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Review Article
Chemical Composition and Biological Effects of Yaji: A Popular Nigerian Composite Suya Sauce

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Abstract

The use of spices in the food industry has been practiced since ancient period. As a means of optimizing the standard and patronage of existing species in this present day, a combination of 2 or more spices as a condiment is being adopted by producers. One of these instances is Yaji, a composite spice consisting of 7 ingredients which serves as a Suya/meat sauce in Nigeria. This study aimed to evaluate the health benefits and toxicity outcome of a Nigerian composite meat sauce "Yaji" in light of previous studies. Information was sourced from electronic databases, Pubmed and Google scholar engines. Yaji's chemical constituents, biological effects, microbial and toxicity profiles and regulatory measures in the improvement of its quality were discussed. From animal data, Yaji possesses health benefits in obesity and cardiovascular disorders besides its culinary usefulness, but also revealed more toxicity and poor microbial standard. Although, the outcome of some animal studies were contrasting, clinical studies using human volunteers are still required to validate the outcome of preclinical studies. In addition, a better regulatory measure in the production and vending processes of Yaji is required.

Key words: Yaji, cardiovascular disorders, suya/meat, microbial safety, spice, biological effects, meat sauce

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INTRODUCTION

Spices are foodstuffs or bio-nutrients from dried leaves, seeds, barks, flowers, rhizomes, roots and fruits of herbal plants[1]. They are used as food additive for the purpose of cooking, preserving, flavoring and coloring[2]. Besides the above uses, spices are applicable in disease treatments, religious ritual and production of cosmetics, due to their aromatic constituents[3]. They originated from the word "species" which in the middle age served as colorful foodstuff and recipes for incenses and perfumes preparation[4].

Varieties of medicinal plants parts including onion (*Alum cepa*), cloves (*Syzygium aromaticum*), thyme (*Thymus vulgaris)*, scent leaf (*Ocimum gratissimum*), cinnamon (*Cinnamomum verum*), pumpkin leaf (*Telferia occidentalis*), Negro pepper (*Xylopia aethiopica*), lemongrass (*Cymbopogon citrates*), cardamom (*Elettaria cardamomum*), ginger (*Aframomum melegueta*), garlic (*Allium sativum*), lime (*Citrus aurantifolia*), turmeric (*Curcuma longa*), calabash nutmeg (*Monodora Myristica*), among others have served as rich sources of spices in different parts of the world, including Nigeria[1,5].

Among the various spices available in Nigeria, Yaji occurs as a compound spice, consisting of 7 ingredients including table salt (sodium chloride), Maggi (monosodium glutamate, MSG), groundnut cake powder (*Apios Americana*), clove (*Syzygium aromaticum*), black pepper (*Piper nigrium*), red pepper (*Capsicum annuum*) and ginger (*Zingiber officinale*) [6,7].

Factually, the name 'Yaji, meaning "hot one" was derived from "Hausa" culture[8]. It serves as a sauce for Nigerian ready-to-eat meat (RTEM), especially "Suya" which are prepared from boneless parts of cattle, goat, pork and chicken[9,10]. Yaji is usually spread over and mixed with processed RTEM before serving to consumers.

In Nigeria, there is an increase in the consumption of RTEM spiced up with Yaji. This high patronage could be attributed to several factors, including industrialization, migration, individuals' busy schedules and lack of time to prepare meals. Also, there is no present regulatory guideline for the production and consumption of Yaji[7]. To this end, regular consumption of Yaji and its constituents have stimulated scientific attentions in recent times. Considering this fact, several scientific findings have been published on its usefulness and risks. However, there is a paucity of recent studies regarding its health benefits and toxicity profile besides its benefits. This necessitated this present review. So, this review was aimed to study the chemical composition and biological outcomes of a Nigerian composite meat sauce "Yaji".

CHEMICAL COMPOSITION AND CONSTITUENTS OF YAJI

This article was prepared from existing literatures that were sourced using research databases including Google Scholars and Pubmed engines. Search terms employed include Yaji, meat's spice, Suya spice, safety of meat's spice in Nigeria. Relevant articles were retrieved after initial examination of their titles and abstract for suitability to this topic. Studies conducted on Yaji from 2007-2019 were selected. Related articles from other relevant sources were also retrieved for the synthesis.

Clove: *Syzygium aromaticum* Linn. (Myrtaceae): Commonly known as the spice Lavang, *Syzygium aromaticum* belongs to Myrtaceae family[4]. It is known as *Caryophyllus silvestris*, *Jambosa caryophyllus*, *Caryophyllus aromaticus*, *Eugenia caryophyllus* and *Myrtus caryophyllus*. Its name "Clove" is derived from French word 'clove' and 'clou' meaning 'nail'. It is a medium sized tree which could attain growth height[11,12] of 10-12 m. Ethno-pharmacologically, it is used in the treatment of throat infections, dental diseases, asthma, cough, stomachache, convulsion and cancer. It can also serve as local anesthetic[4].

The active principles in *Syzygium aromaticum* include eugenol, clove oil, caryophyllene, salicylic acid, vitamin B, tannins[4, 11], copper, potassium, zinc and manganese[13]. Eugenol and monoterpenes were found to be the dominant constituents of its bud[14]. It's essential oil also revealed the presence of saponins, alkaloids, flavonoids, cardiac glycosides, tannins and steroids[15]. Phenolic compounds, gallic acid, kaempferol, rhamnetin, myricetin, salicylic acid, syringic acid, eugenin, caffeic acid, eugenitin, isorhamnetin, quercetin, phenylacetic acid, isorhamnetin, protocatechuric acid and p-hydroxybenzoic acid were detected in its methanol extract[16].

Recent review article published by Kaur and Kaushal[11] revealed that *Syzygium aromaticum* possess the following biological activities; anti-microbial, antioxidant, anti-inflammatory, analgesic and antipyretic, anticancer, nematicidal, acaricidal, anesthetic, herbicidal, insecticidal activities as well as seminiferous tubule degeneration and decrease in daily sperm production. Essential oil from clove was reported safe when administered[17] below 1500 mg kg^{-1}. Its 90 days repeated chronic toxicity study at 300 and 700 mg kg^{-1} in Wistar rats revealed a significant alteration in heamatological, biochemical and histological parameter

characterized by periportal inflammation of the liver, gastritis and tissue necrosis, tubular necrosis of the kidney[18].

Black pepper (*Piper nigrum*): Belonging to the family of Piperaceae, black pepper remains one of the most commonly used spices grown in many tropical regions and other parts of the world. Also called "King of spice", it is used in perfumery, as preservative and as a sauce for meat dishes[19].

Its fruit is useful in the treatment of cough, anorexia, pyrexia, liver disorders, obesity, worm infestation, digestive and respiratory disorders[4, 19].

The following constituents were found to be present in its fruit: beta-carotene, camphene, eugenol, carvacrol, gamma terpinene, lauric-acid, ascorbic-acid, linalyl-acetate, methyl-eugenol, myrcene, terpinen-4-ol, ubiquinone, myristic-acid, myristicin, palmitic-acid and piperine[3,20]. Also, include terpenes, which contributed to its aroma. The high amount of manganese, sodium, zinc, potassium and iron were found to be present in it[13]. Other constituents include chavicine, volatile oil and vitamin B[4].

Reported biological activities of *Piper nigrium* in a recent review study included antioxidant, anti-inflammatory, anti-thyroids, antitumor, anti-platelets, antipyretic, antidiarrheal, analgesic, antispasmodic, antibacterial, antifungal, hepato-protective, anti-apoptotic, insecticidal, anti-spermatogenic and larvicidal activities[19]. Evaluation of its 90 day sub-chronic toxicity at 300, 600 and 1200 mg kg^{-1} revealed no abnormalities in the animal's behavior as well as in clinical, hematology and histopathology[21].

Ginger (*Zingiber officinale*): Belonging to the family of Zingiberaceae, *Zingiber officinale* is a creeping perennial underground rhizome that is indigenous to several countries including Nigeria[22]. It is useful in traditional medicine as a natural remedy in pains, ulcer, inflammation, rheumatoid arthritis, osteoarthritis. It also serves as a preventive remedy for heart attack and stroke[23].

Its rhizome's chemical constituents include 6-Gingerol (responsible for its pungency), 6-shogaol, alanine, ascorbic-acid, beta-carotene, caffeic-acid, camphene, gamma-terpinene, lauric-acid, methionine, myristic-acid, p-coumaric-acid, palmitic-acid, quercetin, selenium and sucrose[24,25]. The whole plant constituents include terpinen-4-ol, tryptophan vanillic-acid, vanillin, capsaicin, chlorogenic-acid, curcumin, delphinidin, ferulic-acid, p-hydroxy-benzoic-acid, kaempferol, beta-sitosterol, myricetin. Shikimic acid was identified in the leaf[3]. Its nutrient analysis revealed moisture (80.9%), protein (2.3%), fat (0.9%), minerals (1.2%), fiber (2.4%) and carbohydrates (12.3%). Minerals present in ginger include calcium, iron, magnesium, manganese and phosphorous[26]. Vitamin C, riboflavin, thiamine and niacin . The compositions vary based on agronomic conditions, curing methods, drying and storage conditions[23]. Studies have shown that ginger possesses growth promoter[27], antioxidant[28], antimicrobial[29,30], immune-stimulant[23,31], anti-inflammatory and analgesic[32], anti-arthritic[33] and anti-hyperlipidemic effects[34].

Single dose (2500 mg kg^{-1}) of *Zingiber officinale* in acute toxicity studies in male rats produced severe hypotension, bradycardia and changes in cardiac tissue. In sub-acute study, 50 mg kg^{-1} produced bradycardia with waviness in cardiac muscle fibers while 500 mg kg^{-1} produced hypotension with bradycardia and degenerative changes in cardiac myocyte tissue. Partial vasorelaxation on rabbit's aortic strip procontracted with phenylephrine were observed *in vitro*[35]. Sub-chronic oral administration of *Zingiber officinale* oil for 90 days at 100, 250 and 500 mg kg^{-1} in male and female Wistar rats did not produce treatment-related alterations in hematological, renal, hepatic parameters as well as histopathology of selected organs[36].

Red pepper (*Capsicum annuum*): Also known as chili pepper, hot pepper, chili, bell pepper and sweet pepper, *Capsicum annuum* belongs to the family of Solanaceae. It is a perennial shrub which can also be grown as an annual and herbaceous plant in temperate regions. It is a good source of vegetable, due to its color, taste and nutritional values[37].

In traditional medicine, its fruits are useful against anorexia, obesity, flatulence, skin disease and pains[4], sore throat, wounds, rheumatism, cancer and loss of appetite[38].

The following constituents have been reported in the fruit of red pepper; alanine, alpha-tocopherol, ascorbic-acid, beta-carotene, caffeic-acid, campesterol, camphene, capsaicin, capsanthin, chlorogenic-acid, eugenol, scopoletin, stigmasterol, selenium, gamma-terpinene, hesperidin, histidine, lutein, methionine, myrcene, myristic-acid, tocopherol, terpinen-4-ol, p-coumaric acid, pentadecanoic-acid and palmitic-acid[3]. Iron, potassium and zinc have been reported to be present in red pepper[39].

A recent review article published by Sanati *et al.*[38], who revealed that red pepper poses the following biological activities; anti-hyperlipidemic, anti-hyperglycemic, anti-diabetic and anti-obesity activities. Its anti-lipid peroxidation activity was also reported by Oboh *et al.*[40]. Its antioxidant, antiviral, anticancer, antimicrobial, anti-diabetic and anti-inflammatory activities were also reported in another review by Olatunji and Afolayan[37]. A review conducted by Srinivasan[41] also reported its anti-ulcer, analgesic, thermogenic and weight reducing effects.

Toxic effects associated with its chronic use include increased skin carcinogenesis following topical application in mice, neurotoxicity, skin and mucous membrane irritation and systemic adverse effect in humans, gastritis and diarrhea, non-sensitivity to painful stimuli and selective degeneration of certain primary sensory neurons, intense tearing, conjunctivitis, pains and blepharospasm following eye exposure[40].

Groundnut (*Apios americana*): Also known as American groundnut, potato bean, it is a perennial food crop which grows between 1-6 m belonging to the family of Fabaceae. Its constituents include protein, fatty acid, oil and carbohydrates. It has both medicinal and nutritional values[42].

Studies showed that its 5% supplementation in rat's diet produced blood pressure reduction by 10% as well as reduction in cholesterol and triglyceride levels[43]. It also, posses antioxidant and anticancer properties against colon, breast and prostate cancers due to its isoflavone content[44,45]. In mice, its flower produced a blood glucose reduction effect, but was also found to be toxic[46].

Monosodium glutamate (MSG): Monosodium L-glutamate (MSG) contains sodium salt and amino acid, free glutamate, which occurs in proteins of living tissues and natural occurring food such as tomatoes, mushrooms, meats, peas, parmesan cheese and corn. MSG, also known as "Maggi white" is a white crystalized powder with pH ranging from 6.7-7.2. It is soluble in water, ether, except alcohol, acetic acid, benzene and methanol[47]. It constitutes 22 and 78% sodium and glutamic acid, respectively[48].

MSG is one of the world's most widely used food additives and flavor enhancer when combined with sodium salt[49]. It is a commercial product called "Aji-no-moto" (meaning the essence of taste) which was launched by the Suzuki brothers[49] in 1909. Scrumptiousness of food is well known to increase following supplementation with the appropriate amount of MSG[50].

MSG is known to enhance appetite, facilitate salivary flow and also reduce dry mouth complications in the elderly[50]. Studies have shown that low level of sodium in food can be substituted with MSG[51]. This is substantiated by report of earlier studies which showed that the quantity of sodium consumed can be minimized by about 32.5% when MSG is used as a substitute. In comparison to sodium chloride, (39.34 g/100 g), MSG has a lesser quantity of sodium of 12.28 g/100 g. Federation of American Societies for Experimental Biology as well as the United States Food and Drug Administration have categorized MSG as a generally safe substance[49]. Recent safety re-evaluation of MSG by the European Food Safety Authority (EFSA) proved that 30 mg kg^{-1} is an acceptable daily intake for MSG[47]. MSG consumption serves as a means of iron fortification by increasing hemoglobin concentration[52].

Recent reviews of scientific literatures of clinical and non-clinical toxic effects of MSG have been documented in diverse species of animals including mice, rats, dogs and rabbits. A review work by Bera *et al.*[50] revealed that MSG produced toxic effects ranging from induction of oxidative stress, obesity, cancer in animals, non-adverse effects in pregnant and lactating mothers, neurotoxicity (characterized by hyperactivity, attention deficit disorder, Lou Gehrig's disease, Parkinson's disease, Alzheimer's disease and multiple sclerosis in animals. A review by Husarova and Ostatnikova[49] also revealed that MSG caused elevation in ALT and AST levels as well as degenerative changes on the liver and dilatation of the central vein, lipid peroxidation, reduction in testosterone level in male rats as well as changes in the ovaries and Fallopian tubes of Wistar rats[49]. The MSG toxic effects on central nervous system, adipose tissue, hepatic tissue and reproductive organs were reported in several animal studies[49]. It was also found to induce obesity and oxidative damage in rodents[53].

In 1986, signs and symptoms, including weakness, head and neck pains, palpitation, asthma, urticaria, dermatitis and tachycardia were reported after the consumption of Chinese food assumed to have contained MSG (Chinese restaurant syndrome). However, there was no association between MSG consumption and supposed symptoms by using double blind, placebo-controlled trial[49,54].

Also, earlier studies carried out over 38 years back showed that prolong supplementation of rodent diet with MSG up to 4.0%, produced no deleterious effect. In a study in dogs that lasted for 2 year following 10% supplementation with MSG, maternal and fetal effects did not occur[55]. Median lethal doses (LD_{50}) in rats and mice species were found to range from[55,56] 15-18 g kg^{-1}. A recent report revealed that the use of MSG as a food additive in human pose no toxicological risk, as approved by the U.S food and drug administration (FDA). It was also classified as a food additive by the European Union[50].

Table salt (sodium chloride): It is a widespread food additive since the history of mankind, dated back to 6000 BC. Sodium chloride serves as a taste enhancer as well as a preservative against microbes thereby extending the shelf life of foods. Table salt is a manufactured form of sodium (called sodium chloride) that is prepared by heating natural form, sea, rock salts at 1200° Fahrenheit. Its natural occurring iodine content

can be lost through this process of heating[57]. Thus, supplementation of salt with synthetic iodine serves as an alternative replacement to lost iodine during the manufacturing process[58].

Although sodium chloride is indispensable to human health, such as maintenance of concentration and charge differences across cell membrane, absorption and transport of nutrients, maintenance of blood pressure and blood volume, excess of it could be toxic. When intake of sodium chloride becomes too much, it results to increase in extracellular fluid volume, due to the transport of water from inside of the cells to the outside of cells for the maintenance of normal sodium concentrations[59]. Ingestion of large amounts of salt could result in nausea, vomiting, diarrhea and abdominal cramps[60]. Other chronic health complications include hypertension[61,62], gastric cancer[63,64], osteoporosis[65,66] and kidney stone[60,67,68]. The acute oral LD_{50} of salt in cattle, dogs and sheep has been established to be ~2.2, ~4 and 6 g kg^{-1}, respectively[59].

BIOLOGICAL EFFECTS OF YAJI

Scientific findings published in various journals have revealed that Yaji possesses both beneficial and risk effects. Table 1 summarized the biological effects of Yaji, a composite spice. Its microbial quality assessments were also carried assessed.

Effects on body weight: An 8 week study on the effects of supplementation of Yaji and its constituents (clove, salt, MSG, ginger, red pepper, black pepper and groundnut, 9 g each) in the feed of Wistar rats was carried out. The study revealed more weight gain in groups feed with salt, MSG and groundnut when compared with control (growers feed). On the other hand, minimal weight gain was observed in groups feed with Yaji, clove, ginger, red pepper and black pepper. The authors concluded that Yaji has the ability to regulate weight gain[69]. In a related investigation, Agbo *et al.*[70] evaluated the effect of 20, 40 and 60% Yaji supplemented feed on body and organ weights of rats for 3 weeks (short term study) and 6 weeks (chronic study). There was a significant decrease in weight gain in 20% Yaji supplemented group during the short term and chronic phases as well as weight gain in 40 and 60% Yaji supplemented group during the chronic phase. They submitted that Yaji has the capacity of regulating weight[70].

Effects on hematological parameters: Researchers did a comparative analysis on short term (4 weeks) and chronic (8 weeks) effect of the Yaji and its constituents (clove, salt, MSG, ginger, red pepper, black pepper and groundnut, 9 g each) on hematological parameters of adult Wister rats. The WBC levels were not significant among various groups, but there was a significant reduction in packed cell volume (PCV) in groups feed with Yaji, ginger and black pepper in the acute study and clove for chronic study[71]. On the other hand, the level of the PCV was increased in groups feed with Yaji, ginger, red pepper and black pepper in the chronic study. They concluded that the effects of Yaji and its constituents were duration and dose dependent and such could have deleterious effects on the well being of consumers. Following a duplicated publication of these findings in another journal, the authors recommended on the need to regulate the amount of additives in Yaji, bearing in mind, the effects produced by the salt supplemented group[72].

The hematological (PCV, hemoglobin concentration and white blood cell count) and biochemical (total plasma protein, serum albumin, blood urea, creatinine) profile of Yaji and its individual constituents (clove, ginger, garlic and red pepper) on Wistar rats (4 g/70 kg) for 14 and 21 days revealed beneficial, without any adverse effects[7].

Renal effects: A study by Ezejindu *et al.*[73] on the supplementation of Wistar rat's diet with graded doses, 5, 10 and 15 g of Yaji for a period of 2 months revealed kidney damage characterized by very slight glomerular congestion, slight hypertrophied glomeruli, stromal edema and lymphocytic cell aggregation. They remarked that kidney failure could result following the continual use Yaji spices.

Three week supplementation of adult rabbit's diet with clove, ginger, red pepper, black pepper and overall constituents, 3% each produced no toxic effect on the kidneys in ginger and red pepper fed groups, however distinct round basophilic bodies in the interstitium of the renal cortex, which were suspected to be mast cells were observed in Yaji, clove and black pepper fed groups. They submitted that clove and black pepper may trigger renal damage in Yaji[8].

Hepatic effects: As a part of the study published by Ezejindu *et al.*[73], 2 months diet supplementation of Yaji, 5, 10 and 15 g to Wistar rats resulted in a significant increase in the activity of liver enzymes, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphate (ALP), which was observed in groups supplemented with 10 and 15 of Yaji spices. They suggested that long term intake of Yaji could be deleterious to the liver[74].

A study by Festus *et al.*[75] evaluated the effects of 10, 20, 30, 40 and 60% Yaji on liver profile of Wistar rats following

Table 1: Biological effects of Yaji, a composite spice on laboratory animals

Biological effects	Dosage and duration of treatment	Observed effect	References
Body weight	9 g of each component for 8 weeks	↓body weight gain	Akpamu *et al.*[69]
	20, 40 and 60% in 3 and 6 weeks	↓body weight gain	Agbo *et al.*[70]
Hematology	9 g of each constituent for 4 and 8 weeks	4 weeks: ↓ PCV, 8 weeks: ↑PCV	Akpamu *et al.*[72]
	4 g/70 kg for 2 and 3 weeks	No deleterious effect	Eruke *et al.*[7]
Liver	3 g of each constituent for 3 weeks	Acute hepatitis	Nwaopara *et al.*[79]
	10 and 15 % for 2 months	Central vein hypertrophy, increased cellularity and increase in vascularity with signs of edema (Hepatotoxicity)	Ezissi *et al.*[80]
	5, 10, 15% for 2 months	↑ ALT, AST and ALP (Hepatotoxicity)	Ezejindu *et al.*[74]
	10, 20, 30, 40 and 60% for 2 and 6 weeks	Alteration in liver enzymes (hepatotoxicity)	Festus *et al.*[75]
	0.5 mL of 250 mg mL^{-1} for 4 weeks	Hepatoprotective against CCL_4	Ezejindu *et al.*[77]
	4 g/70 kg for 2 and 3 weeks	No alteration in liver enzymes	Okoro *et al.*[76]
Kidney	5, 10 15 % for 2 months	Slight glomerular congestion, slight hypertrophied glomeruli, stromal edema and lymphocytic cell aggregation	Ezejindu *et al.*[73]
	9 g of each constituent for 3 weeks	Distinct round basophilic bodies in the interstitium of the renal cortex	Nwaopara *et al.*[8]
Heart	3 g of each constituent for 3 weeks	No deleterious effect	Nwaopara *et al.*[86]
Brain	50% Yaji for 6 weeks	Duration dependent Oligodendroglioma (neurotoxicity)	Nwaopara *et al.*[83]
	10-70% Yaji for 2, 4 and 6 weeks	Dosage duration dependent grades II and IV astrocytoma (neurotoxicity)	Nwaopara *et al.*[84]
	10-70% in 2 weeks	Vacuolations, pyknosis and cavitations in the cerebrum of the rats (neurotoxicity)	Nwaopara *et al.*[81]
	10-70% in 2, 4 and 6 weeks	Cerebrovascular changes including; hypoxia – ischemia and subsequently, brain tissue necrosis (neurotoxicity)	Nwaopara *et al.*[82]
Testes	5, 10 and 15% in 6 weeks	Disrupt testicular functions	Ukoha *et al.*[87]

↑: Increase, ↓: Reduction, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, ALP: Alkaline phosphatase, PCV: Packed cell volume, CCL_4 : Carbon tetrachloride

short term (2-weeks) and chronic (6 weeks) dietary supplementation. The results revealed that Yaji produced dose and duration dependent alterations in liver biomarkers, an indication of liver damage. They recommended that Yaji's consumption should be controlled by consumers[75].

Contrary to the above finding, administration (4 g/70 kg) of Yaji and its components for 14 and 21 days to Wistar rats revealed no significant alteration in body weight as well as liver enzymes (ALT, AST and ALP) in test groups when compared with the control group. The authors postulated that Yaji and its components did not cause hepatocellular damage within the tested doses[76].

Following an intervention study that lasted for 28 days, Yaji extract (0.5 mL of 250 mg mL^{-1}) was found to normalize elevated levels of liver enzymes of carbon tetrachloride (CCL_4) induced hepatotoxic rats[77]. Histological results of this work published in another journal revealed no distortion in hepatocytes of the groups treated with Yaji alone and even in the presence of carbon tetrachloride[78].

Using adult rabbit, 21 days supplementation of diet with individual and combined components of spices (ginger, clove, red pepper, black pepper, 3% each) revealed necrosis and acute hepatitis in histoarchitecture of liver hepatocytes[79].

A two months study by Ezissi *et al.*[80], involving the supplementation of rat's feed with 5, 10 and 15 g of Yaji revealed no deleterious effects on the histological appearance of the liver, except high doses, 10 and 15 g which caused distortion in liver characterized by central vein hypertrophy, increased cellularity and vascularity with signs of edema. They recommended the avoidance of chronic intake of Yaji spices by consumers.

Neurological effects: Two weeks supplementation of Wistar rat's feed with graded doses (10, 20, 30, 40, 50, 60 and 70%) of Yaji caused non-dose dependent neurodegenerative changes characterized by vacuolations, pyknosis and cavitations in the cerebrum of rats. They recommended that consumption of Yaji should be regulated to avoid brain tissue damage[81]. Using similar doses, Nwaopara *et al.*[82] investigated the effects of 2, 4 and 6 weeks Yaji supplemented diet on brain blood supply and they found that high dose induced cerebrovascular changes including hypoxia-ischemia and subsequently, brain tissue necrosis. The authors reported a related finding in another Journal where the group treated with 50% Yaji for 6 weeks presented a duration dependent

oligodendroglioma. They recommended that the observed dose could cause brain tissue damage along with tumor formation[83]. Similarly, daily supplementation of diet with 10-70% Yaji for a period of 2, 4 and 6 weeks caused dosage and duration dependent grades II and IV astrocytoma (brain tumor) in the group feed with 70 and 30% Yaji for 6 and 3 weeks, respectively[84]. Two weeks supplementation of Yaji (10-70%) in the diet of albino rats produced non-dose dependent alterations in cerebellum cellular architecture. There were degeneration and clumping in purkinje and granular cells, respectively. The authors suggested the need for regulation in the production and consumption of Yaji[85].

Cardiac effects: A study carried out on the supplementation of rabbit's feed with spice constituents (clove, ginger, red pepper and black pepper) of Yaji for 21 days. No deleterious effect was observed in the heart. They recommended the inclusion of these spices in herbal medications, especially those used in the management of heart related conditions[86].

Reproductive effects: The effect of 5, 10 and 15% Yaji supplementation in animal's diet for 6 weeks was carried out in male Wistar rats. From the study, there was body weight reduction in groups feed with 10 and 15% Yaji while higher doses of Yaji damaged seminiferous tubules, reduced viable sperm cells and destroyed the arrangement of sperm and leydig cells. They recommended that excessive and uncontrolled intake of Yaji should be avoided, as such could disrupt testicular functions, despite its weight reducing effect[87].

MICROBIAL SAFETY

Ugbogu *et al.*[88] investigated the bacteriological and mycological qualities of commercially prepared ginger based Yaji procured from Wukari Government area of Taraba State. Acidic pHs of 4.87±1.08 to 5.52±0.07 were recorded in all samples. Total viable bacteria count ranged from 1.0×10^8-4.0×10^9 CFU mL^{-1}, while the range of 2.0×10^8-1.7×10^9 CFU mL^{-1} were recorded for fungi. *Staphylococcus aureus* and *Staphylococcus epidermidis* were major bacteria isolated. Fungi isolated include *Aspergillus* and *Penicillium* species. They concluded that microbial contamination observed was as a result of poor hygienic measures adopted by the producers as well as use of deteriorated spices[88].

Bacteriological quality and antibiotic sensitivity pattern of isolates of suya spice (consisting of ginger, garlic, black pepper, hot pepper and groundnut sold in three locations in Port Harcourt, River State was evaluated by Odu and best[9]. There was variation in the total plate counts of samples, 3.45-6.16 (log CFU g^{-1}). All samples presented *Staphylococcus* sp. as the most prevalent bacteria with colony count ranging from 3.69-6.02 log CFU g^{-1}. A proportion of 28.67% of the samples had a prevalence of *E. coli*. In antibiotic sensitivity test, multiple resistances to antibiotics were displayed by some organisms. As against the international Commission on Microbiological Specifications for Foods (ICMSF) standard of 5.70-6.70, high level of total viable count of 7.90 (log CFU g^{-1}) was recorded in tested samples. The authors suggested the provision of control mechanisms and established best practice towards improving spices quality. More studies on effective decontamination, transport and storage methods were also recommended[9].

Fungal biodeterioration, aflatoxin contamination and nutrient value of Suya spices, consisting of *Capsicum* sp., *Piper guineense,* Maggi and salt sold in five locations, including Agbowo, Sabo, Mokola, Ojoo and Sango in Ibadan, Oyo state were evaluated and compared with control Suya spices aseptically prepared in the laboratory. The result revealed the presence of *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus ochraceus*, *Fusarium* sp., *Rhizopus stolonifer*, yeast and *Trichoderma koningii* in samples. Analysis of samples also revealed the presence of Aflatoxin in varying proportion, except control. The authors suggested that the presence of these contaminants in samples could be due to airborne flora in various locations, poor sanitary condition of handlers and producers. They recommended proper handling and storage as well as regular evaluation for aflatoxin on food materials[89].

EVALUATION OUTCOME

The composite spice, Yaji and its components have played significant roles in Nigerian food industry. In this evaluation, few animal studies revealed that Yaji possess therapeutic benefits including regulation of body weights[69,70], hepatoprotective activity against liver damage by CCL_4[78] and cardio protective effect[86]. On the other hand, most animal studies revealed that its repeated consumption could pose hepato-renal, testicular and neuro toxicities. No toxicity was observed on cardiac function. Studies on its microbial quality revealed that the samples were contaminated with bacteria and fungi beyond acceptable limits.

Contrasting results among authors were observed in heamatology and liver profile in animal studies. It is very obvious that disparity in dosage and duration of administration, complexity (presence of other ingredients) and purity as well as test model (human and non-human species) could have contributed significantly to variations in the results observed.

Authors of reviewed articles associated the beneficial and toxic effects of Yaji to its constituents which could elicit either antagonistic or synergistic beneficial and toxic effects, depending on their various metabolic pathways. For instance, the review of literatures above on biological properties of four (4) constituents of Yaji, including Clove (*Syzygium aromaticum*), ginger (*Zingiber officinale*), red pepper (*Capsicum annuum*), MSG and table salts (sodium chloride) revealed various toxic effects besides their therapeutic activities in animal models. On the other hand, other 2 constituents, including black pepper (*Piper nigrum*), Groundnut (*Apios Americana*) posed little or no toxic effect(s) besides their various therapeutic activities.

Although, non-clinical or animal based toxicological researches are relevant in making some scientific conclusions regarding the safety profile of food and drugs[90], it is also necessary to put into consideration the dosage, frequency and duration of Yaji intake alongside with RTEM and other diets by humans which could even interact (potentiate or neutralize) with its toxic effects. To substantiate this, there are no clinical data or case reports regarding the toxic effect of Yaji in human at present. For instance, MSG and table salts were earlier reported to produce cardiovascular and neurological toxicity and may be responsible for the toxicity posed by Yaji[6]. In support of this report, biological assessments of MSG via various routes in animals produced varying effects such as retina and hypothalamus lesions, alteration in hepatic fat metabolism[91,92] as well as brain injury in animals following subcutaneous injection of MSG[47]. On the other hand, these effects were not observed when MSG was administered orally in animal studies[47]. Brosnan *et al.*[93] concluded in their review assessment that the use of MSG is unconnected with any form of human body weight change or obesity.

In terms of quantity consumed, it was found that the oral amount of glutamate needed to achieve brain lesion in mice, 0.5 g kg^{-1} b.wt., cannot be achieved in humans when animal doses are translated to human dose, because even such doses could causes nausea[94].

CONCLUSION AND RECOMMENDATIONS

This review evaluated the benefits and safety profile of a popular Nigerian spice, Yaji. Animal studies evaluated revealed more toxic than beneficial effects while microbial safety is below standard. Results of some animal studies were contrasting. In order to eliminate bias in the translation of the observed animal's results to the human situation, it is recommended for researchers to develop clinical studies using human volunteers. The poor microbial standard of Yaji reported is a clarion call for manufacturers and vendors to exercise proper sanitary conditions. The Nigerian food and drug regulatory agencies should also monitor the production and vending processes.

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