This is true although production per surface area unit of water is many times higher than for some other meat animals and although fish feed conversion is superior to that of beef and pork and slightly better than for chicken (Table 15). These reasons may account for the renewed interest in freshwater fish farming.

Table 15 - Comparison of feed conversions by different types of domesticated animals and cultured fish (Brown, 1973)

Animal	Dressed out percentage	Feed Conversion	
		Liveweight basis	Dressed weight basis
Beef	59.5	7.50 - 1	12.61 - 1
Hogs	77.0	3.25 - 1	4.22 - 1
Broilers	74.0	2.25 - 1	3.04 - 1
Fish			
Channel catfish	55.0	1.50 - 1	2.73 - 1
Rainbow trout	82.0	1.50 - 1	1.83 - 1

Along with production, processing is expected to become an important part of the industry (Boggess et al., 1971 quoting Billy, 1967). Billy further states that improved processing methods are needed. Freezing and frozen storage would help to prevent an over-supply in the fall and winter and a shortage during the remainder of the year.

Chemical Composition of Fish as Related to Fish Flavor

The literature on the chemistry of fresh and not-so-fresh fish is extensive, but little attempt has been made to relate it to the chemical composition of flavor. Jones (1967) divided fish flavor constituents into two main groups. The nitrogenous group is composed on amino acids and peptides, amines and ammonia, mononucleotides and their derivatives, and other nitrogenous bases. The non-nitrogenous group contains volatile carbonyls, alcohols, free lower fatty acids, volatile sulfur compounds, carbohydrates and sugar phosphates.

Findings by Jones (1967) indicated that certain amino acids contribute to fish flavor independently of other fish constituents; i.e., glycine contributes a sweetness character while histidine produces a meaty note. The meaty flavor of Japanese marine fish has been imitated through a mixture of glutamic acid, adenosine monophosphate, adenosine triphosphate, and inosine monophosphate (Hashimoto, 1965). The mononucleotides and their derivatives act as flavor enhancers. An example is inosine-5'-monophosphate which gives a "meaty" flavor to the fish muscle (Jones, 1961). The "fishy" character of fish has been related to the amines, particularly trimethylamine.

Other nitrogenous compounds which have been identified in fish are pyridine, piperidine, pyrrolidine and aminovaleric acid. Jones (1967) found through a mixture of these compounds with each other and other compounds such as mercaptans, indole and trimethylamine that odors of freshwater fish, sea fish, "rather old fish", "fish-shop smell", putrid fish and dried fish were simulated.

The volatile carbonyls of low molecular weight were found to be associated with fresh fish flavor while those of high molecular weight were associated with spoiling fish flavor. The flavors of the lower fatty acids have been found in spoiling fish such as cod. Sulfur compounds such as hydrogen sulfide,

dimethyl sulfide, methyl mercaptan and organic sulfides also have been found in spoiling fish.

The characteristic sweetness of fresh fish is attributed to the high initial glucose concentration in the muscle (Jones, 1961). Sugar phosphates also contribute to the sweetish-salty character of fresh sea fish.

Off-flavors in Fish

The biggest problem in farm-raised catfish is off-flavors. Thaysen (1936) investigated the nature of off-flavors in fish and found an "earthy" or "muddy" taint in salmon from a Great Britain river. Water samples from the river had a similar off-note. When contaminated fish were boiled in potable drinking water, the cooking water acquired the earthy or muddy taint and the off-odor appeared in the steam. Thaysen concluded the off-note was some compound in the flesh soluble in water and volatile in steam.

Analysis of the water indicated the abundance of certain types of Actinomycetes, bacteria reported to produce an odor described as earthy or muddy. Thaysen grew cultures of those bacteria, and with Pentelow (1936), subjected untainted fish to water solutions containing 1, 2, 10, 20, and 40 parts per million (ppm) of Actinomycetes. After one hour in the solution, fish were killed and boiled. All fish acquired unpalatable earthy and muddy flavor and aroma with the notes stronger in increasing concentration. Control fish had no earthy or muddy notes.

Thaysen and Pentelow (1936) could not relate muddy off-flavor to mud. Trout exposed to heavy suspensions of taint-free mud for several hours had no muddy flavor or aroma. They concluded the earthy or muddy taint in fish was produced by an odoriferous substance present in Actinomycetes.

In water supplies algae are considered the most frequent cause of tastes and odors (Palmer, 1959). The blue-green group may grow so abundantly as to

produce a surface scum or "water bloom" (Smith, 1950). Decay of this frothy scum produces disagreeable odors and tastes in aquatic animals (Olive, 1918).

Off-flavors in catfish are a hazard from the consumer's point of view as well as the processor's. Off-flavors occur most frequently in late summer when water temperatures are high, the largest amount of feed is being used, and algal blooms are dense. Some causes of off-flavor are: (1) algal bloom; (2) (2) muskgrass which has a strong musty odor; (3) overfeeding, with the fish acquiring the taste of sour water from spoiling feed; (4) other organic matter, such as decaying trees which may give fish a musty taste; and (5) chemicals (Grizzell et al., 1969).

Smoke-processing in Channel Catfish

There are several methods of processing smoked channel catfish as reported by Boggess et al. (1973). Different storage times before brining, fish weight, brining times and formulae, smoking times and temperatures, and storage time after processing influence final product quality. The variations in smoked catfish will depend upon the procedure followed by the processor. He may be unable to duplicate the product of another processor, especially if his smokehouse is designed differently. Although smoking chamber temperatures and times may be consistent, the time of smoking at a specific internal loin muscle temperature is most important. Another important aspect is adherence to the regulations as set forth by the City of Milwaukee Ordinance for smoked fish and smoked fish products established in 1964 and in Current FDA regulations (Code of Federal Register, 1970).

Pace and Krumbiegal (1973) recently summarized the Milwaukee Ordinance:

1. Smoking shall consist of heating every portion of every fish to a minimum temperature of 82.2 C (180 F) for a minimum of 30 minutes;

2. Fish shall be removed from the smoking chamber to a separate room for prompt cooling, and must be packaged within 2 hours after completion of

smoking;

3. The package shall bear the words: "Perishable--Keep Refrigerated";

4. The package shall bear the processing date and expiration date;

5. The package shall not be sealed so that exchange of air is prevented;

6. Every smoked fish shall be maintained at a refrigeration temperature of no more than 4.5 C (40 F) from the time of packaging, during transportations, and during display.

7. The expiration date from smoked fish shall be not more than 7 calendar days following the date of smoking.

Boggess et al. (1973) recommend the maximum refrigeration temperature under point (6) be reduced to 2.8 C (37 F). Adherence to these regulations should preclude the possibility of growth and toxin production of Clostridium botulinum in addition to preserving the organoleptic quality of smoked catfish.

PREFLAVORING LIVE CHANNEL CATFISH

by

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Because preliminary probes at Kansas State University had indicated the feasibility of "preflavoring" farm-raised channel catfish, this study was undertaken to assess through sensory evaluation the flavor effects and retention under use conditions, of a preflavoring treatment of channel catfish; the preflavorant was a commercially available, water soluble, liquid smoke concentrate. Fish were held live for 30 minutes in dechlorinated water-filled aquariums containing preflavoring solutions of 125 ppm, 250 ppm, or 500 ppm. Immediately afterwards, fish were killed and dressed. Some were placed in refrigerated storage for 0-1 day, considered market fresh, and for 3 days, edible although not fresh. Some fish were kept in frozen storage until examined at the end of approximately 2 weeks, 6 weeks, and 8 to 10 weeks. For frozen fish, untreated fish (controls) also were stored.

Fish were cooked by steaming in covered glass casseroles using the microwave oven (control method); by pan-frying breaded fish; and by deep-fat frying breaded fish.

A four-member trained taste panel used the flavor profile method of examining the fish. Interpretation of their findings emphasizes two flavor factors: fish quality and smoky character. A total of 54 preflavored and 29 control fish were examined over the period of July 1 through October 9, 1974.

Preflavored fish refrigerated 3 days before steaming did not show any striking aroma and flavor differences from day-old counterparts. This indicates the smoky flavoring endured throughout the storage period and the fish notes (perceptible aroma or flavor factors) did not change in quality.

Preflavored pan-fried fish were similar in aroma and flavor for both refrigerated storage periods, but there was a decline in smoky character in the aroma and flavor after 3 days with absence of smokiness in aftertaste. Fish identity characteristics were less noticeable than in the steamed fish.

Breading and pan-frying probably were responsible for the decrease in those notes.

In frozen fish cooked by steaming, smoky character endured throughout the 8 to 10 weeks' storage period. Control fish showed development of off-fish notes described as "old" as well as off-notes described as "grassy-pond", "green-water" or "old pond water". With one exception, any possible off-fish or off-notes were covered by the smoky flavoring. A "seasoned" quality was first described at 6 weeks: apparently the flavor of preflavored steamed fish was enhanced, or made fuller, by the smoke flavoring. The smoky character in aroma and flavor endured and remained intact, except possibly in one or two instances which had a change in description although they were recognizably smoky.

Similar findings resulted for pan-fried fish. The breading flavor may have occasionally overpowered the smoky note. However, the smoky character generally remained recognizable and favorably enhanced the flavor of treated fish giving them the "seasoned" effect.

Some probes were made on fish cooked by deep-fat frying from refrigerated storage of 1 day and frozen storage of 2 and 6 weeks. For the refrigerated fish, aroma and flavor notes were quite similar to preflavored pan-fried fish. The major difference was in the texture of the breading. The deep-fat fried fish had a crisp, crunchy texture which the pan-fried fish lacked.

Aroma and flavor similarities were found for fish frozen 2 weeks and cooked by either pan-frying or deep-fat frying. Differences from the pan-fried fish were in the texture of the breading as cited above, and the "seasoned" quality reported for pan-fried fish frozen 6 weeks.

An off-note, earthy, appeared in the deep-fat fried control at 6 weeks which was not found in the preflavored fish. Other characteristics found in

pan-fried frozen fish at 6 weeks were similar in the deep-fat fried fish.

The smoky flavor endured throughout the storage periods and survived the cooking methods maintaining, with a few exceptions, its true identity. It apparently masked, although not intended, undesirable aromas and flavors which developed during prolonged frozen storage. Another significant result is that preflavored fish had more total or fuller flavor than did untreated fish.