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Competitive Quality Analysis of Fermented Condiment Ogiri (Dried Dawadawa) Sold at Mbaise in Imo State

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ABSTRACT

Comparative analysis of dried fermented locust bean (dried dawadawa) purchased from four markets (nkwo lagwa, afor-oru, eke-ise and eke-nguru) in the three (3) local government areas that makes up Mbaise were carried out. The dried dawadawa samples were subjected to amino acid profile and phytochemical analyses. The values obtained for each of the amino acids analysed ranged from, 7.47 to 8.03 (leucine), 5.47 to 6.08 (lysine), 4.20 to 4.47(isoleucine), 3.85 to 4.54 (phenylalanine), 1.24 to 1.35 (tryptophan), 4.98 to 5.47 (valine), 1.24 to 1.34 (methionine), 3.77 to 4.37 (proline), 6.20 to 6.98 (arginine), 3.29 to 3.96 (tyrosine), 2.48 to 3.01 (histidine), 1.64 to 2.37 (cystine), 3.94 to 4.98 (alanine), 13.77 to 16.31 (glutamic acid), 3.97 to 4.47 (glycine), 3.85 to 4.20 (threonine), 3.83 to 4.36 (serine) and 10.04 to 11.05 (aspartic acid). The phytochemical compositions (mg/100g) of the dried dawadawa samples were significantly ($p<0.05$) different from each other. The samples had phytochemical values ranging from 0.00 to 4.90 (daidzein), 3.37 to 14.64 (naringenin), 1.78 to 4.96 (luteolin), 1.08 to 1.63 (kaempferol), 0.00 to 7.62 (ellagic acid), 9.22 to 10.51 (tangeretein), 43.20 to 90.17 (baicalin), 1.11 to 28.15 (naringin), 0.00 to 3.98 (retusin), 2.99 to 8.63 (vanillic), 1.30 to 2.10 (apigenin), 1.16 to 3.72 (hesperidin), 0.00 to 9.19 (isorhsmnetin), 0.00 to 7.82 (myricetin), 2.11 to 4.43 (genistein), 4.40 to 7.53 (resveratrol), 0.00 to 12.66 (gallocatechin),3.51 to 14.97 (epicatechin), 1.55 to 2.71 (silymarin), 1.72 to 13.34 (cutechin) and 0.00 to 117.36 (artemetin). There were other phytochemicals analysed that were only detected in the dried dawadawa sample purchased from eke-nguru market but were not detected in dried dawadawa purchased in nkwo-lagwa, afor-oru and eke-ise. These phytochemicals include; vinnillic, butein, epigallocatechin, epigallocatechin 3 gallate, robinetin, myricetin, nobicetin, and cinnamic acid and these phytochemicals are valued as 2.36mg/100g, 2.02mg/100g, 3.08mg/100g, 1.46mg/100g, 24.90mg/100g, 2.20mg/100g, 7.29mg/100g and 5.31mg/100g respectively. The result showed that the dried dawadawa samples contained all essential amino acids which the body cannot synthesize. The study also showed that all the dried fermented locust bean (dawadawa) samples were rich in amino acids irrespective of the location it was purchased from. Hence, it could be concluded that the consumption of the dried fermented soup condiment (dried dawadawa) could help in ensuring proper functioning of body systems. Furthermore, the study shows that dried fermented locust bean (dried dawadawa) harbors wide range of phytochemicals which could help stimulate the immune system as well modulates the function of various other metabolic reactions in the body.

INTRODUCTION

Ogiri is a traditional Nigerian condiment/seasoning made from fermented oil seeds such as Locust beans (*Parkia biglobosa*), Castor oil seed (Ricinus communis), Melon seed (Citrullus lanatus), Fluted pumpkin seed (*Telferia occidentalis)*, Soybeans (Glycine max) and it adds a unique flavour to dishes like soups, stew and sauces. Ogiri condiment have a strong-smelling, sharp-tasting substance usually used to improve flavour of food (Achi 2005; Odebumi *et al*., 2009, Emijiagha 2009, Oyewole and Isah 2012; Ojimelukwu, et al., 2011).

Ogiri made from locust bean (Parkia biglobosa) is a traditional fermented soup condiment popular in West African particularly in Nigeria. It is commonly referred to as Iru by Yorubas, dawadawa by Hausas and ogiri-dawadawa by the Igbos. This local condiment is used to enhance flavour and intensify meatiness in soups, sauces and other prepared dishes (Beaumont, 2009), and it is also a rich source of protein, fibre and micronutrients (Achi 2005). Production of this ogiri involves the traditional method of uncontrolled solid substrate fermentation resulting in extensive hydrolysis of the protein and carbohydrate component (Babalola and Giwa 2022).

The uniqueness of this condiment is that it can be in both wet and dried state, hence it can be said to be shelve-stable especially in the dried state.

The dried fermented locust beans are well -known condiment with characteristic ammoniacal odour and flavour which enhance the taste of traditional soups and sauces especially those used as compliment to starchy foods. It is also generally added to soups as low-cost meat substitute by low-income families in parts of Nigeria (Odebumi *et al.*, 2010). Dried dawadawa is rich in iron, potassium, magnesium and some vitamins, making it beneficial for immune health and energy level. Dried dawadawa contains essential amino acids like lysine and tryptophan which are critical for the body and typically difficult to find in plant-based sources.

Soup condiment, such as dried dawadawa is often described as the "African Umami" used to deepen flavours, it's taste can be slightly bitter, earthy and tangy which adds complexity to dishes. Its dried state makes it easy to be blended into powdered form. It has high protein content (35 -40%) (Achi, 2005).

The drying process does not diminish its fibre content which aids digestion and support gut health. The high fiber content helps slow down digestion, making it a good choice for those managing blood sugar level and it contains antioxidant and phytochemicals. (Kubumarawa, 2009), that may protect cells from damage.

Traditional artisanal production of dried ogiri dawadawa lacks standardization, leading to variation in taste, texture, aroma and nutrient composition. This inconsistency is due to factors such as differences in microbial composition and load and other variations in production techniques such as variability in the fermentation and drying time.

This study has helped reveal the quality parameters such as amino acids profile and phytochemical compositions of locally fermented dried Ogiri dawadawa. Hence, providing an insight on the potential nutritional and health benefits of this particular traditional food condiment.

MATERIALS AND METHODS

Procurement and Preparation of Samples

The samples were purchased using random sampling method at four different markets in Mbaise (Nkwo Lagwa market, Afo Oru market, Eke Ise market and Eke Nguru market). The procured dried samples were grinded into powdered forms using attrition mill, separately packaged and labeled based on the different purchase point.

Research Location

The research was conducted at Priority Laboratory Services, 186 Rukuba Road, Angwan Jumai, Jos, Plateau State, Nigeria.

Determinations and Analytical Techniques

The dried dawadawa samples were subjected to amino acid profile and phytochemical determination**.**

Determination of Amino Acid Profile

Amino acids determination was done in accordance with the Amino Acid Sequential Technico method of AOAC (2015). Twenty micrograms (20 µg) of the fish samples were dried in conventional hydrolysis tubes. To each tube, l00 µl of 6ml HCl containing 30ml phenol and l0ml 2-mercaptoethariol were added and the tubes were evacuated, sealed and hydrolyzed at 110 °C for 22 h. After hydrolysis, HCl was evaporated in a vacuum bottle heated to about 60°C. The residue was dissolved in a buffer and analyzed for amino acids using RPHPLC with an Agilent 1100 assembly system (Agilent Technologies, Palo Alto, CA 94306, USA) and Zorbax 80A C18 column (4.6 id x 180 mm). The Excitation Wavelength (Ex) of 348 nm and Emission Wavelength (Em) of 450nm were chosen. The column oven was maintained at 60°C. The amounts of amino acids were determined by calculations using the recorded chromatogram. Determination of tryptophan was done by the Ninhydrin method. One gram (1g) of each sample were put into a 25 m1 polypylene test tube with caps, 10ml of 0.075N NaOH were added and thoroughly mixed until clear solution was obtained. The dispersion was shaken for 30 mins and centrifuged at 5000rpm for 10mins and the supernatant liquid transferred into a clean test tube. One half milliliter (0.5 mL) of the supernatants, 5ml of ninhydrin reagent (l0g of ninhydrin in 100ml mixture of 37% HCl and 96% HCOOH) in a ratio of 2:3 for all the samples were added and incubated at 35 °C for 2h. After incubation, the solution was cooled to room temperature (23-25 °C) and the volumes were made up to 10ml using diethyl ether, thoroughly mixed using a vortex mixer, filtered and the clear filtrates were analyzed with the same equipment as described above for the other amino acids. Amino acid was expressed as g/l00g of proteins.

Determination of Phytochemicals

The presence of polyphenols was determined by the method described by (AOAC, 2010).

Sample Preparation for Phytochemicals

Five grams (5g) of samples each was weighed into an already cleaned bottle. Fifty (50) ml of different solvents (methanol, ethanol, butanol, n-hexane, petroleum ether) was added into each of the bottle containing the samples. The bottle was placed in a shaker and shaken for 1 hour at room temperature. The mixture was filtered into a conical flask and labelled.

Solvent preparation for phytochemicals

One (1) ml of conc. H_2SO_4 was pipetted into 100 ml volumetric flask containing water and was made up to mark. Two and half grams (2.5g) of iodine crystal were dissolved in a 12.5g of potassium iodide. Two hundred and fifty (250ml) of water was added to produce solution. A reddish-brown color was expected.

Determination of presence of different types of alkaloids.

Three (3) ml of the extract was pipetted into a test tube and kept in a rack. One (1) ml of 1% HCl (v/v) was pipetted into the test tube containing the extracts. The mixture was heated in a water bath for 5 minutes at 50^{O}C, then cooled and filtered. Then 1 ml of the filtrate was pipetted into another test tube and 0.5ml of Wagner's was added immediately. A reddish-brown discoloration was observed if saponin is present.

Determination of presence of different types of flavonoids.

Three (3) ml of the extract was pipetted into a labelled test tube. Five (5) ml of distilled water was added, and the solution shaken very well. Exactly 1 ml of 10% NaOH solution was added, and a pale-yellow coloration observed if present.

Determination of presence phenols.

Two (2) ml of the extract was pipetted into a test tube and treated with 0.5 ml of acetic acid, 0.5 ml of chloroform and 1 ml of concentrated sulphuric acid. A reddish-brown ring was formed which shows the presence of phenols.

Determination of saponins presence

Frothing test

Two (2) ml of the extract was pipetted into a test tube and 2 ml of distilled water was added. The solution was shaken vigorously. A persistent mass of bubble movement indicates the presence of saponin.

Statistical Analysis

Data obtained from the amino acid and phytochemical compositions of the dried dawadawa samples were subjected to statistical analysis of variance (ANOVA) with the mean value separated by Duncan's multiple range tests at 5% level of significance.

Results and Discussion

Amino Acid Content of Dried Fermented Locust Bean (Dried Dawadawa)

The essential amino acids were all found present in the dried dawadawa samples purchased from four different markets in Mbaise. Their values ranged from 5.47 – 6.08g/100g (lysine), 2.48 – 3.01g/100g (histidine), 4.19 - 4.47g/100g (isoleucine), 7.47 - 8.03g/100g (leucine), 1.24 - 1.34g/100g (methionine), 3.85 - 4.54g/100g (phenylalanine), 3.85 - 4.20g/100g (threonine), 1.24 - 1.35g/100g (tryptophan) and 4.98 - 5.46g/100 (valine) (Table 1). All the essential amino-acids of the dried dawadawa samples showed significant differences ($p<0.05$) with exceptions to histidine, methionine and isoleucine. Leucine is the most predominant essential amino-acid in dried dawadawa followed by valine. Leucine has been reported to be particularly important for immunity, reproduction, extra-endocrine signaling, neurological function, blood flow, osmoregulation, growth and development while valine is very important for muscle development (Namulawa *et al.,* 2012). This therefore makes the consumption of dried dawadawa beneficial. Mischoulon and Fava, (2002) reported that methionine is used for treating liver disorders, improving wound healing and treating depression, alcoholism, allergies, asthma, copper poisoning, radiation side effects, schizophremia, drug withdrawal and Parkinson's disease. Hence the constant consumption of dried dawadawa could contribute in the control of the aforementioned disorders.

Table1: Amino acid profile of dried fermented locust bean (g/100g Protein)

Parameters	NLM	AAM	EEM	ENM	LSD
Lysine	$6.08^{a}\pm0.02$	$5.47^{d}\pm0.14$	$5.73^{c}\pm0.11$	$5.94^{b}\pm0.11$	0.027
Histidine	$2.89^{a}\pm0.01$	$2.66^{a}\pm0.003$	$2.48^{a}\pm0.002$	$3.01^{a}\pm0.005$	0.41
Arginine	$6.75^{b}\pm0.05$	$6.46^{c}\pm0.02$	$6.20^{d}\pm0.02$	$6.98^{a}\pm0.013$	0.036
AA	$10.97^{b}\pm0.018$	$11.06^{a}\pm0.03$	$10.05^{d}\pm0.025$	$10.27^{c}\pm0.02$	0.03
Threonine	$4.04^{b}\pm0.06$	$3.85^{d}\pm0.018$	$3.95^{c}\pm0.12$	$4.20^{a}\pm0.001$	0.02
Serine	$4.26^{b}\pm0.03$	$3.83^{d}\pm0.014$	$4.14^{c}\pm0.08$	$4.36^{a}\pm0.011$	0.02
GA	$16.31^{a}\pm0.014$	$14.99^{c}\pm0.00$	$13.77^{d}\pm0.015$	$15.23^{b}\pm0.011$	0.04
Proline	$4.07^{b}\pm0.16$	$3.85^{c}\pm0.04$	$3.77^{d}\pm0.012$	$4.37^{a}\pm0.05$	0.015
Glycine	$4.33^{b}\pm0.01$	$3.97^{d}\pm0.016$	$4.47^{a}\pm0.010$	$4.24^{c}\pm0.07$	0.013
Alanine	$4.67^{c}\pm0.023$	$4.71^{b}\pm0.01$	$3.94^{d}\pm0.02$	$4.98^{a}\pm0.02$	0.012
Cystine	$1.84^{a}\pm0.00$	$1.64^{a}\pm0.001$	$1.85^{a}\pm0.004$	$2.37^{a}\pm0.01$	0.38
Valine	$4.98^{d}\pm0.14$	$5.37^{b}\pm0.16$	$5.07^{c}\pm0.03$	$5.47^{a}\pm0.11$	0.02
Methionine	$1.27^{a}\pm0.003$	$1.24^{a}\pm0.001$	$1.27^{a}\pm0.01$	$1.34^{a}\pm0.00$	0.03
Isoleucine	$4.37^{a}\pm0.00$	$4.20^{a}\pm0.21$	$4.35^{a}\pm0.20$	$4.48^{a}\pm0.011$	0.26
Leucine	$7.83^{c}\pm0.02$	$7.94^{b}\pm0.12$	$7.48^{d}\pm0.03$	$8.03^{c}\pm0.01$	0.03
Tyrosine	$3.66^{a}\pm0.002$	$3.45^{a}\pm0.03$	$3.30^{a}\pm0.015$	$3.96^{a}\pm0.002$	0.40

Ph	4.45^{b}±0.04	4.54^{a}±0.01	3.85^{d}±0.003	4.18^{c}±0.05	0.04
Tryptophan	1.30^{b} ±0.00	1.24^{d} ±0.02	1.35^{a} ±0.00	1.26^{c} ±0.01	0.015

Values are means of triplicate analysis and standard deviation. Means with same superscripts in the same row are not significantly ($p>0.05$) different.

AA= Aspartic Acid; GA= Glutamic Acid; Ph = Phenylalanine

Note:

NLM - Dawadawa purchased from Nkwo lagwa market

AAM - Dawadawa purchased from Afor-oru market

EEM - Dawadawa purchased from Eke ise market

ENM - Dawadawa purchased from Eke nguru market

The non-essential amino acids present in the dried dawadawa samples had values in the range of 6.20 – 6.98 g/100g (arginine), 10.05 – 11.06g/100g (aspartic acid), 3.83 - 4.36g/100g (serine), 13.77 - 16.31g/100g (glutamic acid), 3.77 – 4.37 g/100g (proline), 3.97 – 4.47g/100g (glycine), 3.94 - 4.98g/100g (alanine), 1.64 - 2.37g/100g (cystine) and 3.30 - 3.96g/100 (tyrosine). The non-essential content of four dried dawadawa samples were all found to be significantly different ($p<0.05$) from each other with exceptions to cystine and tyrosine. Non-essential amino acids are synthesized in the body unlike the essential amino acid. Amongst all the essential and non-essential amino acid profile analysed, glutamic acid is the most predominant and it plays an important role in amino acid metabolism because of its role in transamination reactions and is necessary for the synthesis of key molecules, such as glutathione which is required for the removal of highly toxic peroxides and the polyglutamate folate cofactors (Bimal et al., 2014). Arginine is another non-essential amino acid with high concentration and it has been reported to play important role in the brain development especially at infancy. The variations in the amino acid contents of all dried dawadawa could be attributed to variations in the processing procedures such as fermentation time and drying temperature/duration.

Phytochemical content of dried fermented locust bean (Dried Dawadawa)

Phytochemicals are plant derived chemicals which are beneficial to human health and disease prevention (Anderson, 2004). The term is generally used to refer to those chemicals that may have biological significance, for example antioxidants, but are not established as essential nutrients which when in excess could be detrimental. It is pertinent to state that in as much as they help to strengthen the body defense mechanism serving mostly as antioxidants, moderate consumption is highly recommended so that they will not serve as anti-nutrient to the body (Ifemeje *et al*., 2014).

The concentrations of daidzein in the dried fermented locust bean soup condiment (dried dawadawa) purchased in four different markets in Mbaise were presented in Table 2 in the range of 3.41mg/100g to 4.90mg/100g. Daidzein was not detected in the samples purchased from eke-nguru (ENM) market. Daidzein is a naturally occurring isoflavonic phytoestrogen belonging to the non-steroidal estrogens (Cassidy, 2003) and is mainly derived from leguminous plants (locust bean). It is also the major bioactive ingredient in traditional Chinese medicine Gegen (Wang et al., 2003) which is used frequently in the treatment of fever, acute dysentery, diarrhea, diabetes, cardiac dysfunctions, liver injury etc. (Wong et al., 2011).

Naringenin is a flavonoid and its concentrations in the dried fermented locust bean soup condiment (dried dawadawa) purchased in four different markets in Mbaise were presented in the range of 3.37mg/100g to 14.64mg/100g. Naringenin was detected in all the dried dawadawa samples. The concentration of naringenin content available in dried dawadawa purchased from four different locations in Mbaise were found significantly different ($p<0.05$) from each other. Naringenin is a flavonoid belonging to flavanones subclass. Naringenin is endowed with broad biological effects on human health, which includes a decrease in lipid peroxidation biomarkers and protein carbonylation, promotes carbohydrate metabolism, increases antioxidant defenses, scavenges reactive oxygen species, modulates immune system activity, and also exerts anti-atherogenic and anti-inflammatory effects (Wang et al., 2015). On the other hand, anti-cancer, anti-proliferative and anticarcinogenic effects have also been ascribed to this metabolite (Erlund et al., 2021), mostly linked to its ability to repair DNA.

Artemetin was detected in the dried fermented locust bean condiment (dried dawadawa) purchased in *nkwo-lagwa* (NLM), *afor-oru* (AAM), *eke-ise* (EEM) and *eke-nguru* (ENM) markets in Mbaise in the values of 4.06mg/100g, 0.00mg/100g, 2.72mg/100g and 117.36mg/100g respectively. The artemetin content of sample purchased from *eke-nguru* (ENM) market had the highest (117.36mg/100g) concentration while sample from *afor-oru* had the lowest (0.00mg/100g) artemetin content. The concentration of artemetin detected in all samples were observed to be significantly different ($p<0.05$) from one another.

Ellagic acid content in the dried fermented locust bean soup condiment (dried dawadawa) purchased in nkwo-lagwa (NLM), afor-oru (AAM), eke-ise (EEM) and eke-nguru (ENM) markets in Mbaise were presented in Table 2 above as 2.65mg/100g, 0.00mg/100g, 2.72mg/100g and 7.62mg/100g respectively. Ellagic acid was detected in all the samples. The samples obtained from eke-nguru market had the highest (7.62mg/100g) concentration of ellagic acid and sample purchased from afor-oru market had an insignificant (0.00mg/100g) ellagic acid content. The concentration of ellagic acid in the four samples were statistically found to be significantly different ($p<0.05$) from each other. The presence of ellagic acid in various commercial products giving anti-oxidant activity has also been reported. These molecules have a variety of benefits for their anti-mutagenic, antimicrobial and antioxidant properties, and inhibitors of human immunodeficiency virus (HIV) (Akiyama et al., 2001; Vattem and Shetty, 2003; Ruibal et al., 2003).

Table 2: Phytochemicals Contents of Fermented Locust bean(mg/100g)

Names	Nkwo lagwa NLM	Afor Oru AAM	Eke Ise EEM	Eke Nguru ENM	LSD
Daidzeia	4.90^{a}±0.01	0.00^{c}±0.003	3.41^{b}±0.02	_	0.14
Vinylic acid	_	_	_	2.36± 0.02	_
Butein	_	_	_	2.02± 0.01	_
Naringenin	11.38^{b}±0.07	9.94^{c}±0.03	3.37^{d}±0.01	14.64^{a}±0.07	0.07
Luteolin	_	_	1.78^{a}±0.03	1.08^{b}±0.01	0.03
Kaempferol	_	_	1.63^{a}±0.02	3.08^{b}±0.01	0.01
Epigallocatechin	_	_	_	1.46±0.03	_
Gallocatechin 3 gallate	_	_	_	24.90±0.02	_
Robinetin	_	_	_	2.20±0.04	_
Myricetin	_	_	_	7.29±0.03	_
Nobicetin	_	_	_	17.32±0.12	_
Ellagic acid	2.65^{b}±0.02	0.00^{d}±0.02	2.72^{c}±0.03	7.62^{a}±0.04	0.11
Targretin	10.51^{b}±0.04	9.22^{c}±0.01	_	43.20^{a}±0.06	0.01
Baicalin	90.19^{a}±0.05	76.77^{b}±0.04	_	28.15^{c}±0.02	0.13
Naringin	1.11^{c}±0.04	_	12.58^{a}±0.04	5.31^{b}±0.002	0.03
Cinnamic acid	_	_	_	_	-
Retusin	3.98^{a}±0.07	3.31^{b}±0.02	0.00^{C}±0.02	_	0.04
Vanillic	8.63^{a}±0.04	8.20^{b}±0.01	2.99^{c}±0.02	_	0.05
Apigenin	1.30^{c}±0.02	1.53^{b}±0.01	2.10^{a}±0.03	_	0.07
Hesperidin	3.72^{b}±0.03	8.20^{a}±0.01	1.38^{c}±0.04	_	0.07
Isorhamnetin	9.19^{a}±0.02	2.86^{b}±0.04	0.00^{c}±0.00	-	0.05
Myricetin	7.82^{a}±0.06	0.00^{c}±0.00	3.88^{b}±0.02	4.43^{a}±0.02	0.07
Genistein	2.21^{ab}±0.03	2.11^{b}±0.01	2.29^{a}±0.03	_	0.14
Resveratrol	9.19^{b}±0.04	5.51^{b}±0.02	4.40^{c}±0.03	_	0.07
Gallocatechin	6.96^{b}±0.02	0.00^{c}±0.00	12.66^{a}±0.07	_	0.11
Epicatechin	7.07^{b}±0.02	3.51^{c}±0.01	14.97^{a}±0.04	_	0.05
Hesperdin	1.30^{b}±0.02	1.20^{c}±0.01	17.08^{a}±0.03	_	0.09
Silymarin	5.53^{a}±0.02	1.98^{c}±0.02	2.71^{b}±0.04	-	0.04
Tangeretein	-	-	-	18.79±0.04	
Daidzin	-	-	-	6.22±0.02	
Catechin	13.34^{a}±0.03	3.66^{b}±0.04	1.72^{c}±0.01	-	0.06
Artemetin	4.36^{a}±0.03	0.00^{d}±0.00	2.72^{c}±0.03	117^{a}.36±0.12	0.10

Values are means of triplicate analysis and standard deviation. Means with same superscripts in the same row are not significantly ($p>0.05$) different.

Note:

NLM - Dawadawa purchased from Nkwo lagwa market

AAM - Dawadawa purchased from Afor-oru market

EEM - Dawadawa purchased from Eke ise market

ENM - Dawadawa purchased from Eke nguru market

The following phytochemicals retusin (0.00 – 3.98mg/100g), vanillic (2.99 – 8.63mg/100g), apigenin (1.30 – 2.10mg/100g) hesperidin (1.38 – 8.20mg/100g), isorhamnetin (0.00 -9.19mg/100g), myricetin (0.00 – 7.82mg/100g), genistein (2.11 – 2.29mg/100g), resveratrol (4.40 – 9.19mg/100g), gallocatechin (0.00 – 12.66mg/100g), silymarin (1.98 – 5.53mg/100g), epicatechin (3.51 -14.97mg/100g), hesperdin (1.20 – 17.08mg/100g) and catechin (1.72 – 13.34mg/100g) were only detected in dried dawadawa samples purchased from *Nkwo Lagwa, Afor Oru* and *Eke Ise* markets. The concentration of theses aforementioned phytochemicals in each of the sample were found significantly different ($p<0.05$) from one another. These phytochemicals have been reported by various researchers to be a good contributor to good and healthy life. For instance, retusin plays a significant role in biochemical reactions due to its ability to interact with various biomolecules and these interactions contribute to its antioxidant activity and ability to protect cells from oxidative stress (Stanislav *et al.,* 2015). Ingole *et al.* (2021) reported that vanillic acid can be used in the treatment of vascular dementia and cerebrovascular insufficiency and can serve as a novel neuroprotective agent. It has recently been the focus of extensive studies, and it has shown its effectiveness as a pharmacotherapeutic agent in a variety of diseases. Hence, the consumption of dried dawadawa could help to protect the brain against any harm.

A high number of studies carried out over the years have indicated that apigenin which was detected in samples NLM, AAM and EEM has many interesting pharmacological activities and nutraceutical potential. As an example, its properties as an antioxidant are well known, and it can also be a therapeutic agent to overcome diseases like inflammation, autoimmune, neurodegenerative disease, and even several types of cancers. (Ali et al., 2017; Lotha and Sivasubramanian, 2018).

Hesperidin has neuro-protective properties through negative nitric oxide signaling and reduction of neurodegenerative changes, and protects against cisplatin toxicity and its destructive effects on the liver (Kamisli et al., 2015). It improves cardiac blood flow (Belboukhari et al., 2015); protects against ischaemia reperfusion injury and protects middle cerebral occlusion-induced stroke (Raza et al., 2011). The protective effects of isorhamnetin on the cardiovascular system are almost related to antioxidation, anti-inflammation and anti-apoptosis properties. In addition, isorhamnetin can also improve nerve function, enhance cognition and memory, and prevent and treat neurodegenerative disorders (Gong et al., 2020).

Resveratrol is currently used to treat cancer, slow ageing, cardio-vascular disease, antiviral therapies, inflammation, platelet aggregation, and a number of other disorders (Varoni *et al*., 2016; Zykova *et al.,* 2008). RSV has been related to regulatory pathways that have both growth and death properties as anticancer treatment (Varoni *et al*., 2016). Silymarin has been used medicinally to treat liver disorders, including acute and chronic viral hepatitis, toxin/drug-induced hepatitis and cirrhosis and alcoholic liver diseases. It has also been reported to be effective in certain cancers. Its mechanism of action includes inhibition of hepatotoxin binding to receptor sites on the hepatocyte membrane; reduction of glutathione oxidation to enhance its level in the liver and intestine; antioxidant activity and stimulation of ribosomal RNA polymerase and subsequent protein synthesis, leading to enhanced hepatocyte regeneration (Ajay *et al.,* 2009).

Targretin and baicalin were detected in samples NLM, AAM and ENM and their values ranged from 9.22 to 43.20mg/100g and 28.15 to 90.19mg/100g respectively. The concentration of Targretin and baicalin in the samples significantly differed ($p<0.05$) from each other. Targretin and baicalin was not detected in sample EEM and it could be attributed to variation in processing techniques and probably the specie of locust bean used in the production of the dried dawadawa. Targretin acts as antihyperlipidemic (Decrease total cholesterol HDL and increase lipoprotein lipase activity), antihyperglycemic (reduces blood sugar and increases glucose uptake). It also increases insulin pathway and regulate metabolic pathway (Flavius *et al*., 2023) and baicalin has many functions such as anti-inflammatory, antioxidant, anti-tumor, anti-aging, and lipid-lowering (Wang *et al.*, 2023).

Naringin was not detected in sample AAM but were present in samples NLM, EEM and ENM with values ranging from 1.11 to 12.58mg/100g. The naringin content of the three samples differed significantly ($p<0.05$) from one another. Naringin is a flavanone which prevents CYP (cytochrome) isoenzymes by inhibiting the production of carcinogens, indicating a potential role in the mitigation of cancer (Bacanli et al., 2018). Aside being an anticancer agent, it has variety of biological qualities, such as antioxidant, anti-inflammatory and cardioprotective properties (Alam et al., 2014). Naringin also offers protection against liver damage, reduction of liver fibrosis, antioxidant effects, improvement of liver enzyme levels (Franzoni et al., 2021). Hence, consumption of dried fermented locust bean may have the ability to mitigate the growth of cancer cells in the body.

Luteolin and kaempferol was only detected in samples EEM and ENM. Sample EEM had the highest concentration of luteolin and kaempferol (1.78mg/100g and 1.63mg/100g) while sample ENM had the least (1.08mg/100g and 3.08mg/100g). Luteolin has the ability to penetrate into human skin and effectively treat and prevent of cancer of the skin (Seelinger *et al.,* 2008). Various types of cancer cells development restricted by luteolin. It inhibits the carcinogens metabolism, inhibit new blood vessels growth inside tumors, stopping the progression of cancer cell cycle and also induced the cell death in cancer cells (Pitot, 1993). The anti-carcinogenic potential of kaempferol (Pei *et al.*, 2017), as a positive correlation between its consumption and reduced cancer incidence has been documented; this is in addition to existing epidemiological studies linking increased flavonoid consumption with reduced cancer incidence. The anti-inflammatory role of kaempferol has also been concisely presented by Alam *et al.* (2020), while even its anti-adipogenic potential has come under investigation (Park *et al.*, 2022).

There are other phytochemicals that was only detected in sample ENM but was not detected in samples NLM, AAM and EEM. These phytochemicals include; vinylic, butein, epigallocatechin, epigallocatechin 3 gallate, robinetin, myricetin, nobicetin, and cinnamic acid and these phytochemicals are valued and presented in Table 4.2 above as 2.36mg/100g, 2.02mg/100g, 3.08mg/100g, 1.46mg/100g, 24.90mg/100g, 2.20mg/100g, 7.29mg/100g and 5.31mg/100g respectively. Most of these phytochemicals has some therapeutical benefits. For instance, epigallocatechin gallate is a polyphenolic

compound responsible for most of the therapeutic benefits of green tea consumption. Biological and pharmacological properties of epigallocatechin gallate includes anti-oxidative, antimicrobial, anti-allergic, anti-diabetic, anti-inflammatory, anti-cancer, chemoprotective, neuroprotective and immunomodulatory effects (Bartosikova and Neca, 2018). Epigallocatechin gallate controls high blood pressure, decreases blood cholesterol and body fat and decreases the risk of osteoporotic fractures (Bartosikova and Neca, 2018).

Conclusions

The results obtained showed that the dried dawadawa samples contained all essential amino acids which the body cannot synthesize but require for good health and development. The study also showed that all the dried fermented locust bean (dried dawadawa) samples are rich in amino acids irrespective of the location it was purchased from. Hence, it could be concluded that the consumption of dried dawadawa could help in ensuring proper development and functioning of body systems. Furthermore, the study shows that dried fermented locust bean (dried dawadawa) harbors wide range of bioactive components of phytochemicals which could help stimulate the immune system as well modulates the function of various other metabolic reactions in the body.

Recommendations

With respect to the essential amino acids and the wide range of phytochemicals present in the dried dawadawa samples, the consumption and incorporation of this product into other foods products is hence recommended.

Traditional method of manufacturer should take advantages of biotechnological progress to assure reasonable quality and at the same time assure safety of these products.

With respect to the essential amino acids and the wide range of phytochemicals present in the dried dawadawa samples, the consumption and incorporation of this product into other foods products is hence recommended. The partial replacement of analytical animal feeds with dried dawadawa flour is recommended to ensure the neuroprotective, cardiovascular protective effects of the phytochemicals found presents in the dried dawadawa samples.

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