NUTRITIONAL IMPROVEMENT OF GARI WITH DRIED YEAST PROTEIN

By

Loveday Elechi Nwobilor

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WITH DRIED YEAST PROTEIN

Thesis Approved:

Sue Knight
Thesis Adviser

P. L. Claypool

Esther Winterfeldt

Lee L Ebro

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

> . . .From the Public Health point of view, these children are the greatest problem in the world today. Control of communicable disease, the installation of safe water supplies, and sanitary sewage disposal would probably save lives; but without adequate protein, the malnourished children will never attain their potential growth (FAO, 1964).

An estimated 20 million people in Africa require immediate help for food and shelter. Food in the continent is at risk due to insufficient rainfall, fragile soils, difficult microclimate, and extreme temperature. As the state department reported, drought and widespread famine have become the most serious problem facing the entire continent since after passage of colonialism (State Dept., 1985). Further, national policies in many developing countries tend to favor production of crops for export to aid in balance of payments rather than food for internal consumption.

One of the food crops of nutritional and economic importance is cassava. Cassava supplies much of the caloric need for more than 200 million people in Africa (Cooke and Maduagwu, 1978) and about 500 million across the equatorial belt (Lancaster, Ingram, Lim and Coursey, 1982). They estimated that cassava accounts for 37% of

calories in Africa, 11% in Latin America, and 6% in Far East. In 1979, the Food and Agriculture Organization (FAO) of the United Nations estimated a total production of 119 million tons (FAO, 1979) as shown in Table I. Most of the cassava is consumed in Africa and Asia.

In Nigeria, one of the major products consumed is called gari (pronounced gar-ree). Gari is a grits-like product made from grated, fermented, and heat dried cassava root. It is a staple and is produced in large amounts throughout the country. Raw cassava contains 62% water, 35% carbohydrate, 1% protein, and 1% minerals. It is high in Vitamin C and calcium, but the processed gari contains only 36% of the original protein found in raw cassava has lost much of the vitamin C (Lancaster et al., 1982).

Purpose and Objectives

The purpose of this study was to:

(1) Develop a nutritionally improved gari by incorporating dried yeast protein (Provesteen-T).

(2) Test various levels of the gari/yeast product (0%, 8%, 10%, and 12%) for acceptability.

(3) Test whether gari enriched at the 10% level with dried yeast protein would be acceptable to Nigerians when used as part of traditional food entrees.

TABLE I

WORLD PRODUCTION OF CASSAVA (1976-1978)
IN THOUSAND METRIC TONS

	1976	1977	1978
World total (x1000)	112,662	117,863	119,374
Africa	43,218	43,508	44,056
Angola	1,740*	1,760	1,700*
Ghana	1,819	1,800	1,850*
Madagascar	1,370	1,412	1,322
Mozambique	2,400*	2,450	2,450*
Nigeria	10,800*	10,600*	10,844*
Tanzania	3,900*	4,000*	4,076*
Uganda	1,100*	1,100*	1,100*
Zaire	12,130	12,300	12,512
N. and C. America	721	732	764
S. America	29,977	31,027	30,840
Brazil	24,839	25,844	25,358
Colombia	1,846	1,960	2,200
Parguay	1,600*	1,700*	1,763*
Asia	38,536	42,383	43,499
India	6,638	6,375	6,493
Indonesia	12,191	12,488	12,488*
Philippines	794	1,707	1,707*
Thailand	10,138	12,372	13,000**
Oceania	209	213	216
Developing Market Economies	105,022	109,367	110,526

Source: FAO Production Yearbook 32, 1979.
*FAO Estimates
** Unofficial Figure

Assumptions

The author assumed the following:

(1) That the panelists were well trained in the principles of sensory evaluation methods.

(2) That sensory data collected are reflections of panelists' perceptions, attributes, and experience.

(3) That the gari samples are representatives of the traditional product except for the yeast enrichment.

(4) That a panel composed of Nigerian students at this university would accurately estimate product acceptability for a range of the Nigerian population.

Limitations

Since gari is not familiar to most non-Africans, the sensory panelists were limited to Nigerian nationals. Also, the panelists were all students (or students'spouses) at Oklahoma State University since it was impractical to travel to Nigeria to perform the research. Therefore, educational, cultural, and socio-economic background of the panelists may not be reflective of the entire Nigerian population.

The gari samples for this study included only those made from 0%, 8%, 10%, and 12% substitution of dry yeast protein produced by Provesta Corporation.

Hypotheses

The following hypotheses were postulated for this research.

H1: There was no difference in means for a selected attribute among the four levels (0%, 8%, 10%, and 12%) of gari/yeast products. The attributes considered were color, odor, texture, flavor and overall acceptability.

H2: The 10% gari/yeast mixture will be unacceptable (mean rating less than 6) when served as a part of a traditional food entree.

Definitions

Allelopathic: Type of growth suppression by which larger plant release chemicals which kills smaller plants (Smith, 1977).

Cassava: A tropical plant of the genus Manihot esculanta or M. utilisima. The root is used for the production of gari, tapicoa, bread, glue (The American Heritage Dictionary of the English Language, 1981).

Glucoside: The group of organic compounds in plants that produces sugars and related substances upon hydrolysis (The American Heritage Dictionary of the English Language, 1981).

Hedonic: Relates to a pleasurable feeling associated

with experience (Amerine, Panghorn and Roessler, 1968).

Micro-climate: The climate of a specified place within an area contrasted with the climate of the area as a whole (Smith, 1977).

Provesteen-T: A brand of dried torula yeast grown on sugar-based substrate produced by the Provesta Corporation (Provesta, 1986).

Format of This Thesis

Chapter III of this thesis was organized and prepared as an individual manuscript for publication, which is in accordance with the Style Guide for Research Papers, Institute of Food Technologists and the Journal of Food Science. The references cited in Chapter III will also be cited in the Selected Bibliography section.

CHAPTER II

LITERATURE REVIEW

This literature review includes a short history of cassava, the traditional method of gari production, the economic importance of cassava. The use of yeast single-cell proteins in food and sensory evaluation of foods are also reviewed.

History of Cassava

Basically, cassava is a tropical plant originating in tropical America about 4000 years ago (Cooke and Coursey, 1981). Sophisticated methods for processing cassava were introduced by the Europeans in 1492 and the food crop reached the mouth of the Congo River and West Africa by the 16th century (Cocke and Coursey, 1981). They also reported that European travelers introduced cassva to the Far East and India during that century. Several names were given to cassava by this early users. Early literature called cassava Manihot esculenta and placed it in the family of Euphoriaceae, which contains about 100 species that are distributed throughout the tropics. Different regions of the world call cassava different names.

COUNTRY	NAME
England	Cassava Manioc
Netherlands	Cassave
France	Manioc
Germany	Maniok
Brazil	Mandioca
Latin America	Yuca
Mexico	Guacamote
Central America	Caxcamote
Puerto Rico	Manoco
Nigeria	Cassava

Source: (Cooke and Coursey, 1981).

The discovery of cassava led to an increase in demand and production. Brazil now produces one-third of the production of cassava while the other parts of the world produce the other two-thirds. The total annual production is about 119 million tons (FAO, 1979).

Traditional Method of Gari Production

Gari is made from tubers of the cassava plant. Cassava grows from one and fifty meters in heights. The tubers are thickened roots the plant and may become the tap root system if the seeds are used for planting; but if the plant is propagated from stem cuttings it does not form the tap root system (Cooke and Coursey, 1981).

The roots may grow to a length of six to twenty-four inches and be one-half inch to three inches in diameter.

The roots are peeled with a cutlass (machete) and washed several times for sanitation and to improve the quality. The raw cassava is grated with locally made tin graters to a coarse mass. The grated cassava is collected in cotton or raffia sacks, tied up, and placed between logs. Another set of logs is placed on top of the sacks. High pressure is applied at both ends of the logs by tying the ends together with ropes. They are pressed every four to six hours for 24 hours.

The purpose of pressing the sacks is to insure quick loss of water before the cassava mass is totally fermented. Fermentation with too much moisture results in an entirely different kind of product called "fufu".

The fermented cassava is sieved using locally made bamboo or tin sieves to reduce the quantity of root fibers and coarsely qrated tuber parts. The sieved cassava is then heated in between two and three feet in diameter, shallow non-stick pans to evaporate the moisture. Low heat with stirring is used to allow drying without browning. The final gari is a white to off-white, dry granular product somewhat similar to white corn grits. To produce yellow gari, a small amount of red palm oil is added during heating.

Economic Importance of Cassava

The basic economic importance of cassava and cassava foods such as gari depends on the individual. Etejere

and Bhat (1985) reported that gari is "a very popular meal among Benin, Itsekiri, Ibo, and Urhobo tribes, but less popular among Yoruba and Hausa." Nevertheless, cassava production in Nigeria is high and has remained stable in recent years. Estimated cassava production in Nigeria for the years 1976, 1977, and 1978, was 10.80, 10.60 and 10.84 million metric tons respectively (Lancaster et al., 1982). It would be hard to foresee any decrease in production considering the fact that new varieties of cassava are being developed.

The importance of cassava could be viewed from the standpoint of usage in the developing and underdeveloped countries (Table I). In the United States of America and Europe, topioca, a cassava product, is used for desserts. The FAO of the United Nations Organization (UNO) predicted a possible increase in cassava use in the area of bread-making and animal feeds to replace wheat in the developing countries. However, cassava is lower in protein than wheat even though it is a high in carbohydrate food (Grace, 1977).

Nutritional Value of Cassava

Protein deficiency is a major problem in populations with cassava-based diets around the world. The protein content of gari is about 1.2% (Ojofeitimi, Ahrens and Prather, 1981). The effects of protein deficiency include kwashiorkor in children and pregnant women. The Protein-

Calorie Advisory Group (PAG) of the UN (1975) recommended a protein/calorie ratio of 1:20 for "moderate activity" persons. The protein must come from high quality source. Persons on "light activity" require a higher ratio. Kwashiorkor and its associated disease, marasmus, are considered maladaptation to protein and energy/protein deficiences.

Another problem with cassava is it contains linamarin, a bitter cyanoganic glucoside. This compound has been implicated in certain goiters, mental retardation, and cretinism. Also, the cyanide in linamarin causes deficiency of some B vitamins (Nartey, 1981). But Nartey postulated that the cyanide acts as a preservative for metabolic activities and as a deterrent against insects. Further, he suggested that cyanide may have allelopathic influence against weeds.

Some researchers do not think that the cyanide content of cassava is high enough to kill people. Solomonson (1981) reported that cyanide is less toxic on a molar basis than some vitamins and minerals. Further, cyanide is detoxified in several ways. An inherent enzyme found in cassava, rhodenase, catalyzes the detoxification reaction of cyanide to the less toxic thiocyanide in the presence of sulfur. Also, heating reduces cyanide content of cassava; and the addition of glucose, equimolar to cyanide eliminates the glucoside (Oke, 1968).

Yeast Single-Cell Protein

The world food problem is complicated by the reliance on animal products and soybean for protein sources. It is widely known that the consumption of animal food protein is related to the affluence of a society; and there is a direct relation between grain production and animal production (Altschul, 1968), which is dictated to a very large extent by the availability of land.

Limited land for farming and overpopulation result in lack of protein in the third world. People in most third world countries do not consume up to 20 grams of animal protein per day as is done in the developed world (Altschul, 1968). An inexpensive means of producing protein that does not require extensive land use is needed. Protein from microorganisms rather than agriculture is a possible solution.

The term Single-Cell Protein (SCP), was adopted at Massachusetts Institute of Technology (MIT) in May, 1966, at the first International Conference on SCP (Scrimshaw, 1968). The term includes all microbial cells (bacteria, fungi, algae, and yeast) often grown on waste and used as human protein foods. The use of the term was a result of unpleasant biases associated with most microbial protein sources.

The biases are not as strongly associated with yeast SCP. Nearly all organic materials will grow yeast if

supplemented with appropriate minerals and ammonia (Ayres, Mundt and Sandine, 1980). Over 100,000 tons of food and feed yeast (Saccharomyces cerevisiae, Klyveromyces fragilis, and Candida utilis) are produced in the United States. S. cerevisiae is grown on molasses and grain hydrolysates while K. fragilis grows in whey and lactose. In England and Russia, C. lypolytica is grown on alkane petroluem fractions.

Historical Use of Yeast SCP

Yeasts have been used in the brewing and baking industries, dating from 2100 B.C. in ancient Egypt (Ayres et al., 1980). Over 50,000 tons of yeast per year are produced from C. utilis in the United States (Ayres et al., 1980) using wood liquor as the substrate. This yeast, which has the common name torula, is also produced on molasses and refined sucrose (Provesta, 1986).

Most of the yeasts produced today are used for animal feeds, flavor enhancers, and color agents. Proteins extracted from autolyzed yeast cells have whipping, foaming, wettability, and solubility characteristics. These proteins also have fiber-forming properties and may have uses as texture modifiers (Chen and Peppler, 1978). Okezie and Kosikowski (1981) observed that protein concentrates from C. tropicalis could replace soy protein in the manufacture of confections such as whipped toppings They also suggested that use of yeast SCP for fabricated

meats and egg white substitutes.

One of the main problems associated with SCP is the high nucleic acid content. Torula yeast contains six to 12% nucleic acid on a dry-weight basis (Jay, 1986). Individuals predisposed to gout and uricemia should avoid the consumption of more than 20 g of yeast per day as recommended by the PAG (1975). This figure approaches a nucleic acid consumption of two grams per day for humans. Above this level, individuals may develop nucleic acid accumulation in the blood, joints, and possibly as stones (Scrimshaw, 1975).

Several methods have been devised to reduce the nucleic acid content of the yeast. However, each of the methods has inherent disadvantages (Table II) (Sinskey and Tannenbaum, 1975). The nucleic acid content of the cells is lowered by adjusting the growth rate by controlling the substrate dilution. Also, the nucleic acid content is reduced by base-catalyzed hydrolysis. This method requires neutralization after treatment. Other methods are chemical extraction and cell disruption, using exogenous enzymes (bovine pancreatic kinase, microbial phosphodiesterase) or endogenous RNase.

Economic Value of Yeast SCP

The use of yeast in the baking and brewing industries is well known. Specific yeasts are used in the production of various kinds of baked products and wines due to their

TABLE II

SUMMARY OF METHODS FOR RNA REDUCTION IN SCP

METHODS	ADVANTAGES	DISADVANTAGES
1. growth & cell (growth rate, substrate limitation)	only proper fermentation	limited reduction economics
2. base-catalyzed hydrolysis	simple and rapid	loss of weight & N, salt addition, deleterious effects of high pH
3. chemical extraction	simple, rapid, remove polymerized RNA	chemical residue, loss of weight & N
4. cell disruption (physical separation, enzymatic treatment and chemical)	only if protein isolate desired	economics, others specific to process
5. exogenous RNase	rapid, simple, choice of enzyme	cost and availability of enzyme, loss of dry matter
6. endogenous RNase (heat shock, anions, etc.)	simple, cells direct from ferm., no added chemical	weight loss, slow, only certain cells, added chemical

Source: Sinskey and Tannenbaum, 1975.

characteristic attributes. Saccharomyces spp. of high fermentative ability are highly involved (Ruiz, Pelayo, Arroyo and Inigo, 1986). Apart from the direct fermentation of bread dough, yeast also contributes to the removal of glutathione, leading to a high quality bread dough (Karpenko, 1985).

In baking, the living, growing yeast cells are used to produce carbon dioxide for leavening; in brewing, the yeast cells, grown anaerobically, produce alcohol (ethanol). However, for SCP, yeast is produced in bulk to be used as a protein food. The final step in yeast production is pasteurization, which kills the cells, rendering them useless for alcohol or carbon dioxide production. The economic value of producing food yeast for direct consumption is based on the following criteria:

1. The microorganisms must have very short generation time and, therefore, provide rapid cell mass increase.
2. The yeast should be modified genetically for desired results.
3. The protein produced must be of high quality.
4. The yeast can be produced using readily available substrates (sulfite liquor, whey, molasses, and hydrocarbons.
5. The production must be continuous and not dependent on climatic changes (Kihlberg, 1972).

Candida lypolytica is grown on petroleum substrates (Bunker, 1968). Other feedstocks of equal importance

in the process are natural gas, methanol, ethanol, mine waste products, peats, and sulfite waste from timber industries. (Rimmington, 1985). Candida utilis (torula), another yeast species, is produced via fermentation of molasses or sugar (Phillips, 1985). The yeast proteins are fed to people directly or indirectly as animal feed in powdered, granulated, or pellet forms. Saccharomyces and Kluyveromyces spp. are also used for SCP production (Ayres et al., 1980).

The first intensive SCP production started in Germany during the First and Second World Wars. The yeasts were grown on molasses and sulfite waste liquor (Litchfield, 1983). Currently, the most economical and significant operation is carried out in the Soviet Union (Annon., 1974).

The Soviets have built and expanded a petroleum-based yeast and other SCP plants which serve the entire country. The Soviet planners see this as a new source of protein to offset the severe shortage in agricultural livestock (Rimmington, 1985).

Apart from the protein from the yeast, the Soviets plan to use the lipid fraction to produce high quality soaps, libricating oils, phospholipids for the medical industry, and oleic acids for paints. The plants would also produce, as by-product, ergosterol for vitamin D synthesis. The economic value of the plants are a boost to animal production: addition of one ton of SCP to feed creates 0.4 to 0.6 tons of pork, 25,000 to 30,000 eggs,

and saves five to seven tons of grain (Rimmington, 1985).

Similar petroleum-based ventures were in operation as early as 1969 in Europe in anticipation of a protein shortage by 1980. The projects were discontinued when the predicted shortage did not materialize, and the price of petroleum went up. Also, other projects failed due to lack of appeal; and, further, health authorities refused to give approval for animal and human consumption (Zanetti, 1984).

Ayres et al. (1980) reported that 1,000 pounds of yeast would produce 100,000 pounds of protein per day while the same weight of soybean plants or live cattle would produce 100 pounds and one pound of protein per day, respectively. In another report, Atlas and Bartha (1981) stated that 100 kg carbohydrates as feedstock can yield up to 65 kg yeast, but the same amount of carbohydrate would yield only 10-20 kg meat products when used as animal feed.

Smith, Osothsilp, Bicho and Gregory (1986) explored the ubiquitous growth nature of yeasts. These researchers found that 30.4 g of high quality yeast can be produced from 100 g dry cassava in 48 hours at 45 degrees Centigrade, if milled dry cassava roots are supplemented with a mineral salt solution of high ionic strength and fermented in an aerated bench tray.

There seems to be a great economic potential for yeast SCP production, but, for the most part, this

potential is largely undeveloped. The developmental lag is not due to a lack of technology, but to lack of acceptance, regulatory problems, and fluctuating cost of substrates (Zannetti, 1984).

Nutritional Value of Yeast SCP

The value of a food used as a protein source depends on its total protein, amino acid composition, and its digestability. The total protein content of the food in question is calculated by multiplying the total nitrogen content of the food by a factor 6.25 or dividing the total nitrogen by 0.16. It is postulated that average protein contains 16% nitrogen by weight (McGilvery, 1983), whereas neither carbohydrate nor fat contains nitrogen.

The protein content of yeast (torula) ranges from 47.43% (Bressani, 1968) to about 55% (Phillips, 1985). The carbohydrate content is between 22.5% (Phillips, 1985), and 38.82% (Bressani, 1968). Phillips (1985) reported low mineral content in torula yeast, but the yeast is very high in B-vitamins, though fat soluble vitamins, E and D are low (Table III).

The bioavailability of yeast vitamins had been questioned. Von Loesecke (1974); Kingsley and Parsons (1947); and Price, Marquett, and Parsons (1947), cited by Bressani (1968), indicated that very little thiamine was absorbed from fresh yeast in humans. However, about 93-100% was utilized by rats. No indication of

TABLE III

NUTRIENT COMPOSITION OF PROVESTEEN-T

Composition	Weight (%)	Vitamin Content	mg/kg	Amino Acid	Weight (%)
Protein		Biotin	0.14	Lysine	3.4
Crude	55.3	Folic acid	21.1	Arginine	2.6
True	47.0	Niacin	511	Threonine	2.4
		Pantothenic acid	194	Glutamic acid	8.4
Ash	11.4	Pyridoxine	56.1	Glycine	2.3
Lipids	4.6	Vitamin B-12	0.003	Valine	2.8
Carbohydrates	22.5	Thiamine	8.7	Leucine	3.6
		p-Aminobenzoic acid	51.9	Isoleucine	2.4
Mineral Content		Riboflavin	50.5	Tyrosine	1.6
		Choline	3820	Histidine	1.0
Calcium	0.07	Inositol	2980	Aspartic acid	4.4
Magnesium	0.35			Serine	2.3
Phosphorus	3.70			Proline	1.8
Potassium	1.80			Alanine	3.3
Sodium	0.02			Methionine	0.6
	PPM			Phenylalanine	2.1
Iron	271			Cystine	0.2
Copper	36			Tryptophan	0.5
Zinc	203				
Manganese	19				

Source: Phillips, 1985.

malabsorption of other nutrients was given, and little information on yeast thiamine absorption has been reported since then.

Prior to this time, Osborne and Mendel (1919) studied the digestibility of dried yeast in animals. They fed 30 and 40% yeast diets to rats for more than one year. The yeast was the only source of protein for the animals. The animals did not exhibit any abnormal growth. In contrast, Still and Koch (1928) reported sub-normal growth in rats fed a ration containing 30% yeast as the only protein source. Kon and Markuze (1931), however, suggested that the growth rate in the rats on a brewer's yeast diet could be improved by wheat substitutions. Klose and Fevold (1947) discovered that yeasts are low in sulfur containing amino acids, methionine and cysteine, hence were improved when supplemented with wheat.

Wheat flour supplemented with C. utilis (torula yeast) showed an increased protein efficiency ratio (PER). The PER of the wheat flour increased from 0.82 to 2.31 (Jarquin, Noriega and Bressani, 1966). In weaning rats, the daily weight gain was improved when one and three percent yeast was added to the white bread diet, apparently due to improved protein quantity and quality, and yeast vitamins (Seeley, Ziegler and Summer, 1950).

One of the problems often encountered in new food development in consumer acceptability. The C. utilis is well accepted at relatively high levels. Torutein,

a protein from torula yeast, was very acceptable when added to cereals, tortillas, meat patties, and cakes (Schnell, Akin and Flannery, 1976). At 7.5% of the flour, no negative sensory remarks were made about date bars and the flavor of the yeast was rated highly acceptable by patients in six main foods. The foods were soups, meatloaves, casseroles, gravies, tomato sauces, and mashed potatoes (Klapka, Duby and Paucet, 1958).

A product, Incaparina, was developed by the Institute of Nutrition in Central America and Panama (INCAP). The product consists of a mixture of ground maize, sorghum, cottonseed flour, torula yeast, calcium carbonate, and vitamin A (Krause and Mehan, 1984). Feeding Incaparina does correct nutritional deficiency symptoms, but parents have shown a tendency to use the product as a medicine for sick children rather than as a food to keep children healthy.

Although an excellent source of nutrients, yeast SCP is included in such products as meat pies, hot dogs, sausages, and ham as flavor enhancers and meat extenders. Yeast derivatives may be used to mask the cereal or legume off-flavors generated during the retorting of combination meat products, thereby improving acceptability of cereal extended meats. Due to the high protein content of the yeasts and the mixability of bulk cells, yeast SCP is used for nutritional fortification of many food products such as "Meal-On-The-Go bars" (a high-fiber, light meal

replacement) and as flavor carriers/dispersers (Dziezak, 1987).

Yeast SCP and Coronary Heart Disease

Yeast SCP may play a role in reduction of serum cholesterol. Baker's yeast cell-walls, glycan, and protein isolates, incorporated into rat diets partially or totally prevented the elevation of the serum cholesterol in rats fed cholesterol elevating agents. The reduction level depended on the level of products fed (Robbins and Seeley, 1977).

Provesteen-T Yeast

Provesteen-T brand of dried torula yeast produced by the Provesta Corporation, a subsidiary of Phillips Petroleum Company, is grown on a sucrose substrate. The yeast is produced by a patented SCP production process. This process can be used to produce almost any type of microorganism depending on the substrate or feedstock used. The Provesta Corporation uses regular sugar (sucrose) to produce the Provesteen-T brand torula yeast (Phillips, 1985).

The process (Figure I) includes a fermentor, an air supply unit, a pasteurizer, and a drier. The fermentor is inoculated with the yeast culture at the beginning of the process. The sterile substrate is composed of a carbon source (sucrose), growth nutrients, oxygen, and

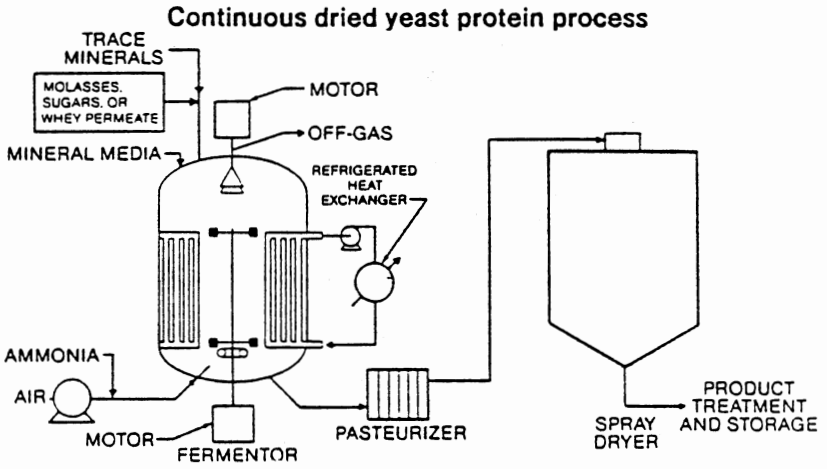

Figure 1. Phillips' SCP Fermentation Process

water. The yeast cells are grown at a density over 13% total solids, which is quite dense compared to the 4% total solids used in conventional processes. The feedstock is dripped into the fermentor in small amounts on a continuous basis so that it is instantly utilized by the dense yeast culture in this ultra-high-cell density process. The yeast cells are directly passed to the pasteurizer and the drier with no rinsing. The process results in a clean, non-polluting system since the only wastes are carbon dioxide and water vapor.

The cost of production is between $0.70 and $1.50/lb with 30 to 50% of the cost being the feedstock. The model plant in use can produce 75 tons of SCP a year (Klausner, 1984). A larger plant is under construction.

Sensory Evaluation

The disparity in choice of one food over the other, from individual to individual, and culture to culture, may never be understood. Studies have shown that acceptance of a food depends on several reasons which may not have any relation to flavor or taste. In some cases, food may be selected due to the nutritional nature or symbolic reasons, while the same food would not be selected for the same reasons in other cultures. In a nutshell, people choose foods for different reasons, but most people select foods due to the sensory attributes of the foods without considering the nutritional value.

Schutz, Judge and Gentry, (1986) reported that sensory attributes of foods determine the purchase and use of foods while the price and brand name were secondary.

The sensory attributes of foods may be determined by sensory of organoleptic analysis. The organoleptic analyst simply tastes, smells, looks at, and feels the food, then makes a subjective judgment. The sensory analyst, on the other hand, is one that has been trained for the job and, as a result, acts as a tool for the researcher (Jellinek, 1985).

Types of Sensory Evaluation

Whether a product is in the developmental stage or being readied for marketing determines the type of sensory evaluation performed. In general, there are three categories of sensory evaluation; namely, discrimination tests, descriptive tests, and affective tests.

Discrimination Tests

Discrimination tests detect differences. Examples of these are paired comparison, duo-trio, and triangle tests. Each of these has distinct characteristics, but all of them are designed to detect differences between or among samples.

The paired comparison, as the name implies, is a two sample test in which one has to identify the sample which has more or less of a specified characteristic.

The test is a forced choice test since the respondent must choose one of the samples even if there is not a perceived difference between the samples. The probability of a panelist selecting a sample by chance is 50%. This test does not indicate the size of the difference between the two samples, just whether there is a detectable difference between the two samples. One sample should be selected 75% of the time, for instance, 15 out of 20 times in a 20 sample test, in order to be different from the other at the 5% level of significance (Larmond, 1977).

The problem with this type of test is that it is often difficult to determine a difference, and the panelists do not always identify the targeted difference if it is not specified. Hence, there is a need for training and familiarization sessions (Stone and Sidel, 1985). However, this is a commonly used test and has been used for many years. The earliest paired comparison test was in the meat industry 50 years ago (Cover, 1936). Another early use, in the 1940's, was in the beverage industry in Copenhagen (Helm and Trolle, 1946).

The duo-trio test requires matching one of two samples to a third reference or control sample. The subject identifies the sample that is different from the reference sample. Like the paired comparison test, the probability of selecting the odd sample is 50%. In a 20 sample test, correct judgment is significant at the 5% level if the odd sample is selected 15 out of 20 times (Larmond, 1977).

Use of the duo-trio test is usually limited to samples having a sharp, burning or lingering aftertaste (Jellinek, 1985).

The triangle test is the most commonly applied test in the industry. Like the duo-trio test, the test requires three samples, but the samples are coded differently. The subject (panelist) determines which two samples are the same. According to Stone and Sidel (1985), this test is used widely in food industries and breweries. In the triangle test, to obtain a valid test of significant difference, the odd sample has to be selected two-thirds of the time (Larmond, 1977).

Descriptive Tests

Descriptive tests include the techniques of ranking and scaling which describe and/or quantify the differences between samples. Ranking is placing samples in rank order of some attribute such as sweetness, and scaling involves indicating the intensity or an attribute on a scale. The scale may be numerical or linear. One or more points may be anchored by a word, description, or reference sample (Brennan, 1984).

Descriptive tests also include the flavor profile, texture profile, and Quantitative Descriptive Analysis (QDA) tests. The sensory characteristics of a product are determined by these tests; hence, they are highly sophisticated (Stone and Sidel, 1985) and usually

incorporate elements of ranking and scaling as components.

The flavor profile test was developed in 1950 by Carincross and Sjostron. To perform this test, a group of highly trained panelists examine the product in terms of flavor and aroma. They determine the intensity of each food attribute, such as saltiness or sweetness, and give their overall impression of the product (Jellinek, 1985). The quality of the results of the flavor profile test depends on the proficiency of the panelists in the use of the organs for smell and taste, and their ability to communicate perceptions to the experimenter (Mackey and Jones, 1954).

In the texture profile test, the panelists subjectively describe the structural make-up of the product. As a result, the texture profile is defined as the sensory analysis of food in terms of its mechanical, geometrical, fat, and moisture characteristics (Stone and Sidel, 1985). These mechanical characteristics are described quantitatively and qualitatively. Also, the geometrical characteristics are evaluated. Hardness, chewiness, gumminess, fracturability, adhesiveness, and viscosity are mechanical properties, while geometrical properties range from grittiness and coarseness to fibrousness (Larmond, 1977). Results of these subjective evaluations of food texture have been compared with objective tests of texture. The Instron Universal Testing machine is widely used in texture evaluation of foods such as

meat products, vegetables, etc. Prusa, Bowens, and Chamber (1982) reported a high correlation between Instron scores and the sensory evaluation of panelists.

The QDA was designed to give more information in the organoleptic characteristics of products. As a new product approaches introduction into the market, there is a need for a more descriptive sensory evaluation. The other tests rely on the established characteristics of the sample, but the QDA method requires the panelists to be fully aware of all sensory characteristics and to describe them. The test requires only a limited number of subjects, but they must highly qualified (Stone and Sidel, 1985).

Affective Tests

Affective tests measure liking, preference or acceptance of a product. Such tests usually, but not always, follow discrimination and description tests. Affective tests can be performed directly by rating acceptability of a single product or by comparing two or more products, and the subject indicates which is more appealing. Or, preference can be measured indirectly by determining which product was significantly more liked than another in a multi-product test. A measure of liking is necessary before a product is marketed as it estimates product acceptance even though it does not guarantee success in the market place, and it is not a substitute

for a larger scale consumer test which is more extensive (Stone and Sidel, 1985).

The two main affective tests are paired comparison and hedonic scales. The paired comparison test was probably the first formal sensory test method developed to assess preference. The test may involve one or more pairs of samples. The subject just has to indicate which of the coded products is preferred. If the subject does not like either of the two, he may respond by designating "no preference." The data is analyzed just as in discrimination tests (Stone and Sidel, 1985).

Market researchers make great use of the paired comparison/preference method, either as a two-product test or as a much larger effort involving many products, which is referred to as a multiple-paired comparison test. This can be cumbersome when there are four to ten pairs to compare (Stone and Sidel, 1985).

The 9-point hedonic scale is probably the most useful sensory test method used in preference measurement (Stone and Sidel, 1985). The scale was developed by the Quartermaster Food and Container Institute in the 1940's. The method introduced the use of bi-polar rating scale in a 9-point, 7-point, or 5-point design. These scales showed no difference in the test-retest reliability. One caution on the 9-point hedonic scale is the positioning. Beginning the scale with "dislike extremely," for instance, may lead to a greater frequency of the

"dislike" categories (Meiselman, 1984) since there is a tendency to be influenced by the first choice.

There are other criticisms of the hedonic scale, but there are similar criticisms for other methods. Some authors object to the use of parametric methods for the analysis of data from a scale that is bi-polar with non-definitive scale intervals. Yet the practicability of the scale predisposes its use in food industries, and the results are most informative. The computations yield means, variance measures, and frequency distributions. Additional information about product differences is obtained from analysis of variance or t-tests (Stone and Sidel, 1985).

Type of Subjects

Sensory evaluation in the food industry involves the use of the senses in relation to social and cultural conditions. Yet, to be useful for analytical purpose, the respondents must be used as a tool in sensory evaluation (Larmond, 1977). Due to variations in the analytical methods, the testers, as some authors call them, may be divided into two categories, untrained and trained. The untrained group, also called consumer panelists, are used to measure overall acceptability of the product, and the number of subjects is kept large. The number of subjects in the second category is smaller, but they give more precise ratings.

The subjects' ages do not always matter for the sensory evaluation panelist selection. Even younger persons may be of greater advantage since they may have more taste buds. The sex of the subjects does not matter either, but smokers must not smoke for a few hours before the test or during tests (Jellinek, 1985).

Undesirables are people who are suffering from colds and those who have sensory dysfunctions. Heavy perfume and cosmetic users and those who work in laboratories where strong smelling substances are prepared pose problems. Such people are advised to avoid these conditions and should take necessary personal hygiene measures before the test (Jellinek, 1985).

Location and Testing Consideration

The validity of the sensory evaluation depends on the interaction between variables, most of which have to be controlled. A dedicated facility for testing must be provided by the company or any institution where sensory evaluation is needed. The more critical considerations include ventilation, lighting, traffic pattern, space, product preparation, subject communication mechanism, and comfort. These objectives are met by provision of distraction-free, light-controlled booths, and person-to-person, interaction-free space. The color of the walls should be neutral and the room air-conditioned to maintain room temperatures (Larmond, 1977).

The preparation of the samples is another aspect of sensory evaluation that needs special consideration. The samples should be representative of the product and should be served at temperature appropriate to the product. Also, the sample should be coded correctly to avoid bias in the panelists. Randomization is essential to prevent positional bias (Larmond, 1977).

CHAPTER III

NUTRITIONAL IMPROVEMENT OF GARI WITH DRIED YEAST PROTEIN

Introduction

An estimated 20 million people in Africa require immediate help for food and shelter as food production on the continent decreases due to insufficient rainfall, fragile soils, difficult microclimate, and extreme temperature (State Dept., 1985). In most parts of the region, only food crops poor in protein and high in carbohydrate are grown. The major staple food for most people in this region is cassava (M. esculanta) which is eaten in many forms; gari, fufu, and tapioca cakes. The most popular form eaten in West Africa is gari.

There are two types of gari: namely, yellow gari and white gari; but the quality of both is judged by uniformity of color and granulation.

The major problem with gari and other cassava products is the low protein content. The protein content of gari is about 1.2% (Ojofeitimi, Ahrens and Prather, 1981). Another problem is the linamarin, a bitter cyanogenic glucoside in cassava which is eliminated by heating and fermentation.

In addition to being low in total protein, compared to grain and legumes, cassava is deficient in most of the essential amino acids (Lancaster, Ingram, Lim and Courser, 1982). Cassava does have some glutamic acid, ornithine, alanine, aspartic acid, lysine, and arginine, but only very small quantities of cystine, methionine, and tryptophan.

Of the vitamins, only vitamin C is found in appreciable quantities in the raw state. Additionally, much of the vitamins are lost during processing, except for riboflavin, which may be increased as a by-product of fermentation (Lancaster et al., 1982). Much of the mineral content of cassava is lost during processing except for calcium which is high in gari. Iron content often increases because of contamination by iron cooking utensils used in gari preparation (Oke, 1968).

Cassava products are high in carbohydrate; and, therefore, cassava is one of the most important staples in the tropics from Southeast Asia to South America. The total production in 1978 was estimated to be 119 million tons (Lancaster et al., 1982).

Preparation of Gari

Gari is made from raw cassava roots of varying sizes. The preparation is essentially the same in Nigeria, Ghana, Cameroon, Sierra Leone, Guinea, Benin, Togo, and in preparation of Brazilian farinha da mandioca (Lancaster

et al., 1982).

To prepare gari, cassava roots are peeled, washed, and grated. The pulp is then placed in a cloth bag or a sack made from jute. The open end is tied, and the sack is placed on a set of logs or heavy stones. Other sets of logs or stones are placed on the top of the bag to which pressure is applied to squeeze out the juice. The juice may be collected if edible starch is wanted. Tapioca and tapioca flour are made from the juice (Lancaster et al., 1982). The pressed pulp is allowed to ferment. The extent of fermentation depends on time.

Fermentation process may last up to three days and is associated with Corynebactrium manihot and Geotrichum candida (Collard and Levi, 1959) and (Akinrele, 1964). More recent studies suggest that other organisms including Lactobacili and Streptococci (Ngabu and Lee, 1979) may be involved. The fermentation process contributes to the characteristic flavor of gari. The fermentation process may be shortened to 24 hours by seeding fresh pulp with cassava juice that is about four days old (Akinrele, 1964).

After the fermentation, the dewatered (about 50% less water) pulp is then heated or "garified" in wide, shallow iron pans and stirred continuously until it becomes dry and crisp but not browned. Palm oil (bright, orange-red in color) may be added to prevent burning (Jones, 1959) and to make the yellow gari cherished by some people. The white gari is produced with palm oil omision. Gari is

fairly stable if water content is maintained at or below 8-10% (Akinrele, Cook and Holgate, 1966).

Good quality gari swells about three times its size by weight when placed in water. The dry gari may be eaten in the dry state with fresh coconut or grilled groundnuts (peanuts), or mixed with palm oil, fish, crayfish, salt and pepper, and into a paste which is fried. In most cases it is steeped in cold water causing the grains to swell and soften but retain their individuality. This is then eaten with soup or stew; with dry coconut, beans, or meal; or avocado (Lancaster et al., 1982). Sometimes, the gari may be mixed with cold water, milk, and sugar to form a gruel which is drunk.

The most popular method of preparing gari in Nigeria is to add about 1:3 by weight of gari to boiled water to form a semi-solid paste called fufu, or Iba in various parts of the country. The paste is eaten with vegetable soup. The soup usually contains fish or meat or both, green vegetables, and spices. Some soups have been named according to the major ingredients in the soup, but the major soups are apono (seed of a tropical tree) soup, okra soup, or equsi (shelled tropical melon seed) soup. The food by be served with desserts and fruits. A typical gari soup with meats and vegetables contains about 13.5 g protien, 67 g carbohydrate, and 16 g fat, and 2.9 g crude fiber (Essien, 1987). But this depends on sociocultural factors. Not all Nigerians can afford a

complete gari soup and the protein food items are not available in all parts of the country. Besides, the distribution of many of the soup components is seasonal.

Single-cell protein in the form of dried yeast is high in protein and many essential amino acids. Yeast also is a good source of many vitamins and minerals. Further, it is not seasonal (Provesta, 1986). Adding yeast to gari could increase its nutritional value, but it is not known if such supplementation would affect acceptability of this staple food.

The purpose of this research is to study the nutritional and organoleptic effects of adding Provesteen-T dried yeast to gari. The protein content of gari, with and without yeast, will be compared and acceptability of yeast enriched gari determined plain and as a part of a gari soup meal.

Materials and Methods

Source and Preparation of Gari Samples

The gari grits and the equsi seeds were purchased at an international food market in Stillwater, Oklahoma. The gari variety was white because palm oil was not added during preparation. Dry gari is shelf stable; but after purchase, the gari was refrigerated to avoid any change during the course of study. The Provesteen-T torula yeast was supplied by the Provesta Corporation, a subsidiary of Phillips Petroleum Company, Bartleville, Oklahoma.

Gari was substituted by yeast at four substitution levels (See Table IV). These levels (0%, 8%, 10%, and 12%) of yeast were weighed out to complement the four different portions of gari so that the total weight of the dry ingredients (gari plus yeast) per portion was 60 g. This was for the discrimination test. Also, another larger portion composed of 10% yeast, was weighed out for testing acceptance of gari as part of a meal.

TABLE IV

COMPOSITION OF DRY MIXTURES FOR SENSORY EVALUATION TRIALS

	0%	8%	10%	12%
Gari	60.0	55.2	54.0	52.8
Yeast	0.0	4.8	6.0	7.2
Total Dry Weight	60.0	60.0	60.0	60.0

Test samples were made up of 4 g gari/yeast mixture, blended with 30 ml water, and were used for the discrimination test. The acceptance (affective) test was designed to determine the acceptability of the 10% yeast/gari mixture when eaten with a traditional Nigerian soup (equsi soup). The 10% yeast mixture was mixed with

water at 1:3 mixture/water ratio by weight.

The ingredients for the equsi soup, prepared according to Nigerian tradition, were:

3 c equsi	1½ c ground shrimp
6 lbs beef	6 T corn oil
3½ lbs spinach, chopped	3 T red pepper
3 c onions, diced	1½ T salt
4½ c tomato paste	4 qt water

The meat was boiled until done. Then the equsi, onions, oil, ground shrimp, tomato paste, and spices were added and simmered for forty-five minutes. Last the spinach was added and the soup was simmered for an additional five minutes. The soup was then served with large bowls of prepared gari which were eaten in or with the soup.

Sensory Evaluation

For the discrimination test the gari/yeast samples were evaluated by 11 Nigerian students at Oklahoma State University, Stillwater, Oklahoma. They rated the organoleptic characteristics of color, odor, flavor, texture, and overall acceptability using the Likert Method of Summated Rating (Best and Kahn, 1986).

The panelists were trained and screened for their ability to distinguish the four basic tastes (sweet, sour, bitter, and salty) at the above-threshold levels reported by the American Society of Testing and Material (Klemmer, 1968). The training score sheets is found in Appendix A. Flavor, odor, color, texture, and overall acceptability of the samples were evaluated. Five was the best possible

rating for flavor, odor, color, and overall acceptability. On the texture scale, three was the best rating. A copy of this score sheet is also in Appendix A. The tests were performed in divided booths with ambient lighting and temperature. Distilled water was provided for mouth rinsing between samples. Sample coding and presentation followed the procedure described in American Society for Testing and Material, STP 433 (Klemmer, 1968).

For the affective testing, the same panelists evaluated a 10% yeast gari eaten with a traditional Nigerian soup (equsi soup) as an entree. The 10% yeast substitution was evaluated for overall acceptability only, with 10 being the best possible rating. The score sheet for this acceptance test is in the Appendix A along with the training score sheets and the discrimination test score sheet.

Experimental Design and Statistical Analysis

The experimental design for the sensory evaluation of the four gari/yeast levels was a split-plot experiment in a randomized complete block design with four levels of gari/yeast substitutions as the subunit treatments. The blocks were the three replication days. The sensory evaluation scores were analyzed with F-tests from the Analysis of Variance (AOV) procedure (Steel and Torrie, 1980). Differences among the means were tested using Duncan's Multiple Range tests with a significant level

of $p \leq 0.05$. Rating differences were tested among the panelist, treatments, and from day to day.

Nutrient Contents

The contents of selected nutrients in the gari/yeast products were calculated using the published information by Lancaster et al., 1982, and by the Provesta Corporation (Phillips, 1985).

Results and Discussions

Sensory Analysis

There were no interactions with day, treatment, and panelist; all F-tests yielded p values for interaction greater than 0.210. The Duncan's Multiple Range tests identified the differences in panelists' ratings of the four levels (0%, 8%, 10%, and 12%) of yeast substitutions over the three days of study. (Analysis of variance tables are in Appendix B).

The overall means for all treatments for all days show that the panelists, generally, gave high marks for the gari mixtures in the discrimination tests as seen in Table V. The lowest mean was 3.17 for the flavor and the highest was 3.81 for the odor. This shows that the panelists in general, ignoring test days and treatments, tend to like gari. The same table shows that the panelists highly accepted the 10% yeast/gari product in the affective test; the mean rating was 9.0.

TABLE V

MEANS AND SIMPLE STATISTICS FOR
RESPONSES TO GARI EXPERIMENT

Variable	N	Minimum	Maximum	Mean	Std. Dev.
Discrimination test					
Color	132	1.00	5.00	3.40	0.99
Texture	132	1.00	5.00	3.24	0.67
Flavor	132	1.00	5.00	3.17	1.07
Odor	132	1.00	5.00	3.81	0.92
Overall	132	1.00	5.oo	3.59	1.02
Affective					
Entree	33	7.00	10.00	9.00	0.83

The yeast/gari substitutions were generally highly rated. In fact none of the rating means for any characteristics or treatments fell below an acceptable level, and the difference among most means were not significant. However, the panelists did tend to rate the products lower as the yeast percentage increased (see Table VI).

Analysis by Day

On a day-to-day basis, the overall mean sensory ratings tended to increase, the rating on day three being significantly better than day one (see Table VII). The only characteristic that did not show an increased rating was odor and this was not significant (see Appendix C for Duncan's Multiple Range tables for the remaining characteristics). This implies that the panelists liked the gari substitutions more with experience.

Effects of Treatments

The Duncan's Multiple Range tests indicate that there was no significant difference in the rating means for the sensory characteristics of odor and texture due to treatments. The panelists could detect a difference in color between the 0% and the 10% and 12% substitutions; but only the 12% was rated as significantly lower than the 0% yeast substitution in flavor and overall acceptability as seen in Table VIII (Duncan's Multiple

TABLE VI

SENSORY EVALUATION RESULTS OF DIFFERENT LEVELS OF YEAST SUBSTITUTION IN GARI RATED ON A SCALE OF 1 - 5

Day No.	Trtmt	N	COLOR Mean	TEXTURE Mean	FLAVOR Mean	ODOR Mean	OVERALL Mean
1	0	11	3.64±0.81	3.09±0.70	3.00±1.27	4.00±0.89	6.46±1.04
1	8	11	3.55±1.04	3.28±0.47	3.37±0.68	4.18±0.70	3.64±0.81
1	10	11	3.37±1.03	3.46±0.82	3.81±1.33	3.91±0.95	3.05±1.13
1	12	11	2.73±1.72	3.09±0.83	3.00±1.27	3.73±1.19	2.96±1.14
2	0	11	3.64±0.92	3.09±0.52	3.78±0.91	3.87±0.98	3.91±0.95
2	8	11	3.18±1.17	3.37±0.68	3.91±1.05	3.73±0.91	3.55±1.04
2	10	11	3.00±1.09	3.28±0.79	3.00±1.09	3.97±0.97	3.28±1.01
2	12	11	3.28±1.01	3.28±0.78	3.09±1.05	3.73±0.91	3.78±1.19
3	0	11	4.00±0.63	3.09±0.30	3.64±1.03	3.73±0.91	4.09±0.83
3	8	11	3.78±0.65	3.18±0.41	3.18±0.88	3.91±0.70	3.91±0.82
3	10	11	3.05±1.13	3.37±0.81	3.81±1.17	3.64±1.22	3.64±1.12
3	12	11	3.81±0.75	3.87±0.81	2.82±1.17	3.73±0.91	3.42±1.13

TABLE VII

MEAN COMPARISON OF THE OVERALL ACCEPTABILITY OF FOUR YEAST LEVELS BY DAY IGNORING EFFECT OF TREATMENT AND PANELISTS

Day No.	N	Mean
3	44	3.77A
2	44	3.61AB
1	44	3.39B

Means with the same letter are not significantly different

TABLE VIII

MEAN SCORES FOR COLOR, TEXTURE, FLAVOR, ODOR, AND OVERALL ACCEPTABILITY RELATED TO YEAST LEVELS FOR ALL DAYS

Characteristics	TREATMENT			
	0%	8%	10%	12%
Color	3.76A	3.48A	3.30BC	3.06A
Texture*	3.09A	3.27A	3.38A	3.24A
Flavor	3.45A	3.15AB	3.12AB	2.97B
Odor	3.85A	3.94A	3.73A	3.73A
Overall accept.	3.82A	3.70AB	3.48AB	3.36B

Means with the same letter are not significantly different.
*All characteristics rated on a scale of 1 to 5 with 5 being the optimum value (except for texture where 3 is the optimum value).

Range test of ratings by treatment levels are in Appendix D).

Differences Due to Panelists (Ignoring Days and Treatments)

The rating pattern among the panelists deserves some scrutiny. The rating of two of the panelists exhibit a polarity of like and dislike. One of the panelists rated the gari and gari/yeast mixtures always in the lowest significance group. This panelist's rating for two sensory characteristics (flavor and Overall acceptability) were so low that they stood by themselves in a significant group alone from all the other panelists. This panelist seemed not to like gari with or without yeast.

In contrast, at the other end, one of the panelists tended to give high ratings for most of the sensory characterstics with or without yeast supplimentation. See Table IX as example of how these two panelists, particularly SM, seemed polarized from the other panelists. (Duncan's Multiple Range tests for the other characteristics are in Appendix E.)

Effect of Yeast on Nutrient Levels

Gari contains little or no nutrients except carbohydrate, calcium and iron. It contains 400 kcal, 33 mg calcium, and 5 mg iron per 100 g gari, but only 1.25 g protein (Table X) (Lancaster et al., 1982). Table

TABLE IX

MEAN COMPARISON OF OVERALL ACCEPTABILITY OF FOUR YEAST LEVELS BY PANELISTS IGNORING EFFECT OF TREATMENTS AND DAY

Panelist	N	Mean
NI	12	4.67A
EM	12	4.17AB
CO	12	4.08AB
JM	12	3.92AB
JA	12	3.92B
JP	12	3.67BC
SP	12	3.58BC
AN	12	3.50C
CM	12	3.17C
IB	12	3.08C
SM	12	1.75D

Means with the same letter are not significantly different.

TABLE X

COMPOSITION OF GARI (A)

Nutrient	Unit	Uncooked Gari	Cooked Gari
Calories	kcal	400.00	400.00
Protein	g	1.25	1.25
Lipid	g	0.70	0.70
Total Carbohydrate	g	96.90	96.90
Fiber	g	1.90	1.90
Ash	g	1.13	1.13
Calcium	mg	33.00	33.00
Potassium	mg	61.00	61.00
Iron	mg	5.00	5.00
Thiamine	mcg	60.00	38.00
Riboflavin	mcg	49.00	49.00
Niacin	mcg	1128.00	1151.00
Vitamin C	mg	6.0	-

(A) Per 100 g dry matter
Source: Lancaster et al., 1982

to enrich the gari. Table XI shows the effect of Provesteen-T yeast enrichment at various levels on some nutrients in gari. The protein content increased by 600% at only 8% substitution. The fact was the nutrients, including protein, increased linearly with yeast enrichment. FAO/WHO requirement for protein is 0.75 g/kg ideal body weight (Whitney and Hamilton, 1984). See Table XII for the protein provided in a typical serving of gari and gari substitutes for an average size adult male and adult female (FAO/WHO, 1973).

Conclusions

The main objective of this research was to improve the nutrient content, especially protein, of gari; but it was very important that the product remained acceptable to the target population despite the yeast enrichment. The ratings of the various gari/yeast treatment levels seem to be encouraging. The panelists were able to detect significant differences in flavor and overall acceptability due to yeast at the highest (12%) level and in color at 10 and 12% levels. However, mean values for all characteristics were not below an acceptable rating for any yeast substitution level.

Moreover, the 10% yeast/gari product, when eaten as part of a traditional entree was rated highly acceptable. The mean rating for this yeast/gari substitution as 9.0 (on a scale of 10), with a standard

TABLE XI

SELECTED NUTRIENTS IN YEAST ENRICHED GARI

	% Yeast Level as Dry Weight of Gari			
	0%	8%	10%	12%
Protein (gm)	1.25	5.57	6.65	7.70
Thiamin (mg)	0.06	0.17	0.14	0.16
Niacin (mg)	1.13	5.13	6.13	7.13
Riboflavin (mg)	0.05	0.45	0.55	0.65

TABLE XII

PROTEIN PROVIDED IN A TYPICAL SERVING OF 100 G WEIGHT OF GARI

	0%	8%	10%	12%
Protein (g)	1.25	5.57	6.67	7.70
% of FAO/WHO* Protein recomm. for men (65 Kg)	2.56	11.43	13.64	15.79
% of FAO/WHO* Protein recomm. for women (55 Kg)	3.03	13.50	16.12	18.67

*These calculations are based on the 0.75 g/Kg ideal body weight, FAO/WHO protein recommendation for adults (Whitney and Hamilton, 1984).

deviation of less than .83 (Table V). The range was 7-10. Even the panelist (SM) who seemed to dislike the gari with or without yeast rated the meal 9 out of 10 on two occasions and 10 on the third day. (See Appendix F for the raw data).

The mean values for the gari/yeast blends indicate that Nigerians think it is all right to add yeast to the gari in order to improve its quality and nutrient content. Hence, protein enrichment of the gari could play a major role in the protein/energy problem in Nigeria. The yeast increased the nutrient value of gari without destroying acceptability.

REFERENCES

Akinrele, A.I. 1964. Fermentation of cassava. J. Sci. Food Agric. 15:58-59.

Akinrele, I.A., Cook, A.S. and Holgate, R.A. 1966.The manufacture of gari from cassava. In First Int'l Cong.Food Sci. Tech., London,1962. PNC Vol. 4, Gordon and Breach, NY. p. 633-644 .

Best, J.W. and Kahn, J.V. 1986. Methods and tools of Research. Research in Education. Prentice-Hall, Cliffs p. 181.

Collard, P. and Levi, S. 1959. A two-stage fermentation of cassava. Nature. 183:620-621.

Essien, E.U. 1987. The Nigerian diets: distribution of protein, carbohyrate, fat, fibre, and mineral. Food Chem. 23:43-54.

FAO/WHO, 1973. Joint FAO/WHO Ad Hoc Expert Committee, Energy and Protein Requirements. WHO Tech. Rep. No.522. Geneva, Switzerland. p.74.

Jones, W.O. 1959. Manioc In Africa. Stanford Univ. Press. Stanford, Calif.

Klemmer, E.T. 1968. Psychological principles of Sensory evaluation. In "Basic Principles of Sensory Evaluation." ASTM STP 433. American Soc. for Testing and Materials, Philadelphia. p.51.

Lancaster, P.A., Ingram, J.S., Lim, N.Y. and Coursey, D.G. 1982. Traditional cassava-base foods: survey of processing technology. In "Cyanide in Biology." E. Vennesland et. al. (Eds.), Academic Press, N.Y. p.12.

Ngaba, P.R. and Lee, J.S. 1979. Fermentation of cassava (Manihot esculenta crantz). J. Food Sci. 44:1570-1571.

Ojofeitimi, E.P., Ahrens, R.A. and Prather, E.S. 1981. Nutritional assessment of cassava. Nutri. Reports Intern. 23:354.

Oke, O.L. 1968. Cassava as food in Nigeria. World Review Nutr. and Diet. 9:227.

Phillips. 1985. "Provesteen-T." Phillips Petroleum Co., Bartlesville, Oklahoma.

Provesta Corporation, 1986. Phillips Petroleum Co., Bartlesville, Oklahoma.

State Dept., 1985. Africa: Potential for Higher Food Production Bulletin, June.

Steel, R.G.D. and Torrie, J.H. 1980. Principles and Procedures of Statistics: a biometric approach. McGraw Hill Books Co., NY.

Whitney, E.N. and Hamilton, E.M.N. 1984. Understanding Nutrition. 3rd ed. West Pub. Co. NY.

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CHAPTER IV

HYPOTHESIS TESTING, SUMMARY, AND RECOMMENDATIONS

The purpose of this research was to: develop a nutritionally improved gari by incorporating dried yeast protein (Provesteen-T); determine levels of acceptability of gari at four levels of yeast substitution (0%, 8%, 10%, and 12%) using a panel of Nigerian students; and ascertain whether the Nigerian students would find a 10% yeast enriched gari acceptable when eaten as a part of a traditional food entree. The four yeast substitution levels were the independent variables while the panelists' rating of the sensory characteristics were the dependent variables. The data were analyzed using analysis of variance (AOV) procedures with Duncan's Multiple Range tests used to identify significant differences among the means with a alpha level established at p=0.05.

Hypothesis Testing and Summary

The first hypothesis (H1) stated that there would be no differences in means for any of the selected attributes among the four levels (0%, 8%, 10%, and 12%) of gari/yeast products. The attributes considered were

color, flavor, odor, texture, and overall acceptability. The analysis indicated that there was no significant difference among the mean response values due to treatment for the 0%, 8%, 10%, and 12% yeast levels for the sensory characteristics of texture and odor (Table VIII). The analysis, however, showed that there was significant difference between the 0% and 12% for flavor; and for color, both the 10% and 12% were significantly different from the 0% level. For the overall acceptability of the gari/yeast mixture, the analysis indicated that there was no significant difference between the mean responses for the 0%, 8%, and 10% yeast levels, but a significant difference exists between the 0% and 12% levels. Due to this evidence, the researcher rejected (H1) for the characteristics of color, flavor, and overall acceptability.

The second hypothesis (H2) stated that the gari/yeast mixture was unacceptable (mean rating less than 6) when served as a part of a traditional food entree. The means and simple statistics for the responses (Table V) indicated that on a scale of 10, the mean response of the panelists on the 10% gari/yeast mixture, when eaten as part of a traditional entree was nine with a standard deviation less than 1.0. Based on this evidence the researcher rejected the second hypothesis (H2).

Recommendations

The study shows that supplementing gari with dried yeast protein up to 12% by weight would not change the organleptic characteristics of the gari beyond an acceptable level when eaten with or without a traditional Nigerian entree.

The following are the recommendations for further gari/yeast substitutions:

(1) Test whether yeast enrichment of yellow gari would prove to cause less of a difference in color ratings, particularly at the higher substitution levels.

(2) Test the market feasibility of the gari/yeast enrichment in target cultures and countries to determine the cost of enrichment, and acceptability of both yellow gari and the white gari.

(3) Evaluate the shelf life on the gari/yeast blends.

(4) Estimate the nutritional impact of gari enrichment on the diet of target cultures.

(5) Analyze the gari production procedure to determine the best step in the manufacturing process to add the yeast enrichment.

(6) Investigate the use of yeast enriched gari as a weaning food.

A SELECTED BIBLIOGRAPHY

Akinrele, A.I. 1964. Fermentation of cassava. J. Sci. Food Agric. 15:58-59.

Akinrele, I.A., Cook, A.S. and Holgate, R.A. 1966.The manufacture of gari from cassava. In First Int'l Cong.Food Sci. Tech., London,1962. PNC Vol. 4, Gordon and Breach, NY. p. 633-644.

Altschul, A.M., 1968. The Agricultural, Scientific, and Economic Basis for Low-Cost Protein Foods. In "Single-Cell Protein." R.T. Mateles and S.R. Tannenbaum (Eds.) The MIT Press, Mass.

The American Heritage Dictionary of English Language, 1981 ed.

The American Society for Testing and Materials (ASTM). 1968. Manual of sensory testing methods. Philadelphia.

Amerine, M.A., Panghorn, R.M. and Roessler, E.B. 1968. "Principle of sensory evaluation of food," Academic Press, London.

Annonymous. 1974. Soviets prepare for massive SCP effort. Food Eng. 46:19.

Atlas, R.M. and Bartha, R. 1981. Microbial ecology: fundamentals and applications. Addison-Wesley Pub. Co. Mass.

Ayres, J.C., Mundt, J.O. and Sandine, W.E. 1980. Microbiology of foods. W.H. Freeman and Co., San Francisco.

Best, J.W. and Kahn, J.V. 1986. Methods and tools of Research. Research in Education. Prentice-Hall, Cliffs p. 181.

Brennan, J.G. 1984. Texture perception and measurement. In "Sensory Analysis of Foods." J.R. Piggott. (Ed.), Elsevier Applied Sci. Pub., NY.

Bressani, R. 1968. The use of yeast in human foods. In "Single-Celled Protein." R.I. Mateles and S.R. Tannenbaum. (Ed.), MIT Press, Cambrige, Mass.

Bunker, H.J. 1968. Sources of single-cell protein: perceptive and prospect, In "Single-Cell Protein."R.I. Mateles and Tannenbaum. (Ed.), MIT Press, Cambridge, Mass. p. 67.

Cairncross, W.E. and Sjostrom, L.B. 1950. Flavor profile-a new approach to flavor problems. Food Technol. 4:308-311.

Chen, S.L. and Peppler, J.H. 1978. "Single-Cell protein in food Application. Dev. in Indust. Micro. 19:9.

Collard, P. and Levi, S. 1959. A two-stage fermentation of cassava. Nature. 183:620-621.

Cooke, R.D. and Coursey, D.G. 1981. Cassava: a major cyanide-containing food-crop. In "Cyanide in Biology." E. Venneland et al. (Ed.), Academic Press, NY. p. 93-113.

Cooke, R.D. and Maduagwu, E.N. 1978. The effect of simple processing on cyanide content of cassava chips. J. Food Technol. 13:229.

Cover, S. 1936. A new subjective method of testing tenderness in meat. Food Res. 1:287-295.

Dziezak, J.D. 1987. Yeast and yeast derivation: application. Food Technol. 2:122-125.

Essien, E.U. 1987. The Nigerian diets: distribution of protein, carbohyrate, fat, fibre, and mineral. Food Chem. 23:43-54.

Etejere, E.O. and Bhat, R.B. 1985. Traditional preparation and uses of cassava. Econ. Bot. 39:158.

FAO. 1964. Protein: at the heart of the world food problem. Food and Agric. Org. of UNO, Rome.

FAO, 1979. FAO production yearbook. Vol. 32., 1978.

FAO/WHO, 1973. Joint FAO/WHO Ad Hoc Expert Committee, Energy and Protein Requirements. WHO Tech. Rep. No.522. Geneva, Switzerland. p.74.

Grace, M.R. 1977. "Cassava Processing." FAO (UNO), Rome. p. 127.

Helm, E. and Trolle, B. 1946. Selection of a panel. Wellerstein Lab. Commun. 9(28):181-194.

Jarquin, R., Noriega, R. and Bressani, R. 1966. Enriquecimi

cuto de harinas detrigo, blanca e integral, con supplementos da origin animal y vegetal. Arch. Latinoam. Nutri. 16:89. (abstract).

Jay, J.M. 1986. Single-Cell Protein: Modern Food Microbiol. Van Nostrand Reinhold Co. Inc. NY. p. 391.

Jellinek, G. 1985. Sensory evaluation of food. Ellis Horwood Ltd., Chichester, England.

Jones, W.O. 1959. Manioc In Africa. Stanford Univ. Press, Stanford, Calif.

Karpenko, V.I. 1985. Dependence of dough characteristics and bread quality on extration of glutathione from yeast. Khlebopekaranaya: Konditerskaya Promyshlennost. 9:40-41. (abstract from FSTA)

Kihlberg, R. 1972. The microbes as a source of food. Ann. Rev. Microbiol. 26:427-466.

Kingsley, H.N. and Parsons, H.T. 1947. The availability of vitamins from yeasts. J. Nutri. 34:321.

Klapka, M.R., Duby, G.A. and Paucek, P.L. 1958. Torula yeast as a dietary supplement, J. Amer. Diet. Assoc. 34:1317.

Klausner, A. 1984. Phillips: wild-catting in biotechnology. Bio/technol. 2(10):1.

Klemmer, E.T. 1968. Psychological principles of Sensory evaluation. In "Basic Principles of Sensory Evaluation." ASTM STP 433. American Soc. for Testing and Materials, Philadelphia. p.51.

Klose, A.A. and Fevold, H.L. 1947. Evaluation of Torula yeast protein in the life cycle of rat. Arch. Biochem. Biophys. 13:349.

Kon, S.K. and Markuse, Z. 1931. The biological values of the protein of breads baked from rye and wheat flours alone or combined with yeast or soya bean flour. Biochem. J. 25:1476.

Krause, M.V. and Mehan, L.K. 1984. Protein: Food, Nutrition and Diet Therapy. 7th ed. W.B. Saunders Co., Philadelphia.

Lancaster, P.A., Ingram, J.S., Lim, N.Y. and Coursey, D.G. 1982. Traditional cassava-base foods: survey of processing technology. In "Cyanide in Biology." E. Vennesland et. al. (Eds.), Academic Press, N.Y. p.12.

Larmond, E. 1977. Laboratory methods for sensory evaluation of foods. Canadian Govt. Pub. Co., Ottawa.

Litchfield, J.H. 1983. Single-cell proteins. Science. 219:740.

McGilvery, R.W. and Goldstein, G.W. 1983. Biochemistry: a functional approach. W.B. Saunders Co., Philadephia.

Markey, A.O. and Jones, P. 1954. Selection of members of a food tasting panel: Discernment of primary tastes in water solution compared with judging ability for foods. Food Technol. 8:527-530.

Meiselman, H.L. 1984. Consumer studies of food habits. In "Sensory Analysis of foods." J.R. Piggott. (Ed.), Elsevier Applied Sci., Pub., NY.

Ngaba, P.R. and Lee, J.S. 1979. Fermentation of cassava (Manihot esculenta crantz). J. Food Sci. 44:1570-1571.

Nartey, F. 1981. Cyanogenesis in tropical feeds. In "Cyanide in Biology." E. Vennesland et al. (Eds.), Academic Press, NY. p. 115.

Ojofeitimi, E.P., Ahrens, R.A. and Prather, E.S. 1981. Nutritional assessment of cassava. Nutri. Reports Intern. 23:354.

Oke, O.L. 1968. Cassava as food in Nigeria. World Review Nutr. and Diet. 9:227.

Okezie, B.O. and Kosikowski, F.V. 1981. Extraction and functionality of protein from yeast cells grown on cassava hyprolysate. Food Chem. 6:7.

Osborne, T.B. and Mendel, L.B. 1919. The nutritive value of yeast protein. J. Biol. Chem. 38:223.

PAG, 1975. Energy and protein requirement-recommdation by a joint FAO/WHO informal gathering of experts. Bulletin. 5(3).

PAG, 1972. PAG Guideline No. 12, On the production of single-cell protein for human consumption, p. 21.

Phillips. 1985. "Provesteen-T." Phillips Petroleum Co., Bartlesville, Oklahoma.

Provesta Corporation, 1986. Phillips Petroleum Co., Bartlesville, Oklahoma.

Price, E.L., Marquette, M.M., and Parsons, H.T. 1947.

The availability of vitamins from yeasts. J. Nutri. 34:311.

Prusa, K.J., Bowers, J.A. and Chambers, E. 1982. Instron measurement and sensory scores for texture. J. Food Sci. 47:653-654.

Rimmington, A. 1985. Single-cell protein; the Soviet Revolution. New Sci. 106:12-15.

Robbins, E.A. and Seeley, R.D. 1977. Cholestrol lowering effect of dietary yeast and yeast fractions. J. Food Sci. 47:653-654.

Ruiz, A.I., Pelayo, R., Arroyo, V. and Inigo, B. 1986. Fermenting agents for grape must. In "The Autonomic Comm. of Madrid." Alimentaria. 173:53-56.

Schnell, P.A., Akin, C. and Flannery, T.J. 1976. Properties of Torutein for food application. Cereal Foods World. 21:313.

Schutz, H.G., Judge, D.S., Gentry, J. 1986. The importance of nutrition, brand, cost, and sensory attributes to food purchase and consumption. Food Technol. 40(11):79-82.

Scrimshaw, N.S. 1968. Introduction. In "Single-Cell protein." R.I. Mateles and S.R. Tannenbaum. (Eds.), MIT Press, Cambridge, Mass.

Scrimshaw, N.S. 1975. Single-Cell Protein for human consumption. In "Single-Cell Protein II." S.R. Tannenbaum and D.I.C. Wang (Eds.), MIT. Press, Mass.

Seeley, R.D., Ziegler, J.F. and Summer, R.J. 1950. The nutritional value of white bread containing nonviable dried yeast. Cereal Chem. 27:50.

Sinskey, A.J. and Tannenbaum, S.R. 1975. Removal of nucleic acid in SCP. In "Single-Cell protein II." S.R. Tannenbaum and D.I.C. Wang. (Eds.), MIT Press, Cambrige, Mass.

Smith, R.L. 1977. "Elements of Field Biology." Harper and Row Pub., NY.

Smith, R.E., Osothsilp, C., Bicho, P. and Gregory, K.F. 1986. Improvement in the protein content of cassava by Sporotrichum pulverulentum. Biotechnol-Letters. 8(1)31:36.

Solomonson, L.P. 1981. Cyanide as a metabolic inhibitor. In "Cyanide in Biology." E. Vennesland et al. (Eds.),

Academic Press, NY.

State Dept., 1985. Africa: Potential for Higher Food Production Bulletin, June.

Steel, R.G.D. and Torrie, J.H. 1980. Principles and Procedures of Statistics: a biometric approach. McGraw Hill Books Co., NY.

Still, E.V. and Koch, E.M. The biological value of yeast proteins for the rat. 1928. Amer. J. Physiol., 87:225.

Stone, H. and Sidel, J.L. 1985. Sensory evaluation practices. Academic Press, NY.

Von Loesecke, H.W. 1946. Controversial Aspects: Yeast in Human Nutrition J. Amer. Dietet. Assoc. 22:485

Whitney, E.N. and Hamilton, E.M.N. 1984. Understanding Nutrition. 3rd ed. West Pub. Co. NY.

Zanetti, R.J. 1984. Breathing new life into Single-Cell protein. Chem. Eng. Feb. p. 18.

APPENDIXES

APPENDIX A

SENSORY EVALUATION TOOLS

SENSORY EVALUATION

TRAINING SESSION

Test the sample solution and complete the following statements.

Sample No. _____? Your Name_____

1. The color is . . . (Circle One)

   a. blue

   b. red

   c. yellow

   d. green

   e. white

   f. purple

2. The taste is . . . (Circle One)

   a. salty

   b. bitter

   c. sour

   d. sweet

3. It is odorless; yes _____, or no _____ (tick one).

ODOR IDENTIFICATION

YOUR NAME: _____

Identify these samples:

A. _____

B. _____

C. _____

D. _____

E. _____

SENSORY EVALUATION

Sample No. _____ Your Name: _____

(Circle what your think about this food.)

1. When you looked at the gari sample was the color . . .

Not Acceptable	Slightly Acceptable	All Right	Very Acc.	Extremely Acceptable

2. When you smelled the gari, was the smell . . .

Very Unpleasant	Slightly Unpleasant	All Right	Good	Very Good

3. When you ate the gari, was the flavor . . .

Not Acceptable	Slightly Acceptable	All Right	Very Acc.	Extremely Acceptable

4. When you ate the gari sample, did you find the texture to be . . .

Too Hard	Slightly Hard	Just Right	Too Hard	Extremely Soft

5. All things considered, how would you rate the gari sample?

Very Bad	Slightly Bad	All Right	Good	Very Good

SENSORY EVALUATION

YOUR NAME_____

How would you rate the gari on a 1 to 10 or low - high scale?

(Circle One)

1 2 3 4 5 6 7 8 9 10

APPENDIX B

ANALYSIS OF VARIANCE DATA

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

11:56 WEDNESDAY, APRIL 13, 1988

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: COLOR

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	131	129.71969697	0.99022669	.	.	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		ROOT MSE		COLOR MEAN
CORRECTED TOTAL	131	129.71969697			0.00000000		3.40151515

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	68.13636364	.	.
DAYNO	2	3.01515152	.	.
PANELIST*DAYNO	20	7.81818182	.	.
TRTMT	3	8.56818182	.	.
DAYNO*TRTMT	6	3.22727273	.	.
PANELIS*DAYNO*TRTMT	90	38.95454545	.	.

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIST*DAYNO AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	68.13636364	17.43	0.0001
DAYNO	2	3.01515152	3.86	0.0383

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIS*DAYNO*TRTMT AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
TRTMT	3	8.56818182	6.60	0.0004
DAYNO*TRTMT	6	3.22727273	1.24	0.2922

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: ODOR

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	131	112.26515152	0.85698589	.	.	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		ROOT MSE		ODOR MEAN
CORRECTED TOTAL	131	112.26515152			0.00000000		3.81060606

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	71.84848485	.	.
DAYNO	2	1.46969697	.	.
PANELIST*DAYNO	20	9.69696970	.	.
TRTMT	3	1.05303030	.	.
DAYNO*TRTMT	6	1.37878788	.	.
PANELIS*DAYNO*TRTMT	90	26.81818182	.	.

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIST*DAYNO AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	71.84848485	14.82	0.0001
DAYNO	2	1.46969697	1.52	0.2439

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIS*DAYNO*TRTMT AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
TRTMT	3	1.05303030	1.18	0.3227
DAYNO*TRTMT	6	1.37878788	0.77	0.5946

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: TEXTURE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	131	58.24242424	0.44459866	.	.	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		ROOT MSE		TEXTURE MEAN
CORRECTED TOTAL	131	58.24242424			0.00000000		3.24242424

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	17.57575758	.	.
DAYNO	2	0.01515152	.	.
PANELIST*DAYNO	20	9.65151515	.	.
TRTMT	3	1.27272727	.	.
DAYNO*TRTMT	6	0.77272727	.	.
PANELIS*DAYNO*TRTMT	90	28.95454545	.	.

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIST*DAYNO AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	17.57575758	3.64	0.0067
DAYNO	2	0.01515152	0.02	0.9844

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIS*DAYNO*TRTMT AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
TRTMT	3	1.27272727	1.32	0.2733
DAYNO*TRTMT	6	0.77272727	0.40	0.8770

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: FLAVOR

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	131	150.99242424	1.15261393	.	.	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		ROOT MSE		FLAVOR MEAN
CORRECTED TOTAL	131	150.99242424			0.00000000		3.17424242

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	73.40909091	.	.
DAYNO	2	0.10606061	.	.
PANELIST*DAYNO	20	12.72727273	.	.
TRTMT	3	4.08333333	.	.
DAYNO*TRTMT	6	5.16666667	.	.
PANELIS*DAYNO*TRTMT	90	55.50000000	.	.

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIST*DAYNO AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	73.40909091	11.54	0.0001
DAYNO	2	0.10606061	0.08	0.9204

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIS*DAYNO*TRTMT AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
TRTMT	3	4.08333333	2.21	0.0927
DAYNO*TRTMT	6	5.16666667	1.40	0.2248

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: OVERALL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	131	137.90909091	1.05274115	.	.	1.000000	0.0000
ERROR	0	0.00000000	0.00000000		ROOT MSE		OVERALL MEAN
CORRECTED TOTAL	131	137.90909091			0.00000000		3.59090909

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	69.40909091	.	.
DAYNO	2	3.31818182	.	.
PANELIST*DAYNO	20	10.18181818	.	.
TRTMT	3	4.15151515	.	.
DAYNO*TRTMT	6	4.43939394	.	.
PANELIS*DAYNO*TRTMT	90	46.40909091	.	.

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIST*DAYNO AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
PANELIST	10	69.40909091	13.63	0.0001
DAYNO	2	3.31818182	3.26	0.0596

TESTS OF HYPOTHESES USING THE ANOVA MS FOR PANELIS*DAYNO*TRTMT AS AN ERROR TERM

SOURCE	DF	ANOVA SS	F VALUE	PR > F
TRTMT	3	4.15151515	2.68	0.0514
DAYNO*TRTMT	6	4.43939394	1.43	0.2101

APPENDIXES C - E

DUNCAN'S MULTIPLE RANGE TESTS

APPENDIX C

DAY BY DAY MEANS IGNORING TREATMENT AND PANELISTS

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: FLAVOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.636364

NUMBER OF MEANS	2	3
CRITICAL RANGE	0.354296	0.372068

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	DAYNO
A	3.2045	44	3
A			
A	3.1818	44	2
A			
A	3.1364	44	1

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: TEXTURE
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.482576

NUMBER OF MEANS	2	3
CRITICAL RANGE	0.308529	0.324006

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	DAYNO
A	3.2500	44	2
A			
A	3.2500	44	3
A			
A	3.2273	44	1

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COLOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.390909

NUMBER OF MEANS	2	3
CRITICAL RANGE	0.277684	0.291614

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	DAYNO
A	3.6136	44	3
B	3.3182	44	1
B			
B	3.2727	44	2

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: OVERALL
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.509091

NUMBER OF MEANS	2	3
CRITICAL RANGE	0.316892	0.332788

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	DAYNO
A	3.7727	44	3
A			
B A	3.6136	44	2
B			
B	3.3864	44	1

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ODOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.484848

NUMBER OF MEANS	2	3
CRITICAL RANGE	0.309255	0.324768

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	DAYNO
A	3.9545	44	1
A			
A	3.7727	44	2
A			
A	3.7045	44	3

APPENDIX D

TREATMENT MEANS IGNORING DAY AND PANELISTS

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: OVERALL
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=90 MSE=0.515657

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.351625	0.369752	0.381466

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	TRTMT
A	3.8182	33	0
A			
B A	3.6970	33	8
B A			
B A	3.4848	33	10
B			
B	3.3636	33	12

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COLOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=90 MSE=0.432828

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.32215	0.338757	0.349489

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	TRTMT
A	3.7576	33	0
A			
B A	3.4848	33	8
B			
B C	3.3030	33	10
C			
C	3.0606	33	12

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: FLAVOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=90 MSE=0.616667

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.384525	0.404348	0.417158

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	TRTMT
A	3.4545	33	0
A			
B A	3.1515	33	8
B A			
B A	3.1212	33	10
B			
B	2.9697	33	12

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: TEXTURE
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=90 MSE=0.321717

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.277739	0.292057	0.301309

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	TRTMT
A	3.3636	33	10
A			
A	3.2727	33	8
A			
A	3.2424	33	12
A			
A	3.0909	33	0

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ODOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=90 MSE=0.29798

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.267296	0.281076	0.289981

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	TRTMT
A	3.9394	33	8
A			
A	3.8485	33	0
A			
A	3.7273	33	10
A			
A	3.7273	33	12

APPENDIX E

PANELIST MEANS IGNORING DAY AND TREATMENT

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: TEXTURE
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.482576

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11
CRITICAL RANGE	0.590788	0.620424	0.640912	0.652898	0.6624	0.669793	0.675572	0.680137	0.683785	0.686729

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PANELIST
A	4.0000	12	SM
A			
B A	3.5000	12	CO
B A			
B A	3.5000	12	CM
B			
B	3.3333	12	JP
B			
B	3.3333	12	IBE
B			
B	3.2500	12	NIK
B			
B	3.2500	12	ANG
B			
B C	3.0833	12	EM
B C			
B C	3.0000	12	JM
B C			
B C	2.9167	12	JA
C			
C	2.5000	12	SP

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: FLAVOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.636364

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11
CRITICAL RANGE	0.678425	0.712456	0.735984	0.749747	0.76066	0.769149	0.775785	0.781028	0.785216	0.788598

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PANELIST
A	4.4167	12	NIK
A			
A	3.9167	12	JM
A			
A	3.8333	12	CO
A			
B A	3.7500	12	JA
B			
B C	3.0833	12	EM
C			
C	3.0000	12	ANG
C			
C	2.9167	12	IBE
C			
C	2.8333	12	JP
C			
C	2.8333	12	CM
C			
C	2.8333	12	SP
D	1.5000	12	SM

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: OVERALL
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.509091

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11
CRITICAL RANGE	0.606802	0.63724	0.658284	0.670595	0.680355	0.687948	0.693883	0.698572	0.702319	0.705343

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PANELIST
A	4.6667	12	NIK
B A	4.1667	12	EM
B A	4.0833	12	CO
B	3.9167	12	JM
B	3.9167	12	JA
B C	3.6667	12	JP
B C	3.5833	12	SP
B C	3.5000	12	ANG
C	3.1667	12	CM
C	3.0833	12	IBE
D	1.7500	12	SM

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: ODOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.484848

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11
CRITICAL RANGE	0.592178	0.621883	0.642419	0.654433	0.663958	0.671368	0.677161	0.681737	0.685393	0.688344

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PANELIST
A	5.0000	12	NIK
A			
A	5.0000	12	CO
B	4.3333	12	EM
B			
B	4.2500	12	JA
B			
B	4.0000	12	JM
B			
C B	3.8333	12	ANG
C			
C D	3.3333	12	JP
D			
D	3.1667	12	SM
D			
D	3.0833	12	SP
D			
D	3.0833	12	CM
D			
D	2.8333	12	IBE

ANALYSIS AS SPLIT-UNIT EXPT IN RANDOMIZED BLOCK DESIGN
BLK = PANELIST, MUT = DAYNO, AND SUT = TRTMT
ERROR(A) = PANELIST*DAYNO & ERROR(B) = PANELIST*DAYNO*TRTMT

ANALYSIS OF VARIANCE PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: COLOR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE

ALPHA=0.05 DF=20 MSE=0.390909

NUMBER OF MEANS	2	3	4	5	6	7	8	9	10	11
CRITICAL RANGE	0.531725	0.558398	0.576837	0.587625	0.596178	0.602831	0.608032	0.612141	0.615424	0.618074

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PANELIST
A	4.8333	12	CO
A			
B A	4.4167	12	NIK
B			
B C	4.0000	12	EM
C			
D C	3.6667	12	JA
D			
D E	3.4167	12	JM
E			
F E	3.0833	12	IBE
F E			
F E	3.0833	12	SP
F E			
F E	3.0000	12	ANG
F E			
F E	2.8333	12	JP
F			
F	2.5833	12	CM
F			
F	2.5000	12	SM

APPENDIX F

RAW DATA

DATA FROM GARI IMPROVEMENT EXPERIMENT ** LOVEDAY NWOBILOR
ENTR5 DENOTES THE ENTREE SCORE MINUS 5!

OBS	PANELIST	TRTMT	DAYNO	COLOR	TEXTURE	FLAVOR	ODOR	OVERALL	ENTREE	ENTR5
1	SP	12	3	3	2	2	3	4	.	.
2	SP	0	1	3	2	2	3	3	.	.
3	SP	8	1	4	3	4	4	5	.	.
4	SP	10	1	4	3	3	4	4	9	4
5	SP	12	1	1	1	1	1	1	.	.
6	SP	0	2	4	3	4	4	4	.	.
7	SP	8	2	2	2	2	3	2	.	.
8	SP	10	2	3	2	2	3	3	7	2
9	SP	12	2	2	2	2	3	4	.	.
10	SP	0	3	4	3	4	3	5	.	.
11	SP	8	3	4	3	4	3	4	.	.
12	SP	10	3	3	4	4	3	4	10	5
13	JA	0	1	4	2	3	5	4	.	.
14	JA	8	1	4	3	4	5	4	.	.
15	JA	10	1	3	3	4	4	4	9	4
16	JA	12	1	1	3	2	3	2	.	.
17	JA	0	2	4	3	4	5	5	.	.
18	JA	8	2	4	3	4	4	4	.	.
19	JA	10	2	4	3	4	5	4	9	4
20	JA	12	2	4	3	4	4	4	.	.
21	JA	0	3	4	3	4	4	4	.	.
22	JA	8	3	4	3	4	4	4	.	.
23	JA	10	3	4	3	4	4	4	9	4
24	JA	12	3	4	3	4	4	4	.	.
25	EM	0	1	4	3	1	5	2	.	.
26	EM	8	1	4	3	2	5	3	.	.
27	EM	10	1	4	3	4	5	4	10	5
28	EM	12	1	4	3	4	5	4	.	.
29	EM	0	2	4	3	4	4	4	.	.
30	EM	8	2	4	4	3	4	4	.	.
31	EM	10	2	4	3	4	4	4	9	4
32	EM	12	2	4	3	3	4	5	.	.
33	EM	0	3	4	3	3	4	5	.	.
34	EM	8	3	4	3	3	4	5	.	.
35	EM	10	3	4	3	3	4	5	9	4
36	EM	12	3	4	3	3	4	5	.	.
37	NI	0	1	5	3	3	5	4	.	.
38	NI	8	1	5	4	4	5	4	.	.
39	NI	10	1	4	4	5	5	5	10	5
40	NI	12	1	4	3	5	5	5	.	.
41	NI	0	3	5	3	5	5	5	.	.
42	NI	8	3	4	3	4	5	4	.	.
43	NI	10	3	5	3	5	5	5	9	4
44	NI	12	3	4	4	5	5	5	.	.
45	CO	0	1	5	4	5	5	4	.	.
46	CO	8	1	5	4	4	5	4	.	.
47	CO	10	1	5	5	4	5	4	10	5
48	CO	12	1	5	4	3	5	3	.	.
49	CO	0	2	5	3	5	5	5	.	.
50	CO	8	2	5	3	4	5	5	.	.
51	CO	10	2	5	3	3	5	4	10	5
52	CO	12	2	5	3	4	5	4	.	.
53	CO	0	3	5	3	5	5	5	.	.
54	CO	8	3	5	3	4	5	4	.	.

DATA FROM GARI IMPROVEMENT EXPERIMENT ** LOVEDAY NWOBILOR
ENTR5 DENOTES THE ENTREE SCORE MINUS 5!

OBS	PANELIST	TRTMT	DAYNO	COLOR	TEXTURE	FLAVOR	ODOR	OVERALL	ENTREE	ENTR5
55	CO	10	3	5	3	3	5	4	10	5
56	CO	12	3	3	4	2	5	3	.	.
57	SM	0	1	3	4	1	3	1	.	.
58	SM	8	1	2	3	3	4	2	.	.
59	SM	10	1	1	4	1	2	1	9	4
60	SM	12	1	3	4	1	4	2	.	.
61	SM	0	2	3	4	2	3	2	.	.
62	SM	8	2	2	4	1	2	2	.	.
63	SM	10	2	3	4	1	3	2	9	4
64	SM	12	2	2	5	1	3	1	.	.
65	SM	0	3	3	3	2	4	3	.	.
66	SM	8	3	4	4	2	4	2	.	.
67	SM	10	3	1	5	1	2	1	10	5
68	SM	12	3	3	4	2	4	2	.	.
69	AN	0	1	4	3	4	4	4	.	.
70	AN	8	1	3	3	3	4	4	.	.
71	AN	10	1	3	2	4	4	4	9	4
72	AN	12	1	2	3	3	3	3	.	.
73	AN	0	2	4	3	4	4	4	.	.
74	AN	8	2	3	4	2	4	3	.	.
75	AN	10	2	3	3	4	4	4	8	3
76	AN	12	2	2	4	3	4	3	.	.
77	AN	0	3	4	4	2	4	3	.	.
78	AN	8	3	3	3	2	4	4	.	.
79	AN	10	3	3	2	4	4	4	8	3
80	AN	12	3	2	5	1	3	2	.	.
81	CM	0	1	3	3	3	4	4	.	.
82	CM	8	1	2	3	3	3	3	.	.
83	CM	10	1	3	4	1	3	2	10	5
84	CM	12	1	2	3	4	4	4	.	.
85	CM	0	2	2	4	4	3	3	.	.
86	CM	8	2	2	3	3	4	3	.	.
87	CM	10	2	1	5	2	3	1	9	4
88	CM	12	2	4	3	4	4	5	.	.
89	CM	0	3	4	3	4	2	4	.	.
90	CM	8	3	3	4	2	4	4	.	.
91	CM	10	3	3	4	2	1	3	9	4
92	CM	12	3	2	3	2	2	2	.	.
93	JP	0	1	3	3	3	3	4	.	.
94	JP	8	1	3	3	3	3	4	.	.
95	JP	10	1	3	3	3	4	4	9	4
96	JP	12	1	2	4	3	4	2	.	.
97	JP	0	2	3	2	3	3	4	.	.
98	JP	8	2	3	4	3	3	4	.	.
99	JP	10	2	2	4	2	4	3	7	2
100	JP	12	2	3	4	2	3	3	.	.
101	JP	0	3	3	3	4	3	4	.	.
102	JP	8	3	3	3	3	3	5	.	.
103	JP	10	3	3	4	2	3	3	10	5
104	JP	12	3	3	3	3	4	4	.	.
105	JM	0	1	3	3	4	4	4	.	.
106	JM	8	1	4	3	4	4	4	.	.
107	JM	10	1	3	3	4	4	4	9	4
108	JM	12	1	3	3	4	4	3	.	.

DATA FROM GARI IMPROVEMENT EXPERIMENT ** LOVEDAY NWOBILOR
ENTR5 DENOTES THE ENTREE SCORE MINUS 5!

OBS	PANELIST	TRTMT	DAYNO	COLOR	TEXTURE	FLAVOR	ODOR	OVERALL	ENTREE	ENTR5
109	JM	0	2	3	3	3	4	4	.	.
110	JM	8	2	3	3	4	4	4	.	.
111	JM	10	2	3	3	4	4	4	9	4
112	JM	12	2	3	3	4	4	4	.	.
113	JM	0	3	4	3	4	4	4	.	.
114	JM	8	3	4	3	4	4	4	.	.
115	JM	10	3	4	3	4	4	4	9	4
116	JM	12	3	4	3	4	4	4	.	.
117	IB	0	1	3	4	4	3	4	.	.
118	IB	8	1	3	4	3	4	3	.	.
119	IB	10	1	4	4	2	3	3	8	3
120	IB	12	1	3	3	3	3	3	.	.
121	IB	0	2	3	3	3	2	3	.	.
122	IB	8	2	2	4	2	3	3	.	.
123	IB	10	2	2	3	3	2	3	8	3
124	IB	12	2	3	3	3	2	3	.	.
125	IB	0	3	4	3	3	3	3	.	.
126	IB	8	3	3	3	3	3	3	.	.
127	IB	10	3	4	3	3	3	3	8	3
128	IB	12	3	3	3	3	3	3	.	.
129	NI	0	2	5	3	5	5	5	.	.
130	NI	8	2	5	3	4	5	5	.	.
131	NI	10	2	3	3	4	5	4	9	4
132	NI	12	2	4	3	4	5	5	.	.

VITA

Loveday Elechi Nwobilor

Candidate for the Degree of

Master of Science

Thesis: NUTRITIONAL IMPROVEMENT OF GARI WITH DRIED YEAST PROTEIN

Major Field: Food, Nutrition, and Institution Administration

Biographical:

Personal Data: Born in Port Harcourt, Nigeria, March 2, 1958, the son of Appolus M. and Patience N. Amadi. Married to Terra L. Smith on August 9, 1986.

Education: Graduated from County Grammar School, Ikwerre/ Etche, Port Harcourt, in June, 1976; received Bachelor of Science Degree in Public Health from Utah State University in May, 1984; completed requirements for the Master of Science degree at Oklahoma State University in July, 1988.

Professional Experience: Graduate Research Assistant, Oklahoma State University, January, 1986 - May, 1987.

Professional Organizations: Institute of Food Technologists, and International Federation of Home Economics.

Awards: Mary Leidigh Scholarship, February, 1988.