FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

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JANUARY 1991 No. 211

LEAST-COST INGREDIENTS WORK WELL FOR CATFISH FEEDS

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ABSTRACT

CHANNEL CATFISH (ICTALURUS PUNCTATUS) WERE REARED IN THE LABORATORY FROM FRY TO 75 G ON A PURIFIED DIET. FISH WERE GROWN FROM 75 TO 150 G ON 21 EXPERIMENTAL DIETS TO EXAMINE THE INFLUENCE OF COMMONLY USED FEED INGREDIENTS ON THE FLAVOR QUALITY OF THE FISH. FEED COMPONENTS, AT LEVELS USED IN COMMERICAL FEEDS, WERE SUBSTITUTED INDIVIDUALLY IN SEMI-PURIFIED DIETS. A TRAINED SENSORY PANEL EVALUATED THE FLAVOR OF THE EXPERIMENTAL FISH USING QUANTITATIVE SENSORY TECHNIQUES. WHILE THE TRAINED PANELISTS COULD DISCRIMINATE AMONG SOME DIETS ON THE BASIS OF PARTICULAR FLAVOR ATTRIBUTES, UNTRAINED LABORATORY PERSONNEL REPRESENTING THE AVERAGE CONSUMER WERE NOT ABLE TO DISCERN DIFFERENCES. THE SIGNIFICANCE OF THE FINDINGS FOR THE FARM-RAISED CATFISH INDUSTRY IS THAT THE PRACTICE OF LEAST-COST FORMULATION FOR FEEDS MAY BE FOLLOWED WITHOUT CONCERN THAT THE FLAVOR QUALITY OF THE FISH WILL BE AFFECTED ADVERSELY.

THE MARKETABILITY OF FARM-RAISED CATFISH DEPENDS LARGELY ON FLAVOR QUALITY. WHILE ENVIRONMENTAL OFF-FLAVORS IMPARTED TO THE FISH ARE THE GREATEST CONCERN OF THE

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INDUSTRY, THERE HAS BEEN RELATIVELY LITTLE WORK ON THE INFLUENCE OF FEED INGREDIENTS ON THE FLAVOR QUALITY OF FISH. FEED INGREDIENTS HAVE BEEN EVALUATED FOR NUTRITIVE VALUE BY ASSESSION PRODUCTION PERFORMANCE, RATE OF GROWTH AND CONVERSION EFFICIENCY (ROBINSON 1989), WHILE THE INFLUENCE ON FLAVOR HAS BEEN LIMITED TO TESTS OF ACCEPTABILITY (DUPREE ET AL., 1979; SMITH ET AL. 1988).

THE PRACTICE OF LEAST-COST FEED FORMULATION HAS BEEN USED TO A LIMITED EXTENT IN THE U.S. CATFISH INDUSTRY (ROBINSON AND WILSON, 1985). RESEARCH HAS DETERMINED MANY OF THE NUTRITIONAL REQUIREMENTS OF CATFISH, THE NUTRIENT CONTENT OF FREED INGREDIENTS AND THE BIO-AVAILABILITY OF NUTRIENTS FROM THE FEED (ROBINSON, 1989). LIMITED RESEARCH INDICATES THAT LESS EXPENSIVE, LEAST-COST FORMULATIONS DELIVER PERFORMANCE EQUAL TO FIXED FORMULATIONS (ROBINETTE, 1984). HOWEVER, BEFORE INDISCRIMINANT SELECTION OF INGREDIENTS FOR NUTRITIONAL BALANCE IN A LEAST-COST FORMULATION CAN BE RECOMMENDED, EFFECTS OF INGREDIENTS ON THE FLAVOR OF THE FISH MUST BE KNOWN.

OUR STUDY WAS DESIGNED TO EXAMINE THE CONTRIBUTION OF COMMONLY AVAILABLE FEED INGREDIENTS TO THE FLAVOR OF FARM-RAISED CATFISH. FEED COMPONENTS, AT THE LEVELS RECOMMENDED FOR USE IN COMMERCIAL FEEDS, WERE SUBSTITUTED INDIVIDUALLY INTO SEMI-PURIFIED DIETS. A TRAINED SENSORY PANEL EVALUATED THE FLAVOR OF THE FISH FED THE EXPERIMENTAL DIETS USING QUANTITATIVE SENSORY TECHNIQUES. IN THIS WAY, THE CONTRIBUTION OF THE DIFFERENT FEED INGREDIENTS TO SPECIFIC FLAVORS COULD BE MEASURED. THIS INFORMATION IS NECESSARY TO DETERMINE IF LEAST-COST FEED FORMULATION IS COMPATIBLE WITH THE INDUSTRY REQUIREMENT FOR PRODUCING A PRODUCT OF HIGH QUALITY AND CONSISTENT FLAVOR, AND MORE IMPORTANTLY, TO DETERMINE IF AN INGREDIENT IMPARTS FLAVORS TO A DEGREE THAT IT WOULD DECREASE PUBLIC ACCEPTANCE OF THE PRODUCT.

MATERIALS, METHODS

FISH HUSBANDRY: CHANNEL CATFISH USED IN THIS STUDY WERE YOUNG-OF-THE-YEAR, WEIGHING AN AVERAGE OF 4.6 G. FISH WERE INITIALLY STOCKED AT THE RATE OF 600 INDIVIDUALS INTO FOUR ALUMINUM CULTURE TROUGHS (300 CM LONG X 40 CM WIDE X 25 CM DEEP), WHICH WERE SUPPLIED WITH 30°C TEMPERATURE-REGULATED WELL WATER AT THE RATE OF 7.51 PER MINUTE (APPROXIMATELY TWO WATER EXCHANGES PER HOUR).

A COMMERCIAL CATFISH FEED WAS OFFERED TO THE FISH DURING THE FIRST WEEK. A SEMI-PURIFIED, NUTRITIONALLY COMPLETE DIET (TABLE 1) FORMULATED TO CONTAIN 40% CRUDE PROTEIN AND 6% LIPID WAS SUBSTITUTED FOR THE COMMERCIAL FEED DURING WEEK TWO. THIS DIET WAS OFFERED AD LIBITUM TWICE DAILY, SEVEN DAYS A WEEK UNTIL WEEK 24 WHEN THE FISH REACHED AN AVERAGE SIZE OF 75 G. NO ATTEMPT WAS MADE TO MEASURE FEED UTILIZATION EFFICIENCY DURING THIS TIME.

FISH IN EACH TROUGH WERE DIVIDED INTO EIGHT TROUGHS WHEN THE AVERAGE WEIGHT OF THE FISH WAS CALCULATED TO BE 14.5 G. DURING WEEK 10 WHEN THE FISH AVERAGED 36 G EACH, THE LOTS WERE AGAIN DIVIDED AND RESTOCKED INTO 16 TROUGHS. THE FISH REMAINED IN THESE 16 TROUGHS UNTIL REACHING 75 G. FISH WERE THEN RANDOMLY DISTRIBUTED INTO 23 PRODUCTION TANKS FOR THE FEEDING TRIALS.

DIET PREPARATION: EXPERIMENTAL DIETS WERE PREPARED BY INCORPORATING 19 COMMONLY USED FEED INGREDIENTS INTO SEMI-PURIFIED TEST FORMULATIONS AT THE LEVELS USED IN COMMERCIAL FEEDS (TABLE 1). THESE DIETS WERE MADE ISOCALORIC AND ISO-NITROGENOUS BY ADJUSTING THE CONCENTRATION OF THE SEMI-PURIFIED PROTEIN (CASEIN), LIPID (SOYBEAN OIL) AND CARBOHYDRATE (DEXTRIN) COMPONENTS. THE LEVELS OF VITAMINS, MINERALS AND BINDER (CARBOXYMETHYL CELLULOSE) WERE NOT CHANGED. CELLULOSE (NON-NUTRIENT BULK) WAS USED TO ADJUST FEED VOLUMES TO 100%.

REFERENCE AND TEST DIETS WERE PREPARED BY MIXING CASEIN (VITAMIN-FREE, HOT-ALCOHOL EXTRACTED, MICROPULVERIZED), DEXTRIN (WHITE, TECHNICAL), MINERAL MIXTURE (USP XIV), NON-NUTRITIVE CELLULOSE BULK FILLER (ALPHACEL) AND A DRY TEST INGREDIENT COMPONENT (IF APPLICABLE) I N THE QUANTITIES SHOWN IN TABLE 1. THESE WERE THOROUGHLY BLENDED FOR 5-10 MINUTES IN THE MIXING CHAMBER OF AN AMBRETTI NOODLE EXTRUDER (BROOKLYN, N.Y.). THE CARBOXYMETHYL CELLULOSE WAS THEN ADDED AND MIXED FOR FIVE MINUTES FOLLOWED BY ADDITION OF THE OIL COMPONENT(S) AND ANOTHER FIVE-MINUTE MIXING PERIOD.

THE FEED COMPONENTS AND CARBOXYMETHYL CELLULOSE BINDER WERE THEN PRE-CONDITIONED FOR EXTRUDING BY APPLYING STEAM FOR 20-30 MINUTES WHILE THE MIXER WAS OPERATING OR UNTIL THE FEED INGREDIENTS HAD REACHED ABOUT 65°C. WATER AT 70°C WAS THEN ADDED TO GIVE A 65% SOLIDS FEED (15 KG LOTS RECEIVED 8 1 OF WATER). THE WET COMPONENTS WERE THEN MIXED FOR 15-20 MINUTES, OR UNTIL A CONSISTENCY OF BREAD DOUGH WAS OBTAINED TO ENSURE FORMULATION UNIFORMITY AND GOOD BINDING

CHARACTERISTICS. THE VITAMINS WERE THEN ADDED AS THE LAST STEP TO REDUCE THEIR EXPOSURE TO THE ELEVATED TEMPERATURES, AND THOROUGHLY MIXED INTO THE TEST FEEDS. THE TEST FEEDS WERE TIGHTLY COMPRESSED AND EXTRUDED THROUGH A 5 MM TAPERED DIE, CUT INTO 1-3 CM LENGTHS. THE FEEDS WERE STORED IN PLASTIC BAGS AT -18° C UNTIL FED.

FEEDING PROTOCOL: THE 21 EXPERIMENTAL DIETS, EACH CONTAINING ONE OF THE 19 SUBSTITUTED INGREDIENTS PLUS THE PRACTICAL AND REFERENCE DIETS, WERE RANDOMLY ASSIGNED TO ONE OF THREE GROUPS OF FISH (TABLE 1). BECAUSE OF THE LENGTH OF TIME NEEDED TO CONDUCT THE SENSORY EVALUATIONS, THREE STAGGERED HARVESTS WERE MADE TO EQUALIZE STORAGE TIMES BETWEEN HARVEST AND SENSORY TESTS. THE FEEDING TEST PERIODS WRE: GROUP 1 - MARCH 26 TO MAY 26; GROUP II - APRIL 9 TO JUNE 9, AND GROUP III - APRIL 30 TO JUNE 30. FEED ALLOWANCES WERE CALCULATED TO RESULT IN A DOUBLING OF FISH WEIGHT (FROM 75 G TO 150 G) DURING EACH FEEDING PERIOD.

TO ENSURE THAT ALL LOTS OF FISH RECEIVED EQUIVALENT FEED AMOUNTS, AND TO ELIMINATE THE NEED TO NET AND WEIGH, AND THUS STRESS THE FISH DURING THE TEST, WE ELECTED TO CONSTRUCT DAILY FEEDINIG TABLES. THE FEEDING TABLES WERE BASED ON A DAILY FEEDING RATE OF 2.5% PER DAY (DRY WEIGHT BASIS) WITH A FEED CONVERSION EFFICIENCY OF 1.6:1. THE DAILY ALLOWANCE OF EACH DIET WAS WEIGHED DAILY, PLACED IN COVERED PLASTIC CONTAINERS, AND STORED OVERNIGHT IN A HOUSEHOLD REFRIGERATOR (4°C) TO THAW. THE FOLLOWING MORNING, ONE-HALF OF THE FEED WAS OFFERED TO THE FISH, AND THE REMAINDER WAS FED IN THE LATE AFTERNOON.

SENSORY SAMPLE PREPARATION: EXPERIMENTAL FISH WEIGHING APPROXIMATELY 150G WERE PROCESSED USING A MODIFICATION OF COMMERCIAL PROCESSING PRACTICES. FISH WERE DECAPITATED, EVISCERATED AND PLACED INTO AN ICE BATH TO CHILL. SKINNING WAS ACCOMPLISHED WITH A JACCARD MODEL A35-P MEMBRANE SKINNER (ORCHARD PARK, N.Y.) ADJUSTED TO REMOVE SKIN AND FASCIA. SHANK FILLETS WERE PREPARED BY HAND AS ARE MOST COMMERCIALLY PREPARED FILLETS. THE EXPERIMENTAL METHOD DIFFERS FROM COMMERCIAL IN THE EQUIPMENT USED FOR DECAPITATION AND EVISCERATION. THE CRITICAL SKINNING PROCEDURE IS THE SAME.

SAMPLES FOR SENSORY ANALYSIS WERE MADE INTO BLENDED INDIVIDUAL FISH SAMPLES (BIFS) FOLLOWING THE METHOD OF JOHNSEN AND KELLY (1990). BRIEFLY, THESE INDIVIDUAL PORTIONS WERE PREPARED BY COMBINING FILLETS FROM 21 FISH FED THE SAME

EXPERIMENTAL DIET. THE POOLED FILLETS WERE SHREDDED BY A FOOD PROCESSOR. AFTER THOROUGH MIXING, 10 G SAMPLES WERE PLACED IN "SEAL-A-MEAL" BAGS (7 X 7 CM). EXCESS AIR WAS EXPELLED FROM THE BAGS WHICH WERE THEN HEAT SEALED WITH A DAZEY MICRO-SEAL (INDUSTRIAL AIRPORT, KAN). SAMPLES WERE FROZEN AT -20°C FOR 1-17 DAYS UNTIL PRESENTATION TO THE SENSORY PANEL.

SENSORY PANEL PROTOCOLS: EXPERIMENTAL BIFS WERE PLACED IN BOILING WATER AND COOKED FOR FOUR MINUTES AFTER THE WATER RETURNED TO A BOIL. THE BIFS WERE PRESENTED UNDER RED LIGHT TO THE PANELISTS WHO OPENED THE BAGS WITH SCISSORS AND PLACED APPROXIMATELY HALF OF THE CONTENTS INTO THEIR MOUTHS FOR "FLAVOR-BY-MOUTH" ASSESSMENT. INTENSITY OF AROMATICS, TASTES AND FEELING FACTORS WERE RECORDED. DESCRIPTIVE ANALYSIS SPECTRA WERE PREPARED USING AN UPDATED LEXICON (JOHNSEN AND KELLY, 1990) MODIFIED FROM JOHNSEN ET AL. (1987). TERMS AND DEFINITIONS ARE PRESENTED IN TABLE 2. INTENSITIES OF THE ATTRIBUTES WERE JUDGED ON AN OPEN-ENDED SCALE ESTABLISHED IN REFERENCE TO FLAVOR INTENSITIES THAT ARE ASSIGNED TO SPECIFIC CHARACTERISTICS APPARENT IN SEVERAL COMMERCIALLY AVAILABLE FOOD PRODUCTS AS DEFINED BY MEILGAARD ET AL., (1987). DETAILS OF THE SENSORY EVALUATION TECHNIQUE CAN BE FOUND IN JOHNSEN AND KELLY (1990). THE SECOND HALF OF THE SAMPLE WAS EVALUATED SIMILARLY AND INITIAL SCORES WERE CORROBORATED OR ADJUSTED TO REPRESENT THE INTEGRATED SAMPLE. UNSALTED CRACKERS AND ULTRA-FILTERED WATER WERE USED TO RINSE THE MOUTH BETWEEN SAMPLES. TEXTURE WAS NOT ASSESSED.

PANEL SESSIONS BEGAN WITH MEMBERS TASTING AND REVIEWING THE INTENSITY REFERENCE STANDARDS. A COMMERCIALLY OBTAINED CATFISH SAMPLE WAS THEN PRESENTED AND EVALUATED. THE PANEL SCORES FOR INDIVIDUAL ATTRIBUTES WERE CALCULATED AND DISCUSSED. CONSENSUS VALUES WERE THEN AGREED UPON. THIS EXERCISE HELPED INDIVIDUALS ESTABLISH THEIR DAILY CALIBRATION. SAMPLES OF THE EXPERIMENTAL FISH WERE THEN PRESENTED IN A RANDOM ORDER. THE PANEL MET TWICE A WEEK AND EVALUATED SIX EXPERIMENTAL SAMPLES IN TWO-HOUR SESSIONS. ALL PANELISTS RATED THREE REPLICATES OF EACH SAMPLES COVER THE COURSE OF THE EXPERIMENT.

SENSORY DATA ANALYSIS: FISH FED ON THE REFERENCE DIET (TABLE 1,21 A,B,C) WERE INCLUDED IN EACH OF THE THREE HARVEST GROUPS. USING GENERAL LINEAR MODELS, ANALYSIS OF VARIANCE (SAS INC. 1985), DUNCAN'S MULTIPLE RANGE TEST FOR VARIABILITY INDICATED THAT THERE WERE NO SIGNIFICANT DIFFERENCES IN PANELIST RESPONSES AMONG THE REFERENCE GROUPS FROM THE THREE HARVESTS. THUS, THE THREE HARVEST GROUPS WERE CONSIDERED TO BE ONE AND DIETS FROM ALL GROUPS WERE ANALYZED TOGETHER.

Individual panelists tasted three sets of reference fish (Table 1, 21 A,B,C) in three replicate tests for a total of nine evaluations. Means of intensities for each sensory attribute were calculated for each panelist. These values were then subtracted from a panelist's sensory score for the corresponding attribute of each test diet evaluation. Because ingredients of the reference diet were common to all test diets as the carrier, this difference score for each sensory attribute is thought to reflect the contribution of the test ingredient alone.

Using an individual panelist's means rather than group means allows for maximum sensitivity of response. Subtracting individual means results in differences that do not include variance from panelists using slightly different ranges of the intensity scale. In a sense, this normalizes the sensory scores to panelists thus greatly reducing panel effects from the analysis of variance.

RESULTS AND DISCUSSION

Five sensory attributes identified in the lexicon of catfish flavor descriptors (Johnsen and Kelly, 1990) relate to the desirable flavor characteristics of farm-raised catfish. Nutty, chickeny, corn and fat complex are aromatics, while sweet is a basic taste. These five sensory attributes were used in this study to define the flavor spectrum of farm-raised catfish.

Analysis of the influence of feed ingredients on specific flavors is based on the calculated difference in scores between the experimental and reference diets.

The experimental diets can be grouped into three major categories: fats and oils (8, 10, 11, 13), fish meals and animal by-products (3,6,7,9,12,14) and vegetable matter (2,4,5,15,16,17,18,19,20). Examination of diet impact on the individual sensory attributes or the composite rank scores reveals that there was no consistent pattern of effect for the different categories.

While the trained panelists could discriminate among some diets on the basis of particular attributes, untrained laboratory personnel representing the average consumer were not able to discern differences during informal tasting. This was particularly so if samples were evaluated on successive days. They reported that all samples were good-tasting farm-raised catfish.

THE GENERAL CONCLUSION OF THIS STUDY IS THAT THE DESIRABLE FLAVORS OF FARM-RAISED CATFISH ARE PRODUCED BY THE FISH ON THE BASIS OF THEIR OWN BIOCHEMISTRY RATHER THAN THE FEED THEY CONSUME. PREVIOUS STUDIES ON FARM-RAISED CATFISH EXAMINING THE EFFECT OF A HIGH FISH OIL DIET ON FLAVOR INDICATED THAT DIFFERENCES WERE DETECTABLE, BUT DID NOT INFLUENCE ACCEPTABILITY (DUPREE ET AL., 1979). THE PRESENT STUDY EXTENDS THIS OBSERVATION TO CONCLUDE THAT QUANTITATIVE DIFFERENCES FOR PARTICULAR SENSORY ATTRIBUTES WERE NOT AFFECTED BY THE TESTED DIET INGREDIENTS AT THE LEVELS USED TO AN EXTENT THAT A CONSUMER COULD DISCERN DIFFERENCES IN FLAVOR QUALITY.

THE SIGNIFICANCE OF THE FINDINGS FOR THE CATFISH INDUSTRY IS THAT THE PRACTICE OF LEAST-COST FORMULATION FOR FEEDS MAY BE FOLLOWED AT THE LEVELS USED IN THIS STUDY WITHOUT CONCERN THAT THE FLAVOR QUALITY OF THE FISH WILL BE AFFECTED ADVERSELY. THE SUBSTITUTION OF FEED INGREDIENTS ON THE BASIS OF COST, WHILE ENSURING THAT THE DIET IS NUTRITIONALLY BALANCED, WILL ALLOW THE FISH FARMER TO MINIMIZE PRODUCTION COSTS AND STILL DELIVER A CONSISTENT AND HIGH QUALITY PRODUCT TO THE CONSUMER.

TABLE 1. Composition of test diets (g/kg of ingredient in dry diet)

Diet no	Description	Fish	Casein	Dextrin	Oil	Cellulose	Other
Group I							
2	Soybean meal, solvent extracted w/o hulls 48% crude protein	500	168	0	55	177	100
4	Cottonseed meal, solvent extracted w/o hulls 41% crude protein	150	356	92	58	244	100
5	Corn, dent yellow grain 9.6% crude protein	250	396	0	50	204	100
10	Poultry fat, crude renderings	10	420	150	20	270	100
12	Meat and bone meal, rendered 50.4% crude protein	100	368	140	51	241	100
15	Wheat midds, less than 9.5% fiber, 16.4% crude protein	200	386	15	51	248	100
16	Rice bran, 12.7% crude protein	300	395	49	33	223	100
20	"Pro-Pac" fish meal substitute 61.1% crude protein	100	378	150	50	272	100
21A	Reference	—	420	150	50	270	100
Group II							
3	Blood meal, dehydrated flour 86.5% crude protein	100	330	150	59	251	100
6	Catfish meal, processing plant renderings, 57% crude protein	100	361	150	50	239	100
7	Menhaden meal, whole fish 61.1% crude protein	100	357	150	50	243	100
8	Catfish oil, crude processing plant renderings	50	420	150	0	270	100
11	Lard, purified	10	420	150	20	270	100
13	Menhaden oil	50	420	150	0	270	100
17	Milo, sorghum grain 11.1% crude protein	250	392	0	53	205	100
18	Distiller's solids,dehydrated with solubles, 27.6% crude protein	100	392	91	51	266	100
21B	Reference	—	420	150	50	270	100
Group III							
1	Practical, commercial catfish feed	920	0	0	0	0	80
9	Poultry byproducts, includes: blood, feather, meat and bone meal 60% crude protein	200	295	150	48	207	100
14	Herring meal, mechanical extraction 72.0% crude protein	100	345	150	53	351	100
19	Soybean meal, full fat, heat processed, 38.0% crude protein	333	297	20	0	250	100
21C	Reference	—	420	150	50	270	100

[1]Other ingredients in g/kg dry diet: carboxymethyl cellulose - 50.0; salt mixture USP XIV -20.0; and vitamin mixture - 30.0.

Salt mixture USP XIV contains in g/kg: ammonium alum - 0.092; cupric sulfate - 0.078; ferric ammonium citrate - 15.29; manganese sulfate - 0.201; potassium iodide - 0.041; sodium fluoride - 0.507; calcium carbonate - 68.6; calcium citrate 308.3; calcium biphosphate - 112.8; magnesium carbonate - 35.2; magnesium sulfate - 383; potassium chloride - 124.7; dibasic potassium phosphate - 218.8; and sodium chloride - 77.1.

Vitamin mixture for each kg dry diet contains in IU: vitamin A palmitate - 5,000; calciferol - 4,600; and alpha tocopherol acetate -50; in mg: menadione - 20; ascorbic acid - 500; thiamine - 50; riboflavin - 100; pyridoxine - 50; pantothenic acid - 200; nicotinic acid - 750; biotin S; folic acid - 25; and vitamin B-12 - 0.1; and in g: choline - 15, inositol - 2; and non-nutritive bulk (filler) - 11.240

TABLE 2 . Catfish flavor descriptors

Descriptor	Description
Aromatics	
Nutty	The aromatic associated with fresh pecans and other hardshell nuts
Chickeny	The aromatic associated with sweet cooked chicken meat
Fat complex	The aromatic associated with dairy type products, (mild) vegetable shortening, and cooked chicken skin
Corny	The aromatic associated with cooked corn kernels
Tastes	

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