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Review

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Traditional African Fermented Condiments as Sustainable Alternatives to Monosodium Glutamate-Based Bouillon Cubes: Nutritional, Functional, and Health Perspectives

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Abstract: Monosodium glutamate (MSG)-based bouillon cubes are widely used as flavor enhancers in African cuisine, raising concerns about excessive sodium intake and its links to hypertension and cardiovascular disease. Growing demand for natural ingredients has renewed interest in traditional African fermented condiments as alternatives. This narrative review examines the nutritional, functional, and health perspectives of *ogiri, okpei, afitin,* and *iru/dawadawa* (*Parkia biglobosa*) as sustainable substitutes for MSG-based bouillon cubes, including innovations in the ingredients used. Studies published between 2000 and 2026 were retrieved from Scopus, Web of Science, PubMed, ScienceDirect, Google Scholar, and SpringerLink, and synthesized thematically. These condiments are rich in proteins, essential amino acids, peptides, vitamins, minerals, and bioactive compounds, while microbial and enzymatic activity during fermentation produces a characteristic umami flavor, making them effective natural flavor enhancers. Fermentation also improves nutrient bioavailability and confers antioxidant, antimicrobial, and probiotic properties, with bioactive peptides showing antihypertensive, antidiabetic, and lipid-lowering potential. Using these condiments as seasoning may also lower dietary sodium intake, although most evidence comes from *in vitro* and animal studies, and human trials are limited. Their production supports sustainable food systems through local raw materials, indigenous culinary knowledge, and rural livelihoods. Challenges remain in standardization, quality consistency, safety, shelf-life stability, and large-scale commercialization. Nevertheless, these condiments appear to be nutritious, culturally acceptable, and environmentally sustainable alternatives to MSG-based bouillon cubes. Clinical studies, consumer education, and value-chain strengthening are urgently needed to support their wider integration into modern African diets while preserving culinary heritage and food biodiversity.

Keywords: African condiments; monosodium glutamate; fermentation; indigenous foods; bouillon cubes; sustainable nutrition

1. Introduction

The popularity of bouillon cubes across African households can be attributed to their low cost, prolonged storage stability, ease of application, and ability to provide a consistent savory flavor in diverse culinary preparations [1,2]. Their rising consumption reflects broader shifts in African food systems, including

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urbanization, changing lifestyles, and a growing desire for quick meals [3]. Apart from their role in enhancing the sensory qualities of foods, bouillon products have gained attention in sub-Saharan Africa for their potential use as carriers of essential nutrients through food fortification initiatives [4]. Although MSG is commonly perceived as a health concern, available scientific evidence indicates that its consumption at typical dietary levels does not pose a significant risk to human health [5,6]. However, the more pressing nutritional issue is the high sodium concentration found in many commercially produced bouillon cubes, which can substantially contribute to overall salt intake when consumed regularly [2]. The World Health Organization (WHO) recommends limiting sodium intake to less than 2 g per day because excessive sodium consumption is a known risk factor for hypertension, cardiovascular disease, and other non-communicable diseases [7,8]. As a result, lowering the sodium level of popular spice goods has been recognized as a possible public health tactic [4]. African cuisines used a variety of native condiments made from locally accessible plant and animal resources, such as fermented legumes and seeds, herbs, spices, dried fish, and smoked meat, before commercial bouillon cubes became widely used [9,10].

The capacity of traditional condiments like *iru, dawadawa*, and *ogiri* to offer unique savory flavors and fragrances has long been appreciated [10,11]. Proteins, amino acids, minerals, and phenolics are among the nutrients and bioactive substances found in many of these products that may offer further nutritional advantages [12]. Through microbial activity, fermentation contributes significantly to the development of these condiments by improving their flavor, fragrance, and nutritional value [13]. While items like fish supply nucleotides that further increase savory perception, fermented ingredients can naturally produce glutamate and other flavor-active substances that contribute to umami taste [14]. According to Nwatum et al. [9], these features imply that local condiments could be used as an alternative or supplementary flavoring ingredient to sodium-rich commercial bouillon products. Apart from their possible nutritional benefits, local agricultural systems are closely associated with indigenous condiments, which may enhance food security, rural livelihoods, and economic development by reducing reliance on imported seasoning products and adding value [15,16]. There are still issues, though, such as inconsistent raw materials and processing techniques, safety and shelf stability issues, a lack of standardization, and potential consumer opposition because commercial bouillon cubes are more convenient and consistent [17,18].

Indigenous condiments offer a culturally relevant approach that can complement broader sodium-reduction strategies, including food labeling initiatives, nutrition education programs, and product reformulation efforts [10,19]. Rather than completely replacing commercial bouillon cubes, blended or reformulated seasoning products that incorporate locally sourced ingredients may offer a practical way to reduce sodium intake while preserving the flavor attributes consumers prefer [20]. Despite their promising potential, research on native African condiments remains fragmented and limited. Significant knowledge gaps persist regarding their optimal formulation, flavor-enhancing mechanisms, salt and glutamate composition, safety, shelf-life stability, and consumer acceptance as alternatives to conventional bouillon products. Therefore, this review examines the potential of indigenous African condiments as healthier, culturally acceptable, cost-effective, and sustainable alternatives or complements to traditional MSG-containing bouillon cubes, while highlighting key research priorities and technological requirements necessary for their successful development and wider adoption, using articles published between 2000 and 2026.

2. Methodology

The methodology used for the narrative review is described in the flowchart shown in Figure 1.

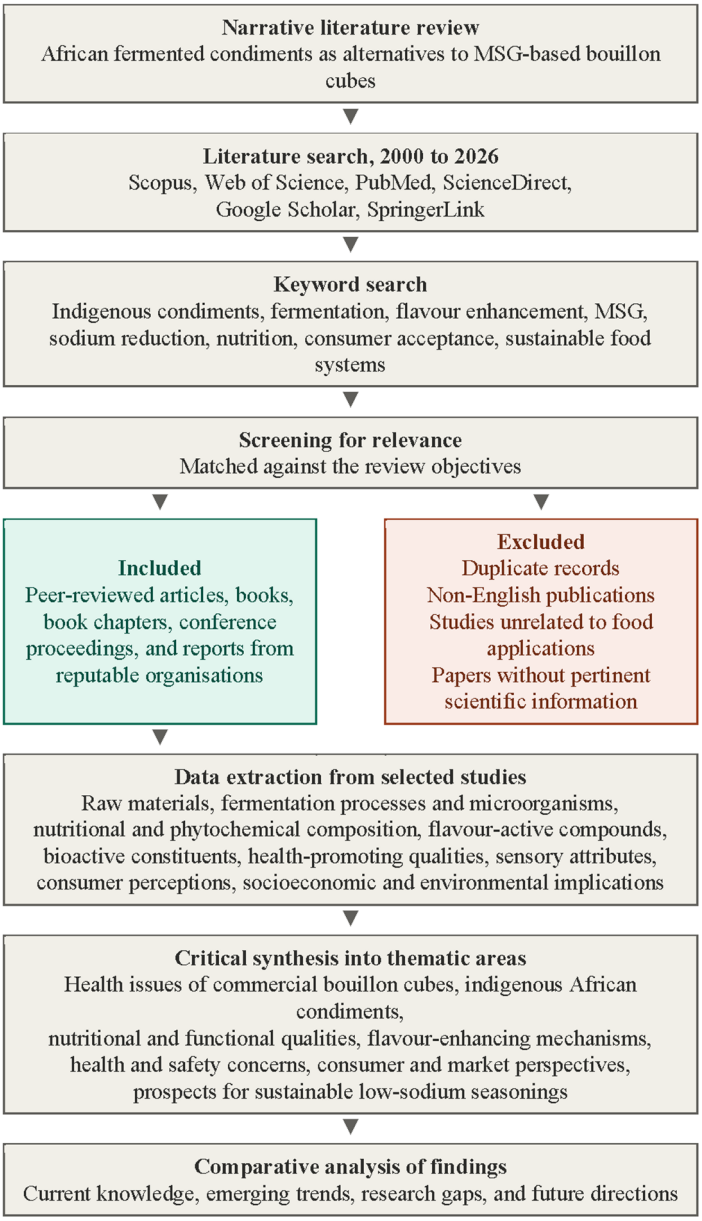


Figure 1. Methodology of narrative reviews.

3. Health Concerns Associated with Bouillon Cubes Consumption and the Need for Indigenous Condiments

It is critical to distinguish between the effects of MSG and the total nutritional makeup of bouillon formulations because the growing use of commercial bouillon products in Africa has raised concerns about their possible health impacts [18]. MSG, the sodium salt of glutamic acid, is widely used as a flavor enhancer because it imparts the characteristic umami taste that consumers find appealing [21]. Current evidence indicates that MSG is generally safe when consumed at typical dietary levels and does not inherently pose a health risk. However, the nutritional concerns surrounding bouillon products extend beyond MSG itself to the high sodium content present in many commercial formulations [22]. This issue is particularly significant in sub-Saharan Africa, where bouillon cubes have become a staple ingredient in daily cooking and food preparation [23]. Although these products are valued for their affordability, convenience, flavor consistency, and ease of use, their frequent consumption can substantially increase overall dietary sodium intake. Consequently, bouillon products have been identified as important targets for sodium-reduction strategies, as reformulating them offers an effective means of lowering salt consumption while allowing consumers to maintain their traditional cooking and seasoning practices [2].

Research suggests that there is a much higher correlation between sodium intake and negative health outcomes than there is between MSG consumption and these effects. Higher sodium intake is positively correlated with an increased risk of hypertension, according to a thorough dose-response meta-analysis by Filippini et al. [24]. In a similar vein, Elsurer Afsar et al. [25] emphasized how important dietary sodium control is for controlling blood

pressure and renal function, especially in people with chronic kidney disease. Excessive dietary salt consumption is widely recognized as an important modifiable risk factor for cardiovascular and kidney diseases. In contrast, the health implications of MSG remain less certain. Experimental studies have reported that prolonged exposure to high doses of MSG may induce alterations in metabolic, neurological, cardiovascular, hepatic, and renal functions; however, these effects have largely been observed under conditions that do not necessarily reflect typical human dietary intake patterns [26]. Furthermore, evidence linking MSG consumption to conditions such as obesity and type 2 diabetes remains inconsistent. Recent reviews have indicated that the available data are insufficient to establish a clear causal relationship, highlighting the need for further investigation [27,28]. Consequently, concerns regarding the regular consumption of bouillon products should focus primarily on their sodium content rather than on MSG itself, given the substantial contribution of these products to overall dietary salt intake.

The exceptionally high consumption of bouillon products in countries such as Nigeria underscores the significance of concerns related to their nutritional impact. Findings from the Nigerian National Food Consumption and Micronutrient Survey revealed that nearly 98% of households use bouillon products, with women of reproductive age consuming an average of 3.6 g daily [29]. Similar studies have shown that bouillon use is widespread across all socioeconomic groups, highlighting its deep integration into household cooking practices and daily meal preparation [30]. Given this widespread and frequent use, even relatively small quantities of salt added through individual meals can accumulate to nutritionally significant levels over the course of a day when consumed repeatedly [31]. In this context, the development and promotion of indigenous African condiments present a promising strategy for improving dietary quality while maintaining the flavor characteristics valued by consumers. Traditionally produced from fermented seeds, legumes, herbs, spices, and other locally available food resources, these condiments have long been used to impart rich savory flavors through naturally occurring amino acids, peptides, and flavor compounds generated during fermentation and processing [10]. Unlike conventional bouillon cubes, indigenous condiments can be formulated with controlled salt levels while simultaneously providing additional nutrients and beneficial bioactive compounds. As a result, they have considerable potential to serve as nutritious, sustainable, and culturally acceptable alternatives or complements to commercial bouillon products, thereby supporting broader sodium-reduction initiatives without compromising flavor preference or consumer satisfaction [32,33]. Increased adoption of these traditional condiments could also strengthen local food systems, promote rural development, and help preserve valuable indigenous food knowledge and culinary heritage.

4. Indigenous Condiments in African Culinary Traditions

African cuisines have long depended on a diverse range of locally available plants, seeds, herbs, spices, and fermented products to enhance the flavor, aroma, and nutritional quality of foods [34]. Before the widespread adoption of commercially manufactured bouillon cubes, flavor enhancement was primarily achieved through indigenous ingredients that were processed using traditional household and community-based techniques such as drying, roasting, grinding, heating, and fermentation [35]. Consequently, these native food resources played a dual role within traditional African societies, serving not only as flavoring agents but also as integral components of cultural food practices and indigenous food systems [36]. Fermented seed condiments are one of the most significant types of traditional African seasonings among these native flavoring ingredients [37]. African locust beans (*Parkia biglobosa*) are widely fermented across West Africa to produce traditional condiments known by different names depending on the cultural and geographical context, including *dawadawa* among Hausa communities and *iru* among the Yoruba people [38]. Other notable indigenous fermented condiments include *ogiri*, *okpei*, *owoh*, and *ugba*, all of which are derived from various seeds and plant materials and play important roles in local food systems [39]. A recent review of Nigerian indigenous condiments identified African locust beans, melon seeds, African oil beans, mesquite seeds, and cottonseed as key raw materials commonly used in traditional condiment production [10,40].

Traditionally, fermentation has been fundamental to improving the sensory attributes, nutritional quality, and storage stability of these condiments. Through microbial activity and enzymatic reactions, fermentation transforms raw materials into more digestible forms while enhancing flavor and extending shelf life [41]. During this process, complex food components are broken down into simpler compounds such as organic acids, peptides, amino acids, and volatile flavor substances that contribute significantly to the characteristic taste and aroma of fermented foods [42]. For example, studies on soumbala, a fermented condiment produced from African locust beans, have shown that fermentation, drying, and heat treatment facilitate protein degradation and the release of free amino acids, particularly glutamic acid and tyrosine, which are largely responsible for its distinctive savory and umami flavor profile [43]. Beyond fermented condiments, indigenous herbs and spices have long been valued for their ability to impart unique flavors, aromas, colors, and pungency to a wide variety of foods, including soups, sauces, meat dishes, vegetable

preparations, and cereal-based meals [44]. In addition to their culinary importance, many of these indigenous spices are rich in nutrients and bioactive compounds and continue to contribute significantly to dietary quality throughout sub-Saharan Africa [12]. Their significance also extends into traditional medicine, where they have historically been used in indigenous healthcare and ethnopharmacological practices [12].

Furthermore, indigenous condiments are deeply embedded in the cultural identity and heritage of African communities. They are often integral ingredients in traditional dishes prepared during festivals, communal celebrations, family gatherings, and ceremonial events, helping to define the unique sensory characteristics of regional cuisines [45]. Consequently, these condiments represent more than culinary ingredients; they embody traditional knowledge, cultural heritage, and historical food practices. A decline in their use therefore has implications beyond nutrition, potentially contributing to the erosion of indigenous food knowledge and culinary traditions [46]. Indeed, Akinola et al. [15] identified the undervaluation of indigenous foods and the gradual loss of traditional knowledge across generations as major threats to the sustainability of African indigenous food systems. These customs have gradually changed since commercial bouillon cubes were introduced and widely used [47]. In contrast to traditional condiments, which frequently require longer preparation times and may show significant batch-to-batch variability, commercial bouillon products offer consumers greater convenience, ease of storage, and a more consistent flavor profile [9]. However, the historical significance and practical qualities of native condiments offer a solid basis for their revival using contemporary food processing techniques [48]. Traditional condiments can be repositioned as useful raw materials for the creation of creative, practical, and nutritionally enhanced seasoning products that satisfy modern consumer preferences while maintaining Africa's rich culinary legacy, rather than being seen as outmoded food items [49]. The development of low-sodium formulations with demonstrated consumer acceptance and health benefits, as well as the investigation of commercialization opportunities, value-chain development, and sustainability, are necessary to advance the use of indigenous African condiments as promising, culturally rooted alternatives to commercial MSG bouillon cubes. This will provide the scientific, technological, and socioeconomic evidence required to establish safe, nutritious, culturally acceptable, commercially viable, and sustainable condiment-based seasoning systems for African food markets. Table 1 shows the indigenous African condiments, their roles, and relevance as alternatives to commercial bouillon products.

Table 1. Indigenous African condiments, their roles, and relevance as alternatives to commercial bouillon products.

Theme	Key Findings	Supporting Citation(s)
Traditional flavor enhancement in Africa	African cuisines have historically relied on locally available plants, seeds, herbs, spices, and fermented products to improve flavor, aroma, and nutritional quality of foods.	[34]
Traditional processing methods	Before commercial bouillon cubes, flavor enhancement was achieved using indigenous ingredients processed through drying, roasting, grinding, heating, and fermentation.	[35]
Cultural significance	Indigenous flavoring resources served both culinary and cultural functions and were integral to traditional food systems and practices.	[36]
Fermented seed condiments	Fermented seed condiments represent some of the most important traditional African seasonings.	[37]
African locust bean condiments	Fermented African locust beans (*Parkia biglobosa*) are widely used in West Africa and are known as *dawadawa* among Hausa communities and *iru* among Yoruba communities.	[38]
Other indigenous fermented condiments	Important traditional condiments include *ogiri*, *okpei*, *owoh*, and *ugba*, which are produced from various seeds and plant materials.	[39]
Major raw materials used	Common raw materials for indigenous condiment production include African locust beans, melon seeds, African oil beans, mesquite seeds, and cottonseed.	[10]
Role of fermentation	Fermentation improves sensory quality, nutritional value, digestibility, and storage stability of indigenous condiments.	[41]
Biochemical changes during fermentation	Fermentation breaks down complex food components into organic acids, peptides, amino acids, and volatile compounds that contribute to flavor and aroma.	[42]
Umami flavor development	In soumbala, fermentation promotes protein degradation and liberation of free amino acids such as glutamic acid and tyrosine, producing a strong savory and umami taste.	[43]
Culinary contribution of herbs and spices	Indigenous herbs and spices contribute flavors, aromas, color, and pungency to soups, sauces, meats, vegetables, and cereal-based dishes.	[44]
Nutritional importance	Many indigenous spices contain valuable nutrients and bioactive compounds that contribute to dietary quality.	[12]
Medicinal significance	Indigenous spices have historically played important roles in traditional medicine and ethnopharmacological practices.	[12]
Cultural heritage value	Indigenous condiments are widely used during festivals, family gatherings, communal celebrations, and ceremonial events and help define regional cuisine identities.	[45]
Knowledge preservation	Indigenous condiments embody traditional knowledge, culinary heritage, and historical food practices.	[45]

Table 1. *Cont.*

Theme	Key Findings	Supporting Citation(s)
Threats to indigenous food systems	Reduced use of indigenous condiments may contribute to erosion of traditional food knowledge and culinary traditions.	[46]
Sustainability concerns	Undervaluation of indigenous foods and loss of traditional knowledge across generations threaten the sustainability of African indigenous food systems.	[15]
Influence of commercial bouillon cubes	The introduction and widespread use of commercial bouillon products has gradually altered traditional seasoning practices.	[47]
Advantages of commercial bouillon products	Bouillon cubes offer convenience, ease of storage, shorter preparation time, and more consistent flavor profiles than many traditional condiments.	[9]
Opportunities for revival	Indigenous condiments can be revitalized through modern food-processing technologies while preserving their historical and cultural significance.	[48]
Product development potential	Traditional condiments can serve as raw materials for innovative, convenient, and nutritionally enhanced seasoning products.	[49]
Future research priorities	Further work is needed on low-sodium formulations, consumer acceptance, health benefits, commercialization, value-chain development, and sustainability.	[48,49]
Strategic importance	Indigenous African condiments have potential to become safe, nutritious, culturally acceptable, commercially viable, and sustainable alternatives to commercial MSG-based bouillon cubes.	Synthesized from [15,48,49]

5. Nutritional Value and Health Importance of African Indigenous Condiments

Because African indigenous condiments are made from a variety of basic components and undergo various fermentation and production processes, their nutritional makeup varies significantly [33]. Many traditional African condiments contain significant amounts of protein, lipids, dietary fiber, minerals, vitamins, and bioactive compounds that may improve dietary quality, in contrast to many commercial seasoning products that are designed primarily to provide flavor [10]. These condiments function not only as flavor enhancers but also as nutrient-rich food ingredients. Recent studies have highlighted the considerable nutritional potential of several indigenous African condiments. A review of Nigerian fermented condiments, including *iru, ogiri, owoh, okpei,* and *ugba*, revealed that these products contain nutritionally valuable constituents and possess promising potential as functional foods [10]. However, researchers have reported substantial variations in their protein, fat, fiber, vitamin, and mineral contents, largely due to differences in raw materials, fermentation practices, and post-processing conditions. Among these condiments, *iru* and *dawadawa*, both produced primarily from African locust beans (*Parkia biglobosa*), are considered particularly noteworthy because of the high nutritional quality of their raw material [50]. Studies on Ghanaian *dawadawa* have reported protein contents ranging from approximately 36% to 50%, alongside appreciable amounts of fat, dietary fiber, iron, zinc, and calcium, underscoring its value as a nutrient-dense traditional food ingredient [51,52]. Awoyale et al. [53] also reported that *Kuru* incorporation into African locust bean to produce powdered *Iru* increased crude protein content from 26.50 to 30.72%, ash from 4.82 to 6.29%, crude fiber from 4.30 to 6.26%, iron from 5.28 to 6.13 mg/100 g, and zinc from 7.66 to 8.48 mg/100 g. These results indicate that to create nutritional databases and provide significant comparisons amongst native condiments, more thorough compositional research and standardized analytical techniques are required.

By encouraging protein degradation and boosting the availability of amino acids and peptides, fermentation also affects nutritional quality [54,55]. For instance, the fermentation of soumbala has been linked to a significant release of free amino acids, especially glutamic acid, which adds flavor and nutritional value [43]. Notwithstanding these encouraging results, little is known about nutrient bioavailability, digestibility, and the impact of various fermentation conditions on nutritional outcomes, underscoring crucial topics for further research. According to Orsar et al. [56] and Oladeji et al. [10], *ogiri*, which is frequently made from melon seeds and other oil-rich seeds, has been found to contain notable amounts of protein, fiber, tocopherols, minerals, and antioxidant chemicals. Comparative studies of Nigerian fermented condiments also showed significant variations in nutritional and phytochemical profiles, with *dawadawa* demonstrating significant phytochemical richness and *ogiri* displaying high nutrient levels [40]. The variability observed among studies highlights the need for further research to identify optimal raw materials and fermentation conditions capable of consistently producing condiments with superior nutritional quality. In addition to their nutritional value, fermented condiments have attracted interest because of their potential health-promoting properties. However, fermented foods are not automatically considered probiotics. The International Scientific Association for Probiotics and Prebiotics distinguishes fermented foods from probiotic products and requires evidence of specific microbial strains, their viability at effective levels, and demonstrated health benefits before probiotic claims can be made [57,58]. Although condiments such as *iru*, *ogiri*, and *dawadawa* may harbor beneficial microorganisms and bioactive compounds produced during fermentation, research on their probiotic properties are still ongoing [50]. According to the criteria established by the International Scientific Association for Probiotics and Prebiotics, further microbiological and clinical studies are

required to identify specific probiotic strains, assess their viability, and verify their health benefits before probiotic claims can be substantiated. Consequently, additional research is needed to determine whether these traditional fermented condiments can deliver measurable probiotic effects in human populations.

Beyond fermented condiments, indigenous African spices such as ginger, garlic, and chili pepper also contribute significantly to the nutritional and functional value of African diets [59]. In addition to enhancing flavor, aroma, and palatability, these spices are rich sources of bioactive compounds that have been associated with various health-promoting properties. Their widespread use in traditional cuisine therefore enhances both the sensory appeal and the potential nutritional benefits of African foods. Garlic has sulfur-containing components like allicin and its derivatives [60], whereas ginger contains bioactive phenolic compounds like gingerols and shogaols [61]. Capsaicin, which is abundant in chili peppers, has been linked to metabolic, anti-inflammatory, and antioxidant properties [62,63]. Much research has concentrated on therapeutic or experimental levels rather than the ones commonly found in foods, despite mounting evidence of their biological function. Therefore, more investigation is needed to elucidate the health consequences of using these substances in indigenous seasoning systems at the culinary level. The nutritional value of indigenous condiments should be considered in the context of usual serving sizes, which are often minimal, even if they may contain valuable nutrients and bioactive substances [64-66]. To measure the total nutritional impact of these condiments in typical African diets, more dietary consumption research is required.

Traditional fermented condiments are rich sources of bioactive compounds that exhibit promising anti-obesity and antidiabetic properties [67]. Evidence from animal, human, and clinical studies suggests that these compounds may improve metabolic health through multiple mechanisms of action [67]. Consequently, fermented condiments have potential applications as functional foods, nutraceuticals, and pharmaceutical ingredients. However, further clinical research is needed to substantiate their therapeutic efficacy and support their broader use in obesity and type 2 diabetes management. The bioactive compounds and probiotics in indigenous condiments in African culinary traditions are shown in Table 2.

Table 2. Bioactive compounds and probiotics in indigenous condiments in African culinary traditions.

Condiment (Substrate)	Dominant Microorganisms/ Probiotic Attributes	Bioactive Compounds	Functional Relevance	Reference
Iru/dawadawa (Parkia biglobosa)	*Bacillus subtilis* is the predominant fermentative bacterium. *B. licheniformis* and *B. subtilis* are also reported in *dawadawa*/*iru*.	Phenolics, antioxidant compounds, ACE-inhibitory peptides	Polyphenol content and antioxidant activity rose with fermentation, and ACE-inhibitory peptides were present in the seeds.	[68-70]
Iru (P. biglobosa)	*B. subtilis* isolates inhibited *Staphylococcus aureus* and *Escherichia coli* and tolerated bile salt.	Bacteriocin-like inhibitory substances; 23 compounds identified by GC-MS	Antimicrobial activity and a probiotic-type trait (bile tolerance).	[71]
Iru (P. biglobosa)	*Bacillus* and *Lactobacillus* spp. dominate fermentation and were described as acid-, heat- and bile-salt-tolerant.	Galacto-oligosaccharides and arabinogalactan (prebiotic fractions)	*Iru* is proposed as a possible dietary source of prebiotics and probiotics.	[72]
Iru fermented with *L. plantarum* (starter culture)	*Lactobacillus plantarum* used as a starter	Fermentation metabolites	Lowered total cholesterol, triglycerides and LDL in hypercholesterolaemic rats.	[73]
Ogiri (castor seed, *Ricinus communis*)	*B. subtilis* and *B. mycoides* predominant; *B. subtilis* OGB3 proposed as a potential biopreservative.	Antibacterial and antioxidant Bacillus metabolites	Natural antimicrobial and antioxidant activity.	[74]
Ogiri Igbo (castor seed)	Not assessed	48 compounds by GC-MS, including 9,12-octadecadienoic acid methyl ester (17.43%)	Retains some health-promoting phytoconstituents despite fermentation losses.	[75]
Ogiri-egusi (melon seed)	*B. subtilis*, *B. megaterium*, *B. firmus*	Not reported in the source	Microbial profile of the fermentation.	[69]
Alkaline-fermented foods generally (*dawadawa/iru, okpehe, ogiri, ugba* and others)	Predominantly *Bacillus* spp.	Peptides, phenolics, and other bioactives formed during alkaline fermentation	Sustainable sources of nutrients and health-promoting bioactives.	[76]

6. *In Vitro, in Vivo* and Clinical Studies on Indigenous Condiments of African Culinary Traditions

In vitro studies provide the mechanistic basis for the health claims made for indigenous African fermented condiments. Traditional fermentation markedly increased the polyphenol content and antioxidant activity of *Parkia biglobosa* seeds (the raw material of *iru*/*dawadawa*), and the seeds contained peptides with angiotensin-converting enzyme (ACE)-inhibitory activity, although the unfermented seeds showed higher ACE inhibition than the fermented

ones [70]. Microbial metabolites also contribute: *Bacillus* species isolated from *iru* and *ogiri* showed antibacterial and antioxidant activity, and a *B. subtilis* strain from *ogiri* was proposed as a potential food biopreservative [74]. *B. subtilis* isolates from *iru* likewise inhibited *Staphylococcus aureus* and *Escherichia coli*, tolerated bile salts, and produced a range of bioactive compounds, including bacteriocin-like inhibitory substances [71].

Animal studies have translated these findings into physiological effects, particularly for glycemic control, lipid metabolism and cardiovascular health. Fermented *P. biglobosa* extracts lowered fasting plasma glucose by about 64–69% in alloxan-induced diabetic rats, comparable to the reference drug glibenclamide [77]. Rats fed a diet containing 20% *iru* showed lower plasma and liver total cholesterol, triglycerides and LDL-cholesterol and higher HDL-cholesterol under induced hyperlipidemia [78]. *Iru* fermented with *Lactobacillus plantarum* also reduced total cholesterol, triglycerides, LDL and cardiac risk indices in hypercholesterolemia rats over 28 days [73]. For blood pressure, fermented seeds ("soumara") were found to be rich in calcium, potassium and magnesium but low in sodium, and their extracts were tested for hypotensive and antihypertensive effects in rats [79].

Clinical evidence, by contrast, remains very limited. The main human-level signal is observational: a community in Togo that consumes *iru* heavily was reported to have a low incidence of hypertension [78], but this shows an association only and cannot establish cause. I found no randomized controlled trials of these condiments, and animal findings should not be assumed to apply to humans at normal culinary intakes. Clinical trials with defined doses and endpoints, and studies extending beyond *iru* to *ogiri*, *okpei* and *afitin*, are therefore needed before firm health claims can be made. Table 3 shows the summary of the *in vitro*, *in vivo* and clinical studies on indigenous condiments of African culinary traditions.

Table 3. *In vitro*, *in vivo* and clinical studies on indigenous condiments of African culinary traditions.

Evidence Level	Condiment/Material	Model or Design	Key Findings	Reference
In vitro/*ex vivo*	Fermented vs. unfermented *Parkia biglobosa* seeds (*iru*/*dawadawa*)	Total phenolics, DPPH, FRAP, cellular antioxidant activity in human red blood cells, ACE-inhibition assays	Fermentation markedly increased polyphenols and antioxidant activity. Both fermented and unfermented seeds contained ACE-inhibitory peptides, with higher activity in the unfermented seeds.	[70]
In vitro	*Bacillus subtilis* isolated from *iru*	Isolation and screening of bacteriocin-like substances; GC-MS and HPLC profiling	Some isolates inhibited *Staphylococcus aureus* and *Escherichia coli* and tolerated bile salts. GC-MS identified 23 bioactive compounds.	[71]
In vivo (diabetes)	Fermented P. biglobosa extracts (*iru*)	Alloxan-induced diabetic rats; aqueous and methanolic extracts (6% *w*/*w*) compared with glibenclamide	Fasting plasma glucose fell by 69.2% (aqueous) and 64.4% (methanolic), comparable to the drug (70.4%). Only the aqueous extract prevented diabetes-related weight loss.	[77]
In vivo (lipids)	*Iru* as 20% of feed	Tyloxapol-induced hyperlipidaemic rats; fluvastatin as reference	Plasma and liver total cholesterol, triglycerides and LDL-C fell, and HDL-C rose.	[78]
In vivo (cardiovascular risk)	*Iru* fermented with *Lactobacillus plantarum*	Hypercholesterolaemic Wistar rats, 28-day treatment	Total cholesterol fell from 100.80 to 56.99 mg/dl, triglycerides from 111.75 to 32.53 mg/dl and LDL from 49.48 to 6.65 mg/dl, with reduced cardiac risk indices.	[73]
In vivo (blood pressure)	Fermented P. biglobosa seeds ("soumara")	Normotensive and hypertensive rats; aqueous and ethanolic extracts	Seeds were rich in calcium, potassium and magnesium but low in sodium. Hypotensive and antihypertensive effects were evaluated.	[79]
Human (observational)	*Iru*, consumed heavily in the diet	Community in Togo	Low incidence of hypertension reported. This is an association only, not a controlled trial.	[78]

7. Flavor Enhancement Attributes of African Indigenous Condiments Without Added MSG

The potential of indigenous condiments as alternatives to commercial bouillon products is closely linked to the biochemical mechanisms responsible for savory flavor development [80]. Umami, one of the five basic tastes, is primarily generated by glutamate and specific nucleotides that activate the T1R1/T1R3 taste receptor complex [81]. During fermentation, microbial and enzymatic activities break down proteins, releasing free amino acids such as glutamate that contribute to the characteristic savory flavor of traditional condiments including *iru* and *dawadawa* [43,82,83]. Furthermore, synergistic interactions between glutamate and nucleotides such as inosine monophosphate (IMP) and guanosine monophosphate (GMP) intensify umami perception beyond that produced by glutamate alone [84,85]. These natural flavor-generating processes provide a scientific basis for the use of indigenous African condiments as effective flavor enhancers and potential sustainable alternatives to commercial bouillon seasonings.

By mixing substances with comparable sensory functions, this scientific principle offers a solid foundation for creating indigenous flavor systems. For instance, umami notes from fermented locust beans, sulfur-containing scents from garlic, warmth and freshness from ginger, and pungency, sweetness, color, and complexity from chili and dry vegetables [86,87]. These pairings could produce flavor profiles that lessen the need for additional salt and MSG. The amounts of naturally occurring glutamate, flavor-active peptides, inosine monophosphate, guanosine monophosphate, and other umami-enhancing substances in native African condiments, however, are still little understood and need further investigation. Therefore, future research should characterize these flavor-active substances, measure their quantities, and ascertain how fermentation, processing, and storage affect their stability and production. A scientific basis for creating low-sodium seasoning compositions that can produce desired sensory qualities without heavily depending on commercial flavor enhancers would be provided by this information.

8. Potential Applications and the Economic, Environmental, and Consumer Considerations of African Indigenous Condiments

The long-standing culinary usage of native condiments indicates significant potential, notwithstanding the lack of concrete evidence showing full substitution of commercial bouillon cubes in African cuisine. While *dawadawa* and *soumbala* continue to be significant flavoring agents in many West African dishes, fermented ingredients like *iru, ogiri,* and *okpei* are already frequently used in soups like *egusi*, okra, vegetable, and *ogbono* soup [10,12]. Converting these traditional components into standardized powders, granules, and seasoning cubes that blend fermented sauces with dried vegetables, ginger, garlic, chili, and onion is a viable strategy [87]. Native condiment-based seasonings have the potential to deliver the convenience of commercial bouillon products while preserving traditional flavor characteristics. However, their suitability as effective bouillon substitutes requires further validation through comprehensive sensory studies, formulation optimization, shelf-life evaluations, and sodium-reduction assessments. The development of seasoning products derived from indigenous condiments could generate substantial economic benefits by adding value to agricultural and food-processing chains based on African locust beans, melon seeds, African oil beans, and related raw materials [88]. Improved processing technologies, product standardization, packaging, and commercialization could expand market opportunities for small-scale farmers and processors while contributing to more sustainable food systems [10,15].

Nevertheless, consumer acceptance remains a critical determinant of commercial success. Commercial bouillon products continue to enjoy widespread popularity because of their affordability, convenience, availability, consistent quality, and long shelf life [2]. Although indigenous condiments possess desirable sensory and nutritional attributes, their wider adoption may be constrained by challenges such as variable flavor profiles, limited shelf stability, inadequate packaging, poor market penetration, and perceptions that they are traditional rather than modern food products [10,89]. Consequently, addressing these limitations is essential for increasing consumer acceptance and facilitating the successful integration of indigenous condiment-based seasonings into contemporary food markets. As a result, future studies should consider customer preferences, branding tactics, market positioning strategies, and readiness to use local seasoning products in addition to nutritional and technological aspects. Comprehensive sensory evaluation and consumer acceptance studies are essential for identifying the optimal balance between preserving traditional flavor attributes and delivering the convenience expected from modern commercial seasonings. Such assessments will provide critical evidence for the development of condiment-based products that meet consumer preferences while maintaining their cultural authenticity. Ultimately, this evidence will play a key role in supporting the design and commercialization of flavoring alternatives to conventional bouillon cubes that are culturally acceptable, nutritionally beneficial, economically viable, and environmentally sustainable.

9. Developments and innovations in bouillon cube ingredients

Bouillon cubes are a heavy and widespread source of dietary sodium in sub-Saharan Africa. Salt typically makes up 40–60% of a cube, and reported intakes are about 1.7–4.3 g per person per day, so cubes are a priority target for sodium reduction [2]. Most reduction work so far has focused on potassium chloride substitution, gradual salt cuts and aroma-based saltiness enhancers. Archer et al. [2] also note that cubes already contain large amounts of MSG and nucleotides, which leaves little room for further sodium savings through added umami compounds. This is the gap that indigenous fermented condiments could fill. Fermentation is a recognized route to natural umami ingredients, alongside enzymatic and acid hydrolysis and the Maillard reaction [14]. African condiments are also rich in glutamic and aspartic acids, the amino acids most associated with savory taste. For example, an African yam bean condiment fermented with a starter culture had glutamic and aspartic acids as its most abundant amino acids [90].

The transition from uncontrolled spontaneous fermentation to controlled starter-culture fermentation has been the primary innovation thus far. The fermentation of traditional *iru* (*Parkia biglobosa*) is alkaline, spontaneous, and produces varying quality. Adewumi et al. [91] suggested using these native strains as starter cultures together with excellent production practices after discovering that *Bacillus subtilis* was the most consistent species across samples. Additionally, they found *Staphylococcus* and *B. cereus*-type signals, which are concerns for safety. Crude protein increased to 44.6% when *Prosopis africana* (*okpehe*) was fermented using a combination of *B. subtilis* and *B. licheniformis* cultures [92]. The best sensory scores and 52.7% protein were obtained by fermenting *P. biglobosa* with *B. subtilis* at 40 °C for three days, although after day three, a strong ammonia odor appeared [93]. African yam bean seeds' amino acid composition was similarly enhanced by starter fermentation, as reported by Okolie et al. [90]. These researchers found that the spontaneously fermented control failed to meet FAO/WHO reference values for several critical amino acids, while *B. amyloliquefaciens* produced the greatest total amino acid content (95.8 g/100 g protein). Evidence on flavor intensity and shelf life should be further examined because this research investigated protein and amino acids.

The other major development is the formulation into cube and powder form; however, the evidence base is still limited and preliminary. There was a trade-off in bouillon cubes produced from castor-seed *ogiri* with cassava starch as the binder. The authors suggested high-protein binders or binder blends because increasing the binder from 20:5 to 20:20 (condiment: binder) reduced protein from 9.93% to 3.49% and increased phytate [94]. Fermented locust beans are only mentioned by Archer et al. [2] as a non-salt sodium source in Nigerian diets, not as a reduction technique. Additionally, the study by Chakraborty et al. [95] showed that pigmented *Chakhao poreiton* black rice can successfully replace traditional binders like hydrogenated fats and MSG in the production of bouillon cubes, resulting in cubes with desired hardness, quick dispersibility, increased antioxidant activity, and improved sensory qualities, especially mouthfeel and aroma. The researchers also noted that under refrigerated vacuum-packaged storage, optimized coriander bouillon cubes maintained their physicochemical and antioxidant properties and remained microbiologically safe for up to 20 days, underscoring their potential as a functional and healthier seasoning product [95]. Nevertheless, a study that directly evaluates fermented condiments as sodium-reduction alternatives in cubes is required. Future research should also focus on other binder optimization, sensory and salt testing of condiment-based cubes on actual plates, and strain selection and safety screening.

10. Conclusions

Indigenous African condiments show strong potential as culturally appropriate, sustainable, and healthier alternatives to high-sodium commercial bouillon cubes. By combining fermented and plant-based ingredients, low-sodium seasoning products capable of delivering desirable umami, savory, and aromatic flavors can be developed, while also supporting local agriculture, rural livelihoods, food value chains, traditional knowledge preservation, and sustainable food systems. However, challenges related to raw material variability, fermentation and processing inconsistencies, product quality, shelf-life stability, and consumer acceptance continue to limit their wider adoption. Significant knowledge gaps remain regarding flavor-enhancing mechanisms, nutrient bioavailability, sodium and glutamate content, microbiological safety, storage stability, consumer preferences, and long-term health effects. Therefore, future research should focus on the comprehensive characterization, standardization, optimization, and development of low-sodium indigenous condiment-based seasonings to establish their health, economic, and environmental benefits. Addressing these gaps will provide the scientific foundation needed to transform native African condiments into safe, nutritious, commercially viable, and sustainable flavoring products that preserve Africa's rich culinary heritage while improving dietary quality.

Author Contributions

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During the preparation of this review article, the authors used Copilot to restructure and polish the grammar and flow of information. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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