Original Research Article

ESTIMATION OF TH E SHELF LIFE OF SEASONING CUBES PRODUCED FROM AFRICAN LOCUST BEAN SEEDS CHICKEN AND SHIITAKE MUSHROOMS

ABSTRACT

Seasoning cubes are taste enhancers added to food to improve their palatability. Seasoning cubes or bouillon cubes are produced around the world for seasoning purposes. Commercial bouillon cubes are composed of ingredients such as salt, sugar, flavour enhancers (monosodium glutamate), herbs, and spices, pieces of vegetables, dyes and fragrances. MSG is a very potent flavour enhancer which elicits the umami or savoury taste at very low concentrations. The consumption of MSG has however been associated with many health hazards such and brain damage. Before the advent of seasoning cubes, Africans used local herbs and spices and fermented legumes to enhance flavour during the preparation of their food. These traditional condiments have not attained commercial status due to the very short shelf life, objectionable packaging materials, stickiness and the characteristic putrid odour. In this study, seasoning cubes were produced from different combinations (%) A (16.6/16.6/66.7), B (16.6/66.7/16.6), C (33.3/33.3/33.3 and D (66.7/16.6/16.6), of traditional condiments: fermented African locust bean (iru), chicken and shiitake mushroom powders using conventional methods for seasoning cube production. The binders used were green plantain flour and palm kernel oil. The physical, sensory properties and storage stability of these cubes were determined using standard analytical methods. The seasoning cubes were found to have physical and sensory properties comparable to the standard maggi cube. The most acceptable product was found to be that which contained 66.7% fermented African locust bean ,16.6% chicken powder and 16.6% shiitake mushroom powder. The shelf life of the most acceptable product was estimated using the Arrhenius model and was found to be 15.5 months at room temperature 28 degrees Celsius and 72 months' refrigeration temperature 4 degrees Celsius.

Keywords: Seasoning cubes; African locust bean; shelf life.

INTRODUCTION

Seasoning of food is the process of supplementing the taste of food via herbs, spices, salt and or sugar to enhance a particular flavour (Saul *et al*., 2018). A wide array of ingredients is usually used to enhance the taste of food and these ingredients act as both seasonings and flavourings. Bouillon cubes are taste enhancers added to food to improve their palatability. Commercial bouillon cubes are composed of ingredients such as salt, sugar, flavour enhancers (monosodium glutamate), herbs, and spices, pieces of vegetables, dyes and fragrances (Irene *et al*.,2025). Industrially, they are prepared by mixing these ingredients with powder-like fat and oil; and pressing to form cube shape (Mejia *et al.,*2015). Bouillon cubes, also called stock cubes or seasoning cubes are usually composed of kitchen salt (between 40% and 70%), hardened vegetable fat, hydrolysed vegetable proteins, starch, herbs, spices, flavourings, and may contain taste enhancers such as monosodium glutamate or yeast extracts. The cubes are typically manufactured by pressing the ingredient mix in a mould and are usually around 4 g in weight, but can be up to 10 g in countries such as Kenya. The powders are produced by granulation. Unlike kitchen salt and other condiments, bouillon cubes are usually not consumed in raw form, but are commonly used for preparing cooked foods such as stews, curries, and sauces, where they may partly replace the use of kitchen salt. One exception is Nigeria, where it is common to crumble cubes on top of the meal as flavouring. Bouillon cubes and powders are popular in sub-Saharan Africa, particularly in West and Central Africa where they have become part of the local culinary culture. Seasoning cubes or bouillon cubes are produced around the world for use as instant food product as well as for seasoning purposes. Seasoning cubes are generally produced using herbs, spices, and salt, sugar and flavour enhancers. Starch and fat are used as binders which facilitate the pressing of the ingredients into a cube. A conventional process to produce seasoning cubes can be summarized as follows. Ingredients like salt, sugar, monosodium glutamate (crystalline ingredients), and furthermore starch, flavours and/or colours (non-crystalline ingredients) are mixed. In general, fat which is used as a binding agent is molten and added during mixing of the crystalline ingredients. In addition, an anti-caking agent such as Styloid (trademark from W.R. Grace & Co) (silica oxide) is often added. After addition of the fat to the crystalline ingredients, the non-crystalline ingredients are mixed into the mass of ingredients. The fat sticks the crystalline and non-crystalline ingredients together, forming big lumps. After mixing, the mixture is allowed to cool down from a temperature of e.g. between 40-60°C, to solidify the fat. This so-called maturation step may take about 20-30 hours. The formed cake is then crushed and sieved. Subsequently, the sieved particles are pressed to seasoning cubes and packaged. (Vlaardingen, 2009). These traditional condiments have not attained commercial status due to the very short shelf life, objectionable packaging materials, stickiness and the characteristic putrid odour.

THE RESEARCH PROBLEM

Before the advent of seasoning cubes, Africans used local herbs and spices and fermented legumes to enhance flavour during the preparation of their food. Nowadays seasoning cubes and powders such as *maggi* cube *(*Plate 1) are popular due to the cheap cost and convenience as they are sold in ready-to use forms thus reducing preparation time and energy. These seasoning cubes are mostly made from monosodium glutamate (MSG) a potent flavour enhancer industrially produced by bacterial fermentation of sugars. MSG is a very potent flavour enhancer which elicits the umami or savoury taste at very low concentrations. The consumption of MSG has however been associated with many health hazards such and brain damage, Chinese restaurant syndrome and organ failures. Commercial seasoning cubes are also produced using corn starch and hydrogenated vegetable fats as binders and these have been associated with chronic diseases such as diabetes, heart problems, obesity and high cholesterol levels. Fermented African locust beans seed (*iru)* contains high levels of free glutamic acid (a non-essential amino acid) which is also a potent flavour enhancer and which can be used to replace MSG in diet to elicit the highly solicited umami taste which makes bland food taste so much better. The concept of umami synergy says that if glutamic acid is combined with 5’ nucleotides: inosinic acid (IMP) found in meats chicken and guanylic acid (GMP) found in mushrooms the umami taste of the resulting mixture is highly intensified. Extensive work has been done on the production of fermented African locust bean seeds and related aspects such as storage, preservation, processing, time taken to be cooked, packaging and other areas (Non-Wood News, 2009). These traditional condiments have not attained commercial status due to the very short shelf life, objectionable packaging materials, stickiness and the characteristic putrid odour (Achi, 2005).Very limited work has been done to produce a ready to use form of this spice. This study therefore aimed at using free glutamic acid found in *iru* in combination with IMP from chicken powder and GMP from shiitake mushroom powder to produce a seasoning cube with physical properties and storage stability comparable to that of commercially sold seasoning cubes such as magi cube.

Plate 1: A picture of maggi, a popular commercially sold seasoning cube.

LITERATURE REVIEW

Seasoning Cubes

Seasoning cubes, also called stock cubes or bouillon cubes are a seasoning ingredient composed of kitchen salt (between 40% and 70%), hardened vegetable fat, hydrolysed vegetable proteins, starch, herbs, spices, flavourings, and may contain taste enhancers such as monosodium glutamate or yeast extracts. The availability in the market, for example, of pre-mixed condiments and various meat powders used for flavouring foods such as instant noodles and similar convenience foods, has simplified the life of working women who do not have the time or the skill to prepare food the way their mothers and grandmothers did at home. The products are affordable and easy to prepare; hence, consumer acceptance is high. In addition, these foods are found everywhere, from neighbourhood stores in the suburbs and countryside to supermarkets in urban centres. The product and process research and development work of food scientists and food technologists, the business acumen of entrepreneurs and the marketing expertise of product distributors ensure the availability of the food products. Despite their lower nutritional content, these cubes have largely replaced many fermented seeds and products, which once contributed diverse flavours and nutritional value to African dishes. Experts liken bouillon cubes to "well-packaged salts," and studies suggest that prolonged exposure to these cubes may have adverse health effects due to their primary ingredients. One of the contents of bouillon cubes which has attracted interest and is of concern is monosodium glutamate (MSG), which has been implicated in toxicity to different organ systems (Umedum *et al*.,2013).

The cubes are typically manufactured by pressing the ingredient mix in a mould and are usually around 4 g in weight, but can be up to 10 g in countries such as Kenya. The powders are produced by granulation. Unlike kitchen salt and other condiments, bouillon cubes are usually not consumed in raw form, but are commonly used for preparing cooked foods such as stews, curries, and sauces, where they may partly replace the use of kitchen salt. For several decades, bouillon cubes are produced around the world for the use as instant food product as well as for seasoning purposes. Recipes may vary regionally, or even within the same region, but mainly comprise most of the following ingredients: salt, sugar, monosodium glutamate, fat, starch, flavours and colours. In the context of this application, solid food concentrates applied for preparing a bouillon, sauce, soup or gravy, or applied for seasoning purposes will be indicated as 'seasoning cube', regardless of its purpose, shape, appearance or content. Besides regionally preferred recipes, also the production process to prepare seasoning cubes may vary from one region to the other, depending on local preferences or production means present. Therefore, differences in parameters as mass, density, hardness and/or consistency and shape of the seasoning cubes may be observed among regions and even between factories. One exception is Nigeria, where it is common to crumble cubes on top of the meal as a flavouring. Bouillon cubes and powders are popular in sub-Saharan Africa, particularly in West and Central Africa where they have become part of the local culinary culture. For several decades, bouillon cubes are produced around the world for the use as instant food product as well as for seasoning purposes. Recipes may vary regionally, or even within the same region, but mainly comprise most of the following ingredients: salt, sugar, monosodium glutamate, fat, starch, flavours and colours. In the context of this application, solid food concentrates applied for preparing a bouillon, sauce, soup or gravy, or applied for seasoning purposes will be indicated as ’seasoning cube’, regardless of its purpose, shape, appearance or content. Besides regionally preferred recipes, also the production process to prepare seasoning cubes may vary from one region to the other, depending on local preferences or production means present. Therefore, differences in parameters as mass, density, hardness and/or consistency and shape of the seasoning cubes may be observed among regions and even between factories. Besides this variation owing to recipes and production machineries, variation among products may also have unwanted causes. The quality of seasoning cubes may depend on the quality of the raw materials used. But also, physical properties such as the particle size of the respective ingredients, their mass and the humidity may influence the behaviour of the ingredients during the production process of the seasoning cube. Variation in these parameters may result in variation in the product quality, even within a single production plant. Examples of this kind of problems are e.g. separation of the mixture of ingredients and caking of the ingredients, e.g. due to the hygroscopic character, during transport and production of the seasoning cubes and sticking of the ingredients to the production machinery. In general, a constant quality of a seasoning cube within single production machinery is desired.

A conventional process to produce seasoning cubes according to European Patents (2 217 097 B1) can be summarized as follows. Ingredients like salt, sugar, monosodium glutamate (crystalline ingredients), and furthermore starch, flavours and/or colour (non-crystalline ingredients) are mixed. In general, fat which is used as a binding agent is molten and added during mixing of the crystalline ingredients. In addition, an anti-caking agent such as Syloid (trademark from W.R. Grace & Co) (silica oxide) is often added. After addition of the fat to the crystalline ingredients, the non-crystalline ingredients are mixed into the mass of ingredients. The fat sticks the crystalline and non-crystalline ingredients together, forming big lumps. After mixing, the mixture is allowed to cool down from a temperature of e.g. between 40-60°C, to solidify the fat. This so-called maturation step may take about 20-30 hours. The formed cake is then crushed and sieved. Subsequently, the sieved particles are pressed to seasoning cubes and packaged. The formed cake is then crushed and sieved. Subsequently, the sieved particles are pressed to seasoning cubes and packaged. (Vlaardingen, 2009).

Umami Taste

The term “umami” was coined from the Japanese adjective for delicious (umai) (Mifflin, 2006). Beyond the four better known tastes of salty, sweet, bitter, and sour, umami finds its place as the fifth basic taste evoking savoury, full-bodied, and meaty flavour sensations.

In general, human taste comprises five basic qualities: sourness produced by hydrogen ions such as HCl, acetic acid, and citric acid; saltiness produced mainly by NaCl; sweetness produced by sugars; bitterness produced by quinine, caffeine and MgCl2; umami (Japanese term for deliciousness) produced by monosodium glutamate contained in seaweeds, disodium inosinate

(IMP) in meat and fish, and disodium guanylate (GMP) in mushroom (Giovanni and Guinard, 2001, Toko, 2000, Zheng and Keeney, 2006).

Until the 20th century, umami was not thoroughly understood in Western societies; however, it has been unknowingly appreciated for years in stocks, broths, aged cheeses, protein-rich foods, tomato products, dried mushrooms, and kelp among others. (Ninomya and Rozin., 2004). Culinary descriptors of the umami taste include savoury, mouth fullness, depth of flavour, and meatiness. Because the umami taste is experienced in a wide variety of foods, the taste of umami is often regarded as distinctive and unique to individual foods. For example, Parmesan cheese and sun-dried tomatoes each contain free glutamic acid which triggers the umami taste receptors; however, both of these foods are uniquely different in their flavour profiles. Overall, umami-eliciting ingredients add to the complexity of a food by synergistically interacting with ingredients to balance, layer, and catalyse flavours. This increases the palatability of food. Although western cultures have previously lacked traditional culinary terms to adequately describe the sensation of umami in foods, it can very simply be explained as a basic taste which increases the palatability or pleasantness of foods. (Yamaguchi and Ninomiya, 2000). The umami compounds are, by nature, not very palatable or tasty by themselves. Although humans only have five basic taste receptors, it is the interaction of food ingredients and these tiny sensory organs on the tongue that result in a plethora of flavours. The most common umami substances are the umami amino acids like glutamic acid and aspartic acid, nucleotides (Populin *et al.*, 2007)., organic acid and their salts, including monosodium glutamate (MSG), disodium guanosine-5′-monophosphate (GMP), disodium inosine-5′-monophosphate (IMP), and disodium succinate etc. (Wu et al., 2022). Recently, more studies reported that umami peptides and relative derivatives are another important class of umami and umami enhancing compounds (Zhang et al., 2019, Zhao et al., 2016). Typical umami substances (umami amino acids, GMP, IMP, disodium succinate) and novel umami substances (umami peptide and Amadori rearrangement product of umami amino acid). An essential discovery of umami perception is the strongly pronounced synergistic effect between MSG and nucleotide such as GMP and IMP (Zhang *et al*., 2019). This improvement is mainly determined by the variety, concentration and their constituent proportion of the umami and umami enhancing substances (Zhang *et al.*, 2022, Zhang *et al*., 2019). The synergistic effect of umami taste compounds may therefore be a universal principle, contributing to good food-pairing across culture, tradition, and geographical distance Based on measurement of umami compounds in champagnes and oysters we suggest that a reason why champagne and oysters are considered good companions may be the presence of free glutamate in champagne, and free glutamate and 5′-nucleotides in oysters.

Flavour Enhancers

A flavour enhancer is a substance that is added to a food to supplement or enhance its original taste or flavour. They have no pronounced flavour or taste of their own but they bring out and improve the flavours in the foods to which they are added (Geha *et al*., 2000). The most commonly used substances in this category are monosodium L- glutamate (MSG), disodium 5′-inosinate (IMP), and disodium 5′-guanylate (GMP). Salt, although not classed as a food additive, is the most widely used flavour enhancer. Flavour enhancers are compounds that are added to a food in order to supplement or enhance its own natural flavour. The concept of flavour enhancement originated in Asia, where cooks added seaweed to soup stocks in order to provide a richer flavour to certain foods. The flavour-enhancing component of seaweed was identified as the amino acid L-glutamate, and monosodium glutamate (MSG) became the first flavour enhancer to be used commercially. The rich flavour associated with L-glutamate was called umami. Other compounds that are used as flavour enhancers include the 5′-ribonucleotides, inosine monophosphate (IMP), guanosine monophosphate (GMP), yeast extract, and hydrolysed vegetable protein. Flavour enhancers may be used in soups, broths, sauces, gravies, flavouring and spice blends, canned and frozen vegetables, and meats. The major use of MSG in cooking around the world is as a flavour enhancer in soups and broths, sauces and gravies, and flavourings and spice blends.

Monosodium Glutamate (MSG) and the controversies surrounding its use

MSG is highly utilized in the food industry as a seasoning or flavour enhancer. It is the sodium salt of glutamic acid, Monosodium glutamate (MSG), also known as sodium glutamate, is the sodium salt of glutamic acid. MSG is one of several forms of glutamic acid found in foods, in large part because glutamic acid (an amino acid) is pervasive in nature. MSG is found naturally in some foods including tomatoes and cheese in this glutamic acid form. (Umami Information Center, 2012). MSG is used in cooking as a flavour enhancer with an umami taste that intensifies the meaty, savoury flavour of food, as naturally occurring glutamate does in foods such as stews and meat soups. It is produced through extraction from fermented molasses made from sugar cane or beets, or the fermentation of starch hydrolysates from cassava, corn, and rice. MSG was first prepared in 1908 by Japanese biochemist Kikunae Ikeda, who was trying to isolate and duplicate the savoury taste of *Kombu*, edible seaweed used as a base for many Japanese soups. MSG balances, blends, and rounds the perception of other tastes. Most seasonings contain monosodium glutamate (MSG) which really spices up the food.

A controversy surrounding the safety of MSG began on 4 April 1968, when Dr. Robert Ho Man Kwok wrote a letter to the New England Journal of Medicine, coining the term "Chinese restaurant syndrome" (Micheal, 2020) In his letter, Kwok suggested several possible causes before he nominated MSG for his symptoms. Since 1998, MSG cannot be included in the term "spices and flavouring". In the United States (U.S.), MSG is classified as a generally recognized as safe (GRAS) substance by the Food and Drug Administration (FDA), (http://www.fda.gov/Food/FoodIngredientsPackaging/ucm328728.htm), while in Europe, MSG is classified as a food additive. Differences in the two classifications between the U.S. and Europe should not be considered significant given the fact that the European Union uses a different regulatory system for categorizing the safety of food ingredients A 1995 report from the Federation of American Societies for Experimental Biology (FASEB) for the United States Food and Drug Administration (FDA) concluded that MSG is safe when "eaten at customary levels" and, although a subgroup of otherwise-healthy individuals develop an MSG symptom complex when exposed to 3 g of MSG in the absence of food, MSG as a cause has not been established because the symptom reports are anecdotal.. Standard 1.2.4 of the Australia and New Zealand Food Standards Code requires MSG to be labelled in packaged foods. The label must have the food-additive class name (e.g. "flavour enhancer"), followed by the name of the additive ("MSG") or its International Numbering System (INS) number, 621. (Australian, 2010). The Punjab Food Authority banned Ajinomoto, commonly known as Chinese salt, which contains MSG, from being used in food products in the Punjab Province of Pakistan in January 2018.In a review which focused on the toxicological effect of monosodium glutamate in seasonings on human health. (Geha *et al*., 2000). MSG was found to induce oxidative stress, renal and hepatotoxicity. It increased total protein and cholesterol. It also induces fibroid. MSG increases the number of platelets, bleeding time and clotting time. It adversely perturbed some sex hormones: testosterone, oestrogen and progesterone. It also leads to increase in body weight and thus obesity (Airaodion *et al*., 2019).Chinese Restaurant Syndrome (CRS) is also attributed to MSG consuption. Consumer protection agencies advise healthy persons to avoid consuming MSG frequently. (Airaodion *et al*., 2019). However, according to the 2007 update to the Hohenheim consensus on MSG, the final ruling stated that glutamate salts should be regarded as harmless for the whole population (Beyreuther *et al* ., 2007).

Considering the controversies surrounding the use of MSG and its safety in human health many believe that it is safer to consume seasoning cubes produced from natural food ingredients such as fermented foods, hydrolysed proteins meat sources sea foods (Dasagupta *et al*.,, 2011) and edible mushrooms, not leaving out local herbs and spices (Arampath and Silva. 2019) It is in the perspective that this study sought to produce safe and shelf stable seasoning cubes from fermented African locust beans seeds. Chicken and shiitake mushroom**.**

Fermented African Locust Bean (*Iru)*

Fermented foods have a long history in Africa. Substrates used in fermented plant food production include vegetables, fruits, seeds, cereals, roots, and tubers. Some fermented products, usually obtained from carbohydrate-rich raw matrices, serve as main course meals or as beverages, while others, resulting from the fermentation of protein-rich seeds, are used as food condiments. Fermented seeds are an important cheap source of dietary protein. Examples of traditional fermented seeds used as flavouring agents include iru (fermented Parkia biglobosa seeds), ogiri (fermented *Citrullus vulgaris* seeds), dawadawa (fermented soybean (Glycine max) seeds), and *okpehe* (fermented *Prosopis africana* seeds). These fermented legumes are rich in vitamins and protein, not considering the flavouring attributes they contribute (Ugwuanyi and Okpara, 2020).

Fermented foodstuffs and condiments are very popular in Nigeria. Prominent among the soup condiments is iru, a fermented vegetable protein from locust bean seeds (*Parkia biglobosa*). Iru is a traditional fermented African Locust bean condiment that serves as flavouring in soups or as a low-cost protein supplement. Fermented African Locust bean is being used popularly as a condiment in many African countries; for example, in Togo, Nigeria, Mali and Benin Republic. In Nigeria, it is produced in mass quantity every year, seeds harvested from the tree undergo dehusking, shelling of pod, soaking of seed in water, washing, and drying to remove the pulp; seeds are fermented to produce a spice known as iru, ogiri or dawadawa by Yoruba, Igbo and Hausa (Onnyi *et al*., 2004); (Sadiku, 2010)). . Proteolysis is the biochemical activity that takes place during the alkaline fermentation of legumes with *Bacillus spp*, especially *B. subtilis* (the principal fermenting microorganism). They produce high amounts of proteases, amylases, and poly-glutamic acid, which helps in the enzymatic hydrolysis of the protein in legumes into amino acids (Oguntoyinbo *et al*., 2007; Olasupo and Okorie, 2019) like glutamic acid which are flavour enhancers. Because of its popularity and role in improving protein intake of many low income earners, a lot of research has been done on iru (Beaumont, 2002. The food condiment from *P. biglobosa* seeds is the main seasoning sauce (Kourouma *et al.*, 2011).

Plate 2: A picture of Fermented African Locust bean seeds (*Iru*)

Chicken (*Gallus gallus domesticus*)

Poultry farming is one of the world's most profitable and important money-spinning businesses. Also, in Nigeria, the contribution of poultry farming was about 25% Agricultural Gross Domestic Product to the country economy (USDA, 2013.) ; (Heise *et al*., 2015). Chicken is meat of domesticated wild hens. About 90% of chickens are broilers, which are bred for food and raised for 50 days. Lately, locally produced chickens or branded chickens are becoming popular. Chicken is one of the most commonly consumed meat types in most of religions and cultures in the world. Poultry meat has high nutritional value and is a good source of protein Chicken is rich in inosinate. （105-230 mg/100g). Chicken also contains naturally occurring glutamate (20-50mg/100g). Disodium inosinate is used as a flavour enhancer, in synergy with monosodium glutamate (MSG) to provide the umami taste.

Shiitake Mushroom

Mushrooms are macro fungi and many of them have been widely used as nutritive and medicinal products in developed countries to improve health and wellness (Bell *et al*., 2022). Many different mushroom species have diversified chemical compositions and nutritional values Mushrooms find their place in traditional folk medicine throughout the world since ancient times. Mushroom proteins contain all the essential amino acids and are especially rich in lysine and leucine. Apart from being excellent sources of crude protein, edible mushrooms have rich sources of dietary soluble fibre, essential minerals, complex polysaccharides, fat-free but high in essential unsaturated fatty acids (>75 %), vitamins B (B2 riboflavin, B9 folate, B1 thiamine, B5 pantothenic acid, and B3 niacin), and secondary metabolites, micronutrients and little energy (Zhao *et al*., 2022). Shiitake mushroom (*Lentinus edodes)* commonly known as Shiang-gu in China and Shiitake in Japan is a white rot wood decay fungus that naturally inhabits the dead wood of many hard wood tree species in Asia.Shiitake is the second most produced mushroom in the world, following the common button mushroom because of its alluring flavour and quality (Ozcelik and Peksen, 2007).

The shiitake mushroom (*Lentinus edodes* (Berk.) Pegler) is liked due to the presence of unique flavor-enhancing compounds. Shiitake mushroom has been highlighted as a potential natural umami ingredient (Poojary *et al*., 2017; Zhang *et al*., 2013), whose umami compound content may vary according to mushroom species, maturity stage, part of the mushroom, quality grade, and storage time (Venkitasamy, *et al*., 2013). Due to its unique flavor properties, which are strongly influenced by the presence of umami compounds, shiitake is highly accepted by the population (Hou *et al.*, 2021) and is one of the most consumed mush- rooms in the world (Rathore *et al*., 2017). Thus, its use as a flavor enhancer can positively affect consumers' perception regarding non-added MSG products (Radam *et al*., 2010). The use of mushroom or mushroom extract as a flavor enhancer has been studied and positive results were found in beef soup (Abd El-Aleem *et* *al*.,2017), beef burger (Mattar *et al*., 2018; Patinho *et al*., 2021), chicken sausage (Jo, Lee, and Jung, 2018), and frankfurter sausage Guevara *et al*., 2020).

OBJECTIVES

The objectives of this study were to:

i. Produce seasoning cubes from different combination of fermented African locust bean(iru)
ii. Determine the physical and sensory properties of these seasoning cubes
iii. Estimate the shelf life of the most acceptable product

MATERIALS AND METHODS

Material Procurement

African locust bean seeds were purchased from Wurukum market, Makurdi Nigeria. Broiler chicken was purchased from Nkwen market Bamenda Cameroon. Shiitake mushrooms, were purchased from Agro unbeatable Bambili Cameroon. They were taken to the national Herbarium centre Yaoundé Cameroon for biological identification. Analytical grade chemicals and reagents were purchased from Emole Nigeria Ltd reagent store Makurdi Nigeria. The ingredients and reagents were transported to the appropriate laboratories for preparation and analyses. Laboratories used for this study were Chemistry lab Benue state university Nigeria, Chez Ayah Foods Research lab Bambili Cameroon and Need-serve Lab Kaduna State Polytechnic Nigeria.

Material Preparation

Production of Fermented African Locust Bean Powder

This was done according to the method described by (Adejumo *et al.*, 2013 and Zannou et al.2018). Dried *P. biglobosa* seeds were washed and sorted in order to eliminate spoiled grains and foreigner particles. The seeds underwent the first cooking which is the first important operation that seeds undergo during condiments production and it consists of boiling seed in water for 24 hours. This operation allows not only a loss of astringency or bitterness of the seed but also the softening of the seminal integument. After this step, the cooked seeds were let to cool and washed in order to take off any remaining impurity and astringency. Seeds were then ready for dehulling. Dehulling is the second major operation involving in the production of the fermented condiments and consists of removing seed coats. Seed coats were taken off by pressing between palms of hands. The second cooking is a short 1 to 2 hours boiling of cotyledons in water. After the cooking, cotyledons were well drained. The fermentation represents the last most important operation involved in the production of seeds condiments. Although above-cited operations prepare cotyledons to render the fermentation most successful, this step is the most sensitive amongst all operations. It gives to cotyledons all their nutritional capacities, microbiologic properties, and organoleptic characteristics. Cotyledons were spread in basket trays, calabash trays or containers, wrapped with heavy cloths, jute bags and/ or polyethylene bags and then left for fermentation which lasts for 72 hr. After the fermentation, the condiment was oven- dried ground to a fine powder and packaged.

African Locust Bean Seeds

↓

Sorting

↓

Soaking (12 hours)

↓

De-pulping

↓

Boiling (24 hours)

↓

De-hulling

↓

Boiling (1 hr)

↓

Draining

↓

Fermenting (35°C 72 hr)

↓

Oven drying (65°C 48 hr)

↓

Grinding

↓

Sieving(250µm)

↓

Iru Powder

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Figure 1: Flow Chart for the Production of *Iru* Powder. Source**:** (Adejumo *et al.*, 2013)

Production of Chicken Powder

Chicken flavouring powder was prepared as shown in Figure 2. Muscle from slaughtered home bred chicken was used. It was washed, sliced into small pieces, salt herbs spices and water were added to it and it was boiled for one hour. It was then ground to a paste using a kitchen blender. The paste was spread in a laboratory drying oven and dried at 60°C for 12hr. It was then ground to a fine powder, sieved and packaged in polythene bags.

Production of Shiitake Mushroom Powder

Mushroom powder was prepared as shown in Figure 3 according to the method described by Balaji *et al*., 2009. Dried shiitake mushrooms were soaked in water in a ratio 3:1(w/v) to rehydrate them. According to Wu and Wang (2000), the aroma of dried shiitake mushrooms is more flavourful and meatier than that of fresh mushrooms. They were washed with clean water to remove impurities and soil particles. They were then boiled in water for one hour together with herbs spices and salt after which they were blended into a paste using a kitchen blender. The paste was oven dried at 90°C for 6 hr. after which it was ground to a fine powder, sieved and packaged polythene bags and stored at room temperature.

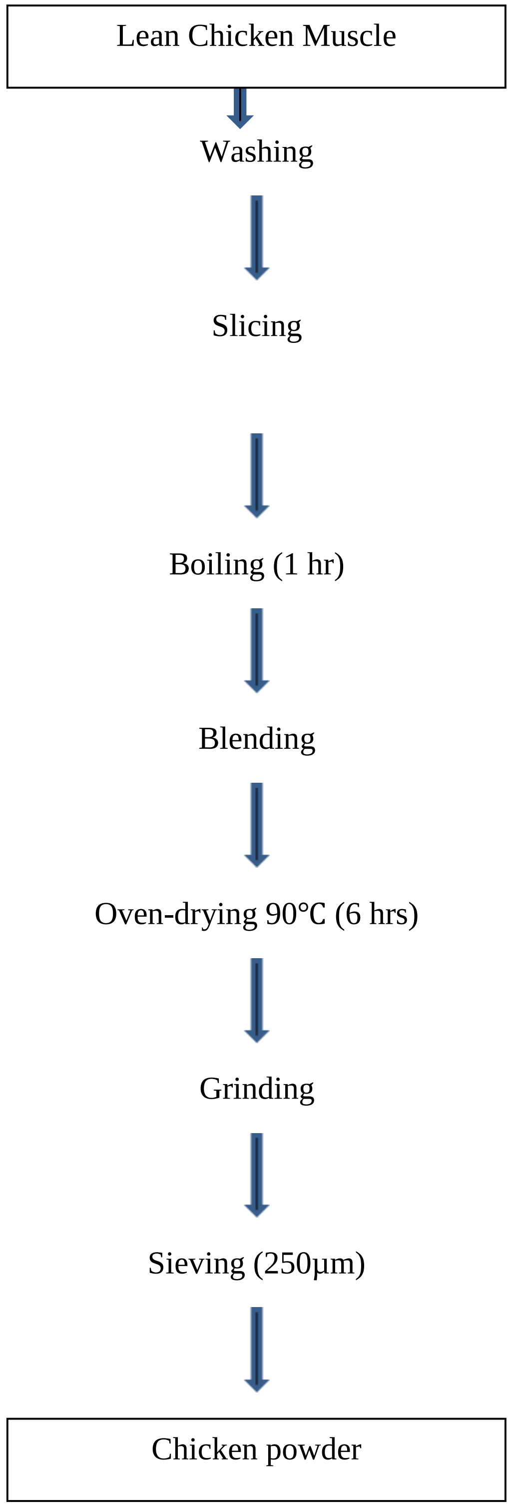

Figure 2: Flow Chart for the Production of Chicken Powder

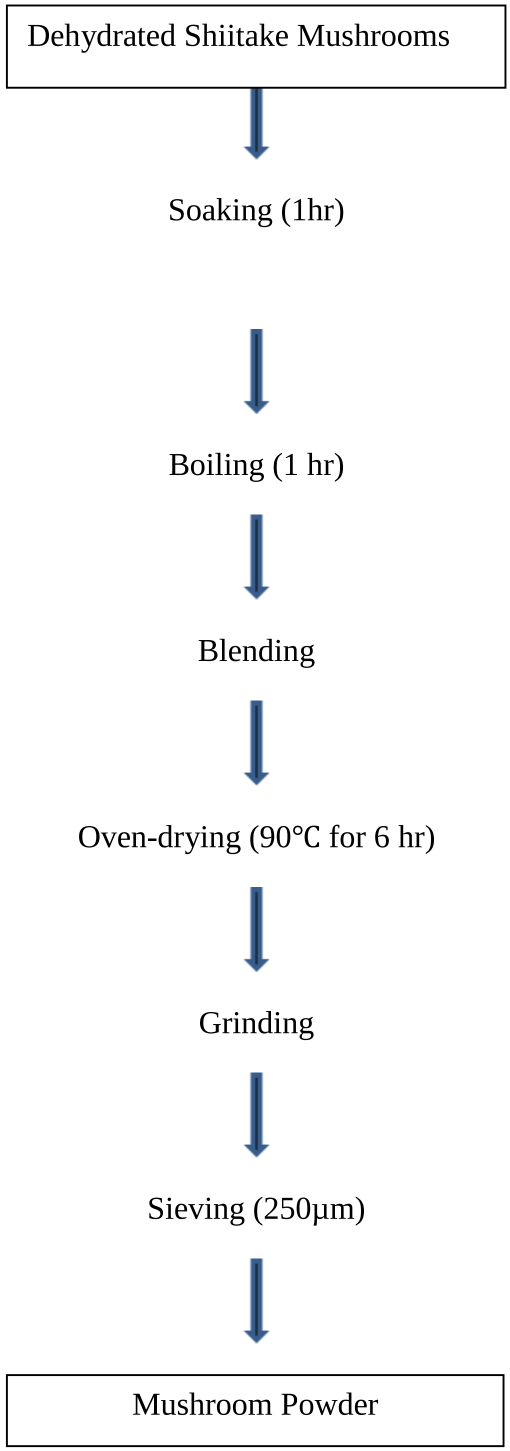

Figure 3: Flow Chart for the Production of Mushroom Powder

Production of Seasoning Cubes

The seasoning cubes were produced as shown in figure according to the method described by (Ajayi *et al*., 2015). Four samples of seasoning cubes were prepared from different formulations if iru, chicken and mushroom flavouring powders as shown in Table 1. The powder 100g was weighed and added to 20g of green banana flour binder in a container. Iodized salt 12g, granulated sugar 7g, and herbs and spices 10g were added and mixed thoroughly. Palm kernel oil 20 ml was added, and the mixture was kneaded and allowed to stand for 24h in order for granulation to occur. Thereafter water 50ml was added and mixed. A cookie cutter was used to mould the resulting cake into cubic shapes of about 4 g each. The resulting seasoning cubes were oven dried at 60°C for 6 hours. These were then cooled and placed in polythene bags and stored at ambient temperature 30 ±2°C in the laboratory for up to 4 months during which time analyses were carried out to evaluate their quality and storage stability.

Research Design

The experimental design used for this study was a completely randomized design. (CRD) of a mixture of three components (iru, chicken and mushroom powders). The total percentages of the components in all the experimental runs summed up to 100.This design studied the effects of the three components in 4 runs on a number of responses that qualified the products.

Table1: Blend Formulations for Seasoning Cube Production

Experimental Runs	*Iru (%)*	Chicken (%)	Mushroom (%)
A	16.6667	16.6667	66.6667
B	16.6667	66.6667	16.6667
C	33.3333	33.3333	33.3333
D	66.6667	16.6667	16.6667

Table 2: Ingredients for Seasoning Cubes

Ingredients	Weight (g)
Seasoning powder	100
Salt	12
Sugar	7
Onion powder	2
White pepper	2
Black pepper	2
Celery powder	2
Parsley powder	2
Palm Kernel oil	20
Green banana Starch	20
Water	50

Source: Adapted from Nigerian Industrial Standards for Bouillon cubes. NIS 283:2019 and Nigerian Industrial Standards for African Fermented Condiments NIS 1111:2020

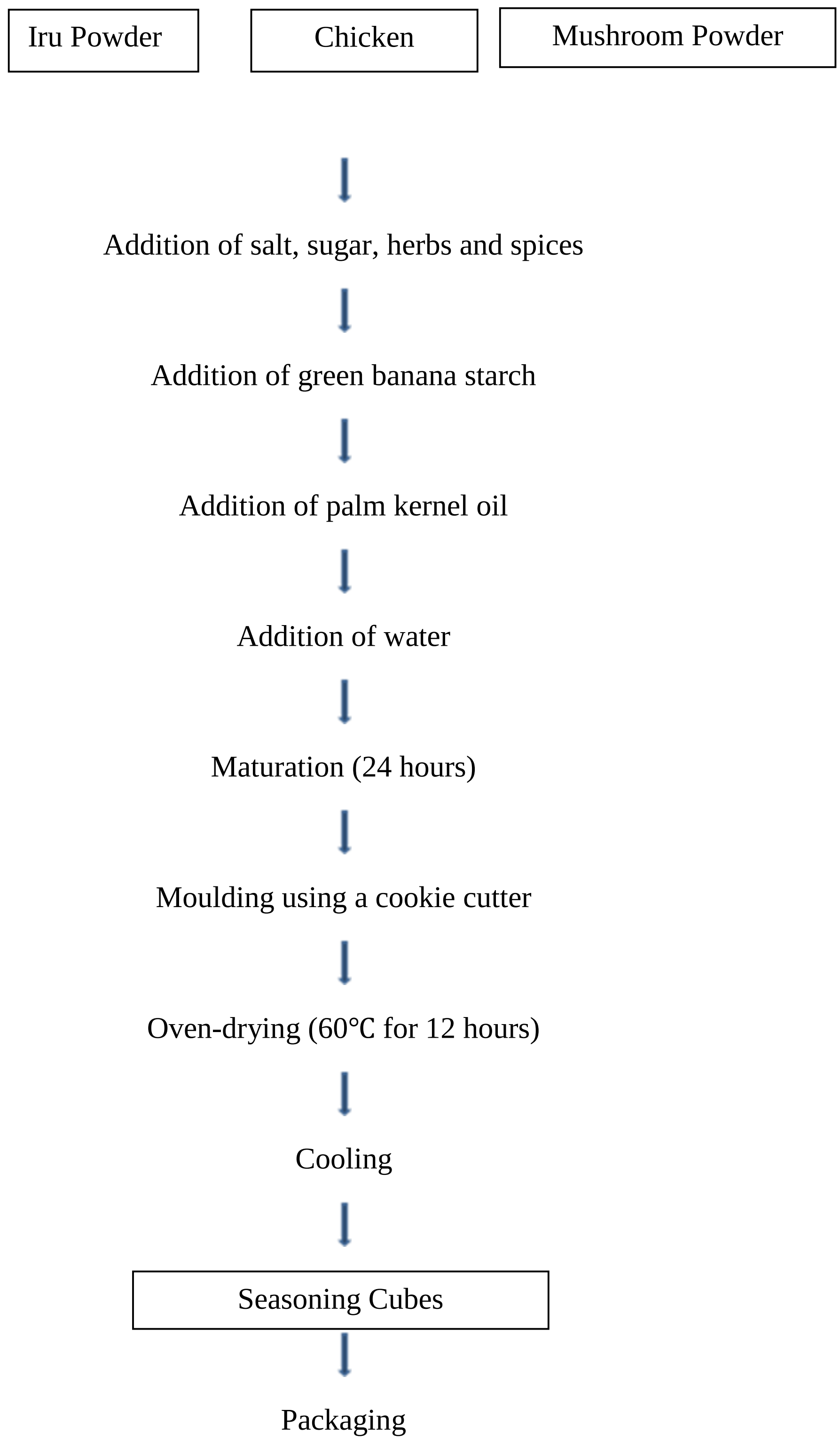

Figure 4: Flow Chart for the Production of Seasoning Cubes

Source: (Ajayi *et al*., 2015)

Methods of Analysis

Determination of Physical Properties of Seasoning Cubes

The weight of the cubes was measured using a laboratory analytical balance. Cube length, width and height were measured using Vernier calipers. the cube volume was obtained by multiplying the length the width and the height. The pH of the dissolved cubes was measured using a digital pH. meter. Dissolution in water time was estimated by immersing the cube in 50 ml of distilled water at room temperature nod noting how much time it took for the cube to disperse in the water.

Evaluation of Sensory Properties of Seasoning Cubes

The seasoning cubes produced were presented for sensory evaluation both as solid and as aqueous solutions. They were evaluated on the basis of taste, appearance hardness, aroma taste and general acceptability. Twenty (20) panelists were selected among the staff and students Center for food technology and research Benue state university Makurdi Nigeria. The cubes were evaluated using a nine-point Hedonic scale for sensory scoring (Iwe, 2002). Samples were served in a randomized manner on white plates (Muhimbula *et al*.,2011).

Plate 3: A picture showing the presentation of seasoning cubes for human sensory evaluation.

Determination of Moisture Content

Principle of Method

The sample is heated under specified conditions, and the loss of weight is used to calculate the moisture content of the sample (AOAC, 2020).

Equipment

Analytical balance, 0.1 mg sensitivity, Forced draft oven, desiccator.

Procedure

The sample (2g) was weighed into a dry crucible of known weight, dried in a laboratory drying oven at a temperature of 105ºC for 3 h. The sample was cooled in a desiccator and weighed using an electronic analytical balance. The whole process was repeated; that is it was returned into the oven for further drying, cooling and repeated weighing until a constant mass was obtained. The difference in mass (weight of % moisture lost) was calculated as:

% Moisture content = $\frac{W2-W3}{W2-W1} \times 100$

Where W1is the weight of empty crucible

W2 is the weight of crucible plus sample before drying

W3 is the weight of crucible plus sample after drying to constant mass

Determination of P -anisidine value

The anisidine value was determined according to the IUPAC Method 2.504 (Mohammed and Hamza, 2008), to analyse the number of aldehydes in the samples. The p-anisidine value is defined by convention as 100 times the optical density measured in a 1 cm cell of a solution containing 1.00 g of the oil in 100 ml of reagents. The reagent solution of 2.5 g/l p-anisidine (Aldrich, p-anisidine, 99%)in acetic acid (J.T. Baker, Acetic acid, 99-100 % glacial) was made. Two parallel samples from each oil sample were weighed according to standard for F samples 4 g and for R samples 2 g in 25 ml volumetric flasks. The volumetric flasks were diluted to volume with isooctane. 2 ml of each sample solutions was pipetted into cuvettes (VIS 340-800 nm). The absorbance of all the samples was measured with spectrophotometer at 350 nm wavelength. The reference cell of the spectrophotometer was filled with solvent. The 5 ml of each solution was pipetted into each test tubes and 1 ml p-anisidine solution was added and shaken with test tube agitator and let to rest for 10 min. Acetic acid-p-anisidine solution reacts with aldehydic compounds in the oil sample and forms a yellowish colour, the intensity of the colour depends on amount of aldehydic compounds and their structure (Cong *et al*.,2020). After 10 min 2 ml of each sample solution was pipetted into cuvette and the absorbance was measured again at 350 nm using blank in a reference cell. Blank was prepared in the same way as the sample but without the oil.

Determination of TVB-N

Measurements of total volatile basic nitrogen (TVB-N) were determined as described by Goulas and Kontominas (2017). About 10g of samples was collected and blended with 50 mL trichloroacetic acid (10% TCA) for 3 minutes and divided into two equal parts. Each part was centrifuged at 400 rpm for 5 minutes, and the supernatant filtered using Whatman No1 filter paper to obtain a clear extract. The filtrate was distilled in tubes containing 2 g of MgO, 1 drop of silicon antifoaming agent and 100 ml distilled. The distillate was collected in tubes containing 25 mL of 3% aqueous boric acid solution and 0.04 ml of methyl-red indicator for titration of the volatile bases. The distillate (distilled TVBN) was then titrated against aqueous 0.1N hydrochloric acid (HCl) solution to complete neutralization and the TVBN in mg of nitrogen per 100g of the sample was then determined using the equation;

$$\text{TVB-N (mg N/100g)} = \frac{V \times C \times 14}{Weight\ of\ sample} \times 100$$

Where V is the volume of HCl added and its concentration (C), 14 represent the molecular weight of nitrogen.

Shelf Life Estimation

Once a food product is made and packaged and starts its journey from the manufacturer's plant to warehouse, distribution center, retail store and finally to the consumer, the rate of quality loss is primarily temperature dependent. The Arrhenius relationship is often used to describe the temperature dependence of deterioration rate where for either zero or first order. The Arrhenius model describes the relationship of the reaction rate constant with temperature; this dependence is shown in the following equation:

$$K = Koe^{-Ea/RT}$$

where:

K – speed constant (day–1);

K_0 – pre-exponential factor (day–1);

E_a – activation energy (cal·mol–1);

R – universal gas constant (1.986 cal·mol–1·K–1);

T – absolute temperature (K).

The activation energy E_a for each decay kinetics is obtained from the slope of the graph of ln K vs 1/T.

$$lnK = LnKo - Ea / RT$$

Thus, a plot of the rate constant on semi-log paper as a function of reciprocal absolute temperature (1/T) gives a straight line. The activation energy is determined from the slope of the line (divided by the gas constant R). A steeper slope means the reaction is more temperature sensitive, i.e., a small change in T produces are large change in rate. Thus, by studying a deterioration process and measuring the rate of loss at two or three temperatures (higher than storage temperature), one could then extrapolate on an Arrhenius plot with a straight line to predict the deterioration rate at the desired storage temperature. This is the basis for accelerated shelf life testing (ASLT) (Bin and Labuza, 2000). Accelerated shelf life testing (ASLT) was used in this study because the deterioration of the quality of seasoning cubes occurs quite slowly under actual storage conditions. Therefore, this test methodology can be adopted to determine its shelf life under accelerated storage conditions (increased temperature). Accelerated shelf life testing reduces the time needed to estimate the product's shelf life (Calligaris *et al*., 2019). ASLTs apply to any deterioration process with a valid kinetic model, whether chemical, physical, biochemical, microbiological, or even sensory. There are several approaches to ASLT, but the most common method is the kinetic model approach, more specifically, the Arrhenius model. The Arrhenius model determines the deterioration constant and chemical kinetics to estimate the shelf life. Shelf life estimation using the Arrhenius model can be described as the relationship between temperature and deterioration rate (Herawati, *et al*., 2017). Another advantage of the shelf life analysis using this method is that it produces an equation that can be used to estimate the shelf life at various storage temperature conditions (Asiah *et al*., 2018).

Statistical Analysis

All analyses were done in triplicates. Results were expressed as the mean ± standard deviation. The data obtained was subjected to statistical analysis by ANOVA using IBM SPSS statistical software. Significant difference was accepted at 5% level of significance. Where significant difference was found, separation of means was carried out using Duncan's Multiple Range test**.**

RESULTS AND DISCUSSION

Physical Properties of Seasoning Cubes

The physical properties of the seasoning cubes produced from blends of seasoning powders made of ALB, chicken and shiitake mushrooms are shown on table. There was no significant difference in the cube weight, cube volume and pH at $p>0.05$. The values for these parameters for all the cubes were found to be statistically the same as those of the control commercially sold magi cubes. According to (Google patents EP 2 217 097 B1) the cube should have a weight of at least 5 grams and less than 15 grams. The cubes produced in this study had weights of approximately 4g which is within this range.

The standard cube S (*maggi*) had the lowest dispersion in water time 3.37 ± 0.05 minutes, and so did the samples A (16.6/16.6/66.7 I/C/M) with 3.35 ±0.01minutes a value found to not statistically different from that of the control at 95% confidence level. The sample D (66.7/16.6/16.6 I/C/M) followed closely with a dispersion time of 4.82 ±0.05 minutes. It is desired that a seasoning cube is obtained that is firm. This means that the seasoning cube does not easily break or crumble during the packaging or transport procedures. However, it is desired that when the product is used by the consumer, it may crumble relatively easily by applying hand force. In this way the crumbled product can be dispensed easily during and/or after cooking and/or dissolves relatively fast in watery solutions. (European patents EP 2 217 097 B1).

Table 3: Physical Properties of Seasoning Cubes

Sample I/C/M %	Cube Weight (g)	Cube Volume (cm^3)	pH	Dissolution in water time(min)
A(16.6/16.6/66.7)	$4.30^a \pm 0.74$	$4.50^a \pm 1.09$	$6.63^a \pm 0.01$	$3.35^a \pm 0.01$
B(16.6/66.7/16.6)	$5.20^a \pm 0.87$	$4.93^a \pm 1.31$	$6.66^a \pm 0.02$	$7.01^c \pm 0.01$
C(33.3/33.3/33.3)	$3.97^a \pm 0.22$	$4.00^a \pm 0.69$	$6.62^a \pm 0.04$	$7.11^c \pm 0.08$
D(66.7/16.6/16.6)	$4.31^a \pm 0.22$	$5.53^a \pm 0.57$	$6.67^a \pm 0.01$	$4.82^b \pm 0.05$
S(Magi Cube)	$4.05^a \pm 0.05$	$2.70^a \pm 0.00$	$6.78^a \pm 0.08$	$3.37^a \pm 0.05$

Values are Means ± standard deviation of Triplicate determinations. Mean values down the column followed by different superscripts are significantly ($p<0.05$) different

Sensory Properties of Seasoning Cubes

The results for the organoleptic properties of the seasoning cubes are displayed in table. The standard sample maggi cube had the highest score for appearance 8.01± 0.94 while among the samples that had all three ingredients the best score for appearance 7.66± 0.32 was registered in sample D (66.7/16.6/16.6 I/C/M %). Among the blends sample D (66.7/16.6/16.6 I/C/M %). had a hardness score of 6.87± 0.44 comparable with that of the standard maggi cube 6.94± 0.15. Hardness in the cubes was found to increase with increasing concentrations of mushroom powder hand hence the highest score for hardness 8.12 ± 0.12 was registered in the sample with 100 % mushroom. According to Google patents hardness and dispensability in seasoning cubes is usually determined by the amount of fat in the cube. Since the cubes produced in this study all had the same amount of fat, the hardness was determined rather by the amount of mushroom powder present in the cubes as shown in figure. Cube hardness increased with increasing concentration of mushroom powder. This observation could have been as a result of the cellulose and lignocellulose content of mushroom powder which tended to confer hardness on the cubes into which it was incorporated. All the blends had aroma scores higher than that of the standard maggi 6.63± 0.17 and the highest aroma score among the blends 7.56 ± 0.45 was registered in sample B (16.6/66.7/16.6 I/C/M%). This same sample had the highest score for taste 7.89 ± 0.76 among the blends even though this score was lower than the taste score for the standard maggi 8.21 ± 0.89. All the scores for general acceptability were above 5. The standard cube magi also had the highest score for general acceptability 8.05± 0.82 closely followed by sample D (66.7/16.6/16.6 I/C/M %). which had a score of 7.59± 0.98. We therefore conclude that the most acceptable seasoning cube produced from fermented ALB, chicken and shiitake mushroom powders was sample D which contained 66.7% Iru,16.6% Chicken and 16,6% shiitake mushrooms.

Table 4: Sensory Properties of the Seasoning Cubes

Sample I/C/M %	**Appearance**	**Hardness**	**Aroma**	**Taste**	**General Acceptability**
A(16.6/16.6/66.7)	$6.67^{a} \pm 0.87$	$8.01^{cd} \pm 0.65$	$6.87^{cd} \pm 0.55$	$6.55^{a} \pm 0.78$	$6.43^{a} \pm 0.98$
B(16.6/66.7/16.6)	$7.01^{ab} \pm 0.54$	$6.22^{a} \pm 0.76$	$7.56^{d} \pm 0.45$	$7.89^{cd} \pm 0.76$	$7.36^{bc} \pm 0.43$
C(33.3/33.3/33.3)	$7.85^{c} \pm 0.43$	$6.52^{b} \pm 0.93$	$5.73^{a} \pm 1.37$	$6.87^{ab} \pm 0.13$	$6.78^{a} \pm 0.65$
D(66.7/16.6/16.6)	$7.66^{c} \pm 0.32$	$6.87^{b} \pm 0.44$	$7.49^{d} \pm 0.86$	$7.44^{c} \pm 0.93$	$7.59^{b} \pm 0.98$
S(Magi Cube)	$8.01^{cd} \pm 0.94$	$6.94^{c} \pm 0.15$	$6.63^{b} \pm 0.17$	$8.21^{d} \pm 0.89$	$8.05^{c} \pm 0.82$

Values are Means ± standard deviation of Triplicate determinations. Mean values down the column followed by different superscripts are significantly ($p<0.05$) different

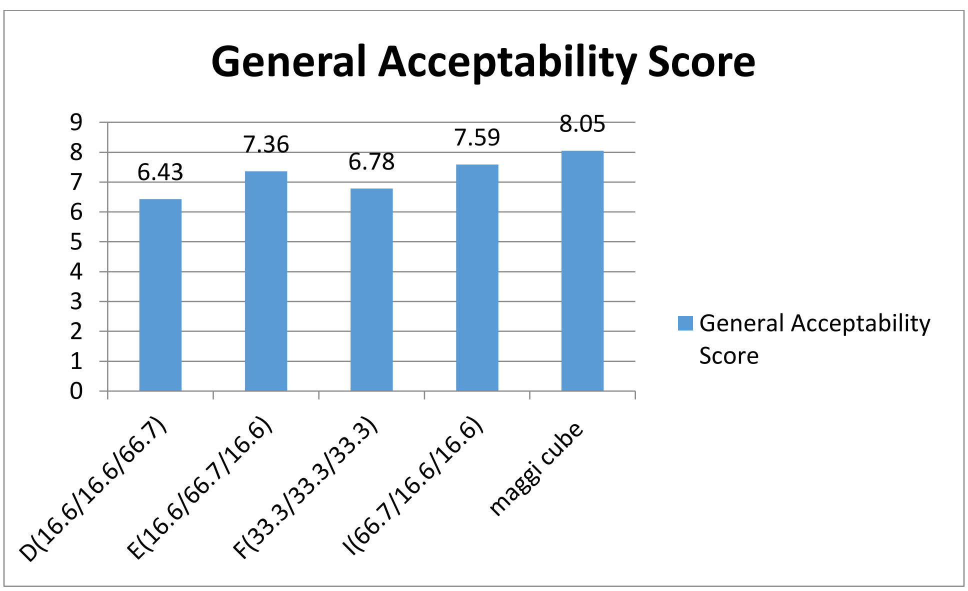

Fig 5: Column Chart of Sensory Properties of the Seasoning Cubes

Key
D is sample A
E s sample B
F is sample C
I is sample D
Maggi cube is the standard sample S

Shelf Life Prediction of Seasoning Cubes

The shelf life of a food can be defined as the time period within which the food is safe to consume and/or has an acceptable quality to consumers (Jaya and Das,2005). For any specific product, its shelf life, depends on the product characteristics (raw materials, ingredients, formulation), and storage conditions. Shelf life testing consists basically of selecting the quality characteristics which deteriorate most rapidly in time and the mathematical modeling of the change (Fu and Labuza, 2000). In this studyit was necesaryy to conduct acelerated shelf lif tests on the most accedptable product since sasoning cubes are known t have very long shelf lives (Matijević and Šarić, 2017). The most acceptableproduct after sensory analyses was found to be the sample which contained 66.7% African locust bean,16.6% chicken powder and 16.6% shiitake mushroom powder, sample D. Accelerated shelf life testing is a method of determining the shelf life of food by subjecting it to conditions that accelerate the aging process. This method predicts the shelf life of a food product in a shorter period than would occur under normal storage conditions. . The food product is stored at higher temperatures and humidity levels than the recommended storage conditions. By monitoring the changes in the food product over a shorter period, it is possible to predict its shelf life. The most aceptable product was stored at elevated temperatures of 38 48 and 58 degrees Celsius for three months and the parameters monitored were moisture content , p anisidine value, Total volatile basic nitrogen and general acceptability.The Arrhenius model was used to predict the shelf life of the seasoning cube. The shelf life of food products is vulnerable to time between production and consumption where the product is in good condition and accepted by the consumer based on the characteristics of appearance, taste, aroma, and nutritional value. Shelf life is obtained from the lowest activation energy value of the critical value of food quality The principle of the ASLT method with the Arrhenius model is to accelerate the physical and chemical damage of food products by increasing temperature, then shelf life can be determined by mathematical calculations. An average outgoing overall aceptability (AOQL) of 6 0n a 9 point Hedonic scale was used to predict the shelf life using zero order reaction kinetics (Terhemba *et al.*, 2025).

$$C = Co - kt$$

The critical objective indices (moisture content,p anisidine value and TVBN) were obtained by fitting the established shelf life into the order of the reaction kinetics that best describe the changes respectively.

Acoording to (Herawati *et al*., 2017), Shelf life estimation steps using the ASLT method with the Arrhrnius approach as follows: Data from product analysis on time are plotted and the linear regression equation is calculated. Then three regression equations are obtained for the three conditions of product storage temperature using Y = a + bx, where:

Y = the characteristic value of poduct,

X = storage time (months),

a = value of characteristic of product at the beginning of storage,

b = rate of change in characteristic value (value b equals value of k).

From each of these equations, the slope value (b) which is the reaction rate constant changes the product characteristics or the rate of degradation (k). The constant value of quality degradation (k) per day is obtained from the slope of the regression equation of the two graphs. After obtaining a value of k, then look for the value of ln for each storage temperature. Arrhenius plots were then made, with the x axis declaring 1 / T (K-1) and the y axis indicating ln k at each storage temperature used (38°C, 48°C and 58°C). The value of k is the gradient of linear regression obtained from the three storage temperatures. From the linear regression obtained on the Arrhenius curve it can be predicted the shelf life of the product using the formula:

$k = k_o\ e^{-(Ea/RT)}$

information :

k = quality change constant

k_0 = constant (not dependent on temperature)

E_a = activation energy

T = absolute temperature (K)

R = gas constant (1.986 cal / mol oK or 8.314 J / mol. OK)

By changing the above equation to:

$\text{Ln } k = \ln k_0 + (-Ea/R)1/T$

k_0 is the constant of product quality degradation which does not depend on temperature, while k is the quality reduction constant of one of the temperature conditions used (38 ºC, 48 ºC and 58ºC) and Ea / R is the gradient obtained from the Arrhenius plot. With calculations using this formula, a value of k_0 will be obtained. The shelf life according to the order of reaction one is obtained by the formula:

t =

where :

t = prediction of shelf life (days)

A_0 = initial quality value (Parameter initial value)

A_t = value of product quality remaining after time t

k_0 = constant

From the formula above can be predicted shelf life in months. If the reaction follows a zero reaction order, then the shelf life can be obtained using the formula:

t =

Where :

t = prediction of shelf life (months)

A_0 = initial quality value (initial moisture content)

A_t = value of product quality remaining after time t

k_0 = constant

From the formula above can be predicted shelf life in months. The results for the acelerated shelf life studies done on the most aceeptable seasoning cube at temperatures 38 48 and 58 degrees Celsius are shown on Tables 5 (General acceptability)6 (moisture content) 7(p anisidine value) and 8 (TVBN).

The water content can be affected by temperature, with the higher the temperature as well as the longer the storage time causing greater evaporation of water from within the material (Wijayanti et al., 2011).

Table 5: General acceptability mean scores with time

Time (months)	38ºC/311.15K		48ºC/321.15K		58ºC/331.15K	
	C	ln C	C	ln C	C	ln C
0	9	2.197	9	2.197	9	2.197
1	8.6	2.151	8.7	2.163	8.2	2.104
2	8.1	2.091	7.9	2.067	6.9	1.931
3	7.9	2.067	7.6	2.028	5.9	1.775

Table 6: Moisture Content Mean Values(%) With Time

Time (months)	38ºC/311.15K		48ºC/321.15K		58ºC/331.15K	
	C	ln C	C	ln C	C	ln C
0	1.36	0/307	1.36	0.307	1.36	0.307
1	2.01	0.698	1.78	0.576	1.52	0.419
2	2.94	1.078	2.19	0.783	1.93	0.657
3	3.58	1.275	2.96	1.085	2.15	0.765

Table 7: P Anisidine Mean Values With Time

Time (months)	38ºC/311.15K		48ºC/321.15K		58ºC/331.15K	
	C	ln C	C	ln C	C	ln C
0	0.83	-0.186	0.83	-0.186	0.83	-0.186
1	1.07	0.0676	1.73	0.5481	2.59	0.9517
2	2.11	0.7466	2.95	1.0818	4.83	1.5748
3	2.51	0.9203	4.12	1.4158	6.27	1.8357

Table 8: TVBN Mean Values With Time

Time (months)	38ºC / 311.15K		48ºC / 321.15K		58ºC / 331.15K	
	C	ln C	C	ln C	C	ln C
0	6.70	1.902	6.70	1.902	6.70	1.902
1	7.34	1.993	7.69	2.039	8.21	2.105
2	8.11	2.093	8.95	2.191	9.75	2.277
3	9.30	2.300	10.50	2.351	11.2	2.416

The order of reaction was determined by graphing the two orders by plotting the parameter data for each order with the length of storage, then creating a linear regression equation and determining the value of the coefficient of determination (R^2). The regression equation and the coefficient of determination on the parameters are shown on table 10.

Table 9: Regression Equations And R ^{2} Values For General Aceptability At Different Storage Temperatures.

Storage Temperature	Zero Order Equation	Zero Order R^2	First Order Equation	First Order R^2
38 ºC / 311.15 K	$y = -0.38x + 8.97$	0.9757	$y = -0.045x + 2.194$	0.9763
48 ºC / 321.15 K	$y = -0.5x + 9.05$	0.9615	$y = -0.603x + 2.204$	0.9622
58 ºC / 331.15 K	$y = -1.06x + 9.09$	0.9926	$y = -0.1439x + 2.217$	0.9861
Total R^2		2.9298		2.9246

General aceeptability followed zero order kinetics

Table10: Regression Equations And R^2 Values For Moisture Content At Different Storage Temperatures.

Storage Temperature	Zero Order Equation	Zero Order R^2	First Order Equation	First Order R^2
38 ºC / 311.15 K	$y = 0.759x + 1.334$	0.9944	$y = 0.328x + 0.3469$	0.9802
48 ºC / 321.15 K	$y = 0.521x + 1.291$	0.9731	$y = 0.2543x + 0.306$	0.9955
58 ºC / 331.15 K	$y = 0.278x + 1.323$	0.9734	$y = 0.1612x + 0.295$	0.9754
Total R^2		2.9409		2.9511

Moisture content was obseved to follow first order kinetics.

Table 11: Regression Equations And R^2 Values P Anisidine Values At Different Storage Temperatures.

Storage Temperature	Zero Order Equation	Zero Order R^2	First Order Equation	First Order R^2
38 ºC / 311.15 K	$y = 0.608x + 0.718$	0.9438	$y = 0.3998x - 0.212$	0.9468
48 ºC / 321.15 K	$y = 1.109x + 0.744$	0.9959	$y = 0.5339x - 0.085$	0.9727
58 ºC / 331.15 K	$y = 1.956x + 0.846$	0.9938	$y = 0.6688x - 0.041$	0.9204
Total R^2		2.9355		2.8399

P anisidine value was observed to follow zero order kinetics.

Table 12: Regression Equations And R^2 Values TVBN At Different Storage Temperatures.

Storage Temperature	Zero Order Equation	Zero Order R^2	First Order Equation	First Order R^2
38 ºC / 311.15 K	$y = 0.857x + 6.577$	0.9787	$y = 0.1294x + 1.878$	0.9561
48 ºC / 321.15 K	$y = 1.266x + 6.561$	0.9903	y =0.1499x+1.8959	0.9988
58 ºC / 331.15 K	$y = 1.504x + 6.7$	0.9999	$y = 0.1714x + 1.192$	0.9931
Total R^2		2.9689		2.9530

TVBN was shown to follow zero order kinetics.

The next analysis stage was chosen based general aceptability and on the highest R^2. Table 13 shows the value of k and ln k parameters of general aceptability. When the k value is ln (natural logarithm) and plotted in graphical form with 1/T (in Kelvin units) at the three storage temperatures, the Arrhenius equation is obtained based on the regression equation (Asiah *et al.*, 2018; Patel *et al.*, 2007). The values of k, ln k, and 1/T of general aceptability can be observed in Table 14. Then the values of ln k and 1/T and the graph of the relationship between the two(the Arrhenius plot) can be observed in Fig 6. Calculations from the Arrhenius pkot showed that there is a high correlation (R^2 = 0.9171) between the rate constant and temperature.

Table 13: .Arrhenius parameters for general aceptability

Storage Temperature (ºC)	T	1/T	K	ln K
38	311.15	0.00321	0.38	- 0.968
48	321.15	0.00311	0.50	- 0.693
58	331.15	0.00302	1.06	- 0.058

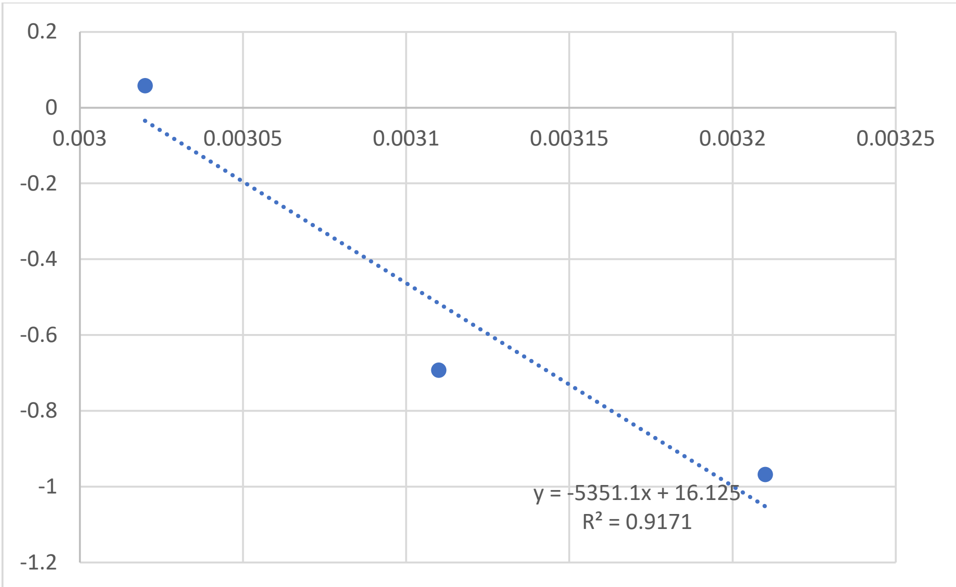

Fig 6: The Arrhenius plot for General Acceptabilitywith ln K on the y-axis and 1/T on the x-axis

Based on the regression equation on the graph ln k to 1/T(°K) it can be seen that the Arrhenius equation generally has the equation formula ln k = -Ea/R (1/T) + ln ko. The Arrhenius equation and the parts of the equation are shown in Table 14.

Table 14 : Arrhenius Equation and Activation Energy Value of General Aceptability

Component Analysis Result	Analysis Component
Regression or Arrhenius Equation ln k vs 1/T(°K)	$y = -5351x + 16.125$
Coefficient of Determination (R^2)	0.9171
Ea/R(K)	5351.1
R (Ideal Gas Constant) (cal/mol°K)	1.986
Ea (Energy activation) (cal/mol)	10627.28
ln ko	16.125

The Ko gotten from the Arrhenius plot was used in the Arrhenius equation again to calculate the rate constant K at room temperature (28ºC) and at refrigeration temperature (4ºC).The obtained rate constants were then inserted in the zero order kinetics equation

$$C = Co - kt$$

In order to obtain the shelf life of the product at these desired temperatures as shown in Table 15

Table 15. Final Analysis Results and Product Shelf Life based on general aceptability

Storage Temperature	ln K	K month $^{-1}$	Shelf life in months
Room temperature (28ºC	-1.6438	0.19324	15.52
Refridgerator temperature(4ºC)	-3.1822	0.04149	72

CONCLUSION

After the completion of this study it was observed that:

- Seasoning cubes were successfully produced from different combinations of fermented African locust bean seeds (iru), chicken and shiitake mushroom powders.
- The seasoning cubes were found to have physical and sensory properties comparable to the standard maggi cube at 5% level of significance.
- The most acceptable product was found to be that which contained 66.7% fermented African locust bean ,16.6% chicken powder and 16.6% shiitake mushroom powder.
- The shelf life of the most acceptable product was estimated using the Arrhenius model and was found to be 15.5 months at room temperature 28ºC and 72 months at refrigeration temperature 4 ºC.

RECOMMENDATIONS

The authors hereby recommend that the formulation containing 66.7% iru,16,6% chicken powder and 16.6% shiitake mushrooms should be produced on industrial scale and put on the markets in order to encourage people to consume safer seasoning cube free from additional MSG.

It is also recommended that more research should be carried out on the possibility of using other oil seeds like pumpkin seeds which are abundant in Africa to produces elf stable seasoning cubes in order to reduce our dependence on imported seasoning cubes and flavour enhancers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE) Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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