

FORMULATION AND ACCEPTABILITY OF *L. TOGOLANA* ROOT AS A NUTRACEUTICAL FOODS IN SECURING FAMILY FUTURE FOR SUSTAINABILITY IN RETIREMENT

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Abstract

This study focuses on investigating the potential and acceptability of *Landolphia togolana* as a nutraceutical food through formulation techniques. Two (2) research questions were raised and two (2) hypotheses were formulated and tested at a significant level of 0.05. *L. togolana* root was prepared in the following ratios: 100:0% (A), 100:0% (B), 50:50% (C), 70:30% (D), and 80:20% (E). The panelists used for the study were comprised of thirty (30) mothers. The sensory evaluation considered parameters such as colour, taste, aroma, and overall acceptability. The Diphenyl-2-picryl-hydrazyl (DPPH) scavenging effect was also investigated at different concentrations (20, 40, 60, 80, and 100 µg/mL). From the results, the mean scores of formulated different levels of functional food showed that 20% of formulations were most preferred in all sensory parameters. There was a significant difference ($p < 0.05$) in terms of the level of acceptance of the formulated soup as functional foods. Therefore, 20% of the level of *L. togolana* root was most acceptable as a functional food in terms of general acceptability. Further results revealed that the inhibition percentage was highest (100.2%) at 100 µg/mL concentration compared with the standard ascorbic acid, with an inhibition percentage of 98.53% at 60 µg/mL. *L. togolana* has a nutraceutical benefit, particularly for the elderly and retirees who struggle to pay medical bills. Its consumption should be promoted by home economists in order to bring its acceptability into prominence.

Keywords: Functional Food, Culinary, Employment, Formulation, Colour

Introduction

Nutraceutical foods are foods that contain inherent compounds with demonstrable biochemical consequences and appealing health benefits (Donno et al., 2018; Srivastava et al., 2015). Typically, antioxidants, phytochemicals, fatty acids, amino acids, and probiotics, among other bioactive derivatives gathered from dietary sources, are major constituents of nutraceutical foods (AlAli et al., 2021). These compounds are well-known for their roles in illness treatment and prevention, anti-aging qualities, and cancer prevention, with either established or potential effects. In addition, nutraceutical foods are commercially desired because of their applicability, availability, and affordability than dietary supplements (Donno et al., 2018). A plethora of studies have indicated that nutraceutical foods have a positive impact on immune system activities. Enhancing the infection response mechanism, increasing immunomodulatory activity, and helping to reduce the effects of autoimmune illnesses and hypersensitivity are some of the role nutraceutical food plays in the body. Nutraceuticals have also been found to have anti-inflammatory, anti-cancer,

and antioxidant properties (Chen et al., 2016; Pitchaiah et al., 2017). The nomenclature of nutraceuticals and functional foods seems to overlap in many definitions. Uniquely, traditional nutraceuticals are classified as natural foods with possible health benefits, such as fruits, vegetables, cereals, fish, dairy, and animal products (Prabu et al., 2012), whereas functional foods are conventional foods which may either be fortified or enriched, and enhanced foods or supplements (Scrinis, 2008). Besides their promising health advantages, nutraceutical diets are gradually gaining prominence in the industry, with more than USD 6–60 billion realized in the past decade, benchmarked at a compound annual growth rate of 5% per annum (Prabu et al., 2012). In parallel to this, according to recent studies focusing on the US market, herbal dietary supplement sales reached USD 10 billion in 2020 for the first time, up 17.3% from 2019 (Mitchell et al., 2022). These statistics evidence a paradigm shift in the food industry to natural products, especially those that are derived from plants. Plants and their derivatives have been utilized as food and medicine by humans for thousands of years. Plants and natural products are currently

widely employed as key ingredients in culinary preparations or as spices all over the world, while they are also used as sources of bioactive substances for the creation of medications and health-promoting goods (Peron & Hošek, 2022).

L. togolana is one of the medicinal plants with relatively unknown popularity as nutraceutical food. They belong to the family of *Apocynaceae* fondly called vine rubber. *Landolphia* plant has about sixty species on the African continent but the most popular amongst these species are the *togolana* and *owanriensis* which have been researched by some scholars (Asante-Kwatia et al., 2019; Opaleke et al., 2022). According to Opaleke and colleagues, *L. togolana* and it is known locally by various names in Nigeria, *Ibo* – *Eso/utu*, *Yoruba Mba* / *Alakitipa*, *Hausa* – *Ciwa*. It is commonly found in the rain forest region of Nigeria and other parts of Africa. The flowers are seen mainly at the beginning of the rainy season, and also at the end of the dry season. Its fruits span throughout the year (Opaleke et al., 2022). In Nigeria and some parts of West Africa (e.g., Ghana), *Landolphia* plant roots have attracted attention due to their amazing ethnomedicinal benefits and are extensively sold as aphrodisiacs thus standing as a prospect of income generation for the herbal industry (Asante-Kwatia et al., 2019). In household use, postpartum mothers have found *Landolphia togolana* effective in the management of postpartum depression, hemorrhage, and pregnancy stress. However, there is very scanty information about the overall effect of the consumption of this plant and their standardization to control the intake by humans (Asante-Kwatia et al., 2019).

Retirement refers to the termination or end of employment or a career, especially due to aging, attained length of service, new role, or health reasons (Davies et al., 2017; Meng et al., 2017). The topic of retirement is equivocal. While some consider it as a permanent release from demanding labor (Amorim & França, 2019), a rising number of people regard retirement as a personal loss because it comes at a productive and satisfying professional stage of life (Barbosa et al., 2016; Henning et al., 2021). Retirement could be categorized into voluntary or mandatory (involuntary) (Mosca & Barrett, 2014; Sarabia-Cobo et al., 2020). In many cultures, a voluntary retirement is linked with a fulfilled career after serving an organization or many organizations in different capacities. Mandatory (involuntary) retirement, often known as enforced retirement, is the age at which people in specific jobs or offices

must leave their work or retire due to industry custom or regulation (Sarabia-Cobo et al., 2020). Many scholars have affirmed that retirement has a huge impact on the mental and health of the population (Abramowska-Kmon & Łątkowski, 2021). Along with loneliness, happiness, and other unquantifiable drawbacks, another negative effect of retirement is the decline in financial resources (Yeung, 2018). It was, however, suggested that the wealth a retiree has amassed throughout his or her working life, may lessen or strengthen this effect. In other words, the better a person's financial situation is, the less likely they are to face a fall in life satisfaction as they approach retirement (Abramowska-Kmon & Łątkowski, 2021; Pinquart & Schindler, 2007). In advanced economies, where retirees are faced with unaffordable medical bills, a larger percentage of them rely on the subsidized government health programmes. This is in contrast to what is obtainable in many developing countries where unlike the developing countries where plant foods are the panacea to the aging nature of many retirees. Nevertheless, since the menace has been well-rooted and arguably no potential risk to their sustainability has been reported, the trend of consumption of bioactive plants is well-adopted in society. However, proper plant food formulation contributes significantly to the well-being of consumers, particularly financially disadvantaged retirees.

Objective of the Study

The aim of this study was to investigate the acceptability of *L. togolana* root as a nutraceutical food using different formulations as a panacea to securing family future for sustainability in retirement. Specifically, the study

- i. Formulated and compared different ratios of *L. togolana* with a common soup (melon)
- ii. Analyzed the radical scavenging activity of *L. togolana* at different concentrations (20, 40, 60, 80, 100 µg/mL).

Research Questions

- i. What is the significance of formulation ratios of the soup with respect to their aroma, texture, taste, colour, and acceptability?
- ii. What is the effect of concentration level of *L. togolana* roots on radical scavenging activity?

Research Hypothesis

The following hypothesis was formulated for the study:

H₀: There is no significant difference between the measured sensory parameters of the formulated soup.

H₁: There is a significant difference between the measured sensory parameters of the formulated soup.

Materials and Method

The *L. togolana* root was obtained from Adelabu Salami's farm in Owo, Owo Local Government Area of Ondo State, Nigeria in June, 2017. The plant was carefully up-rooted, with the leaves and stem and was identified by a Professor of Botany in the Department of Plant Biology and Biotechnology, Faculty of Life Science, University of Benin, Benin City, Nigeria. The *L. togolana* root species were extracted at the Department of Plant Pharmacy, laboratory, University of Benin. The root extract was used specifically for this study because of its

chemical, nutritional, and medicinal properties. The nutritional and chemical characteristics have been reported (Opaleke et al., 2022). All chemicals were purchased from Sigma-Aldrich (St. Louis, MO). Laboratory test procedures were performed in the Food and Biotechnology laboratory of the Department of Food Technology, Steve Bako Campus, Durban University of Technology, Durban South Africa. An electrical weighing balance and blender were used for weighing the *L. togolana* powder root and melon powder.

Soup Formulation Ratio

Table 1 shows the layout of the formulated samples. Two of the samples (A and B, i.e., 100% *L. togolana* powdered root and 100% melon soup) served as controls. Other formulations were 50% of melon and 50% of *L. togolana* root extract (Sample C), 70% of melon and 30% of *L. togolana* root extract (Sample D), 80% of melon and 20% of *L. togolana* root extract (Sample E).

Table 1: Product formulation at different ratio

Samples	Soup(soup)	Thickener/powdered root
A	100	0
B	0	100
C	50	50
D	70	30
E	80	20

Diphenyl-2-picryl-hydrazylradical scavenging assay

Oriakhi and colleagues described the procedures of diphenyl-2-picryl-hydrazyl (DPPH) scavenging effect of crude methanol extract/fractions of *T. conophorum* seed (Oriakhi et al., 2018). This method was adopted for this study. Ascorbic acid was used as a standard. The percentage inhibition of the samples was calculated using the equation below:

Percentage Inhibition (%) = $[(A_0 - A_1) / (A_0)] \times 100$,
Where A₀ is the absorbance of DPPH radical + methanol; A₁ = absorbance of DPPH radical + sample extract /standard.

Reducing Potential Assay

The reducing potential activity of the extract was determined according to the method described in the report of several scholars where ascorbic acid was used as the standard (Gülçin et al., 2010; Lalhminghlui & Jagetia, 2018).

Method of Data Analysis

Data collected was analyzed using Wilcoxon sign test analysis for food attribute testing scores, mean differences, and standard deviation for the general acceptability of the formulated samples. The data was subjected to analysis of variance (ANOVA) for significant differences at 0.05 on the formulated soup attributes; colour or appearance, aroma, taste and texture, and general acceptability.

Results

The Wilcoxon signed-rank test, a non-parametric test equivalent to the student t-test for pair comparison, was used to test the hypothesis. For each of the parameters – aroma, texture, taste,

flavour, colour and general acceptability. In this study, the attributes of 100% melon as the control were used to compare the formulated samples. The result of the aroma is presented in Table 2.

Table 2: Wilcoxon signed-rank test for pair comparison test of aroma of soups

Parameter: aroma	Z	P-value	Decision
A-B	-1.639	0.101	Not significant
A-C	-1.889	0.059	Not significant
A-D	-0.409	0.682	Not significant
A-E	-0.222	0.824	Not significant

There was no significant difference in all the formulated soup. That is, between 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.101; 100% melon soup versus 50% melon *L. togolana* soup with a p-value of 0.059; 100% melon soup versus 70% melon 30% *L. togolana* soup with

a p-value of 0.682; and 100% melon soup versus 80% melon 20% *L. togolana* soup with a p-value of 0.824 in respect to their aroma. The stated null hypothesis (H_0) was thus accepted for all formulated soup in terms of their aroma.

Table 3: Wilcoxon signed-rank test for pair comparison of texture of soups

Parameter: texture	Z	P-value	Decision
A-B	-2.007	0.045	Significant
A-C	-1.227	0.220	Not significant
A-D	-1.129	0.259	Not significant
A-E	-0.177	0.859	Not significant

There was no significant difference in all but one of the formulated products – between 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.045. 100% melon soup versus 50% melon-*L. togolana* soup with a p-value of 0.220; 100% melon soup versus 70% melon 30% *L. togolana* soup with a p-value of 0.000; and 100% melon soup versus

80% melon 20% *L. togolana* soup with a p-value of 0.259 do not show significant difference in respect to their texture. The stated null hypothesis (H_0) was thus accepted for all formulated soup in terms of their texture but for 100% *L. togolana* soup for which the alternate hypothesis (H_1) was accepted.

Table 4: Wilcoxon signed-rank test for pair comparison of taste of soups

Parameter: taste	Z	p-value	Decision
A-B	-2.488	0.013	Significant
A-C	-1.531	0.126	Not significant
A-D	-2.243	0.025	Significant
A-E	-0.062	0.951	Not significant

There was a significant difference in two of the formulated products, that is between 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.013 and 100% melon soup versus 70% melon 30% *L. togolana* soup with a p-value of 0.025 in respect to their taste. For the two other products — 100% melon soup versus 50% melon *L. togolana*

soup with a p-value of 0.126 and 100% melon soup versus 80% melon 20% *L. togolana* soup with a p-value of 0.951, there was no significant difference in respect to their taste. The alternate hypothesis (H_A) was thus accepted for the two products in terms of their taste.

Table 5: Wilcoxon signed-rank test for pair comparison of colour of soups

Parameter: colour	Z	p-value	Decision
A-B	-4.963	0.000	Significant
A-C	-3.388	0.001	Significant
A-D	-3.412	0.001	Significant
A-E	-1.927	0.054	Not significant

There was a significant difference in colour for all the formulated products, but between 100% melon soup versus 80% melon 20% *L. togolana* soup with a p-value of 0.054 in respect to their colour. 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.000; 100% melon soup versus 50% melon-*L. togolana* soup with a p-value of 0.001; and

100% melon soup versus 70% melon 30% *L. togolana* soup with a p-value of 0.001 show significant difference in colour. The alternate hypothesis (H_1) was thus accepted for all formulated soup in terms of their colour, but between 100% melon soup versus 80%:20% melon *L. togolana* soup show Not Significant.

Table 6: Wilcoxon signed-rank test for pair comparison of general acceptability of soups

Parameter: acceptability	Z	p-value	Decision
A-B	-2.536	0.011	Significant
A-C	-2.516	0.012	Significant
A-D	-1.390	0.165	Not significant
A-E	-0.039	0.969	Not significant

There was significant difference in two of the formulated soup, that is between 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.011 and between 100% melon soup versus 50% melon-*L. togolana* soup with a p-value of 0.012 in respect to their general acceptability. For the two other products, 100% melon soup versus 70% melon +

30% *L. togolana* soup with a p-value of 0.165 and between 100% melon soup versus 80% melon 20% *L. togolana* soup with a p-value of 0.969, there was no significant difference in respect to their general acceptability. The null hypothesis (H_0) was thus accepted for the two products in terms of their general acceptability.

Table 7: DPPH Radical Scavenging Activity of Different Concentrations of Ascorbic acid and Extract From the root of *Landolphia togolana*

Concentration (µg/mL)	% Inhibition of methanol extract of <i>Landolphia togolana</i>	% Inhibition of ascorbic acid (standard)
20	84.8±0.03 ^a	63.59±0.01 ^a
40	97.8±0.04 ^b	96.97±0.07 ^b
60	100.1±0.05 ^b	98.53±0.01 ^b
80	98.7±0.02 ^b	98.82±0.08 ^b
100	101.2±0.25 ^b	99.41±0.01 ^b

Values are expressed as Mean ± SEM, n=3. Values with different lowercase letters are significantly different between means p<0.05

DPPH radical scavenging activities of different concentrations of vitamin C and extract from the root of *L. togolana* showed that the methanol extract of the root of *L. togolana* demonstrated remarkable and dose dependent increase in radical scavenging activity. The methanol extract of the root of *L. togolana* showed the highest inhibition percentage (100.2%) at 100 µg/mL concentration compared to standard ascorbic acid with inhibition percentage of 98.53% at 60 µg/mL.

Discussion

The study revealed that the level of respondents' acceptance of novel food products regards to sensory attributes vary significantly. For instance, in aroma, there is a significant difference in two of the formulated soup, that is, between 100% melon soup versus 100% *L. togolana* soup with a p-value of 0.011 and between 100% melon soup versus 50% melon-*L. togolana* soup with a p-value of 0.012 in respect of their general acceptability. For the two other formulated soup, 100% melon soup versus 70% melon 30% *L. togolana* soup with a p-value of 0.165 and between 100% melon soup versus 80% melon 20% *L. togolana* soup with a p-value of 0.969, there was no significant difference with respect to their general acceptability. This result was consistent across parameters – aroma/flavour, texture, taste, colour and general acceptability – for the comparison between 100% melon soup versus 70% melon and 30% *L. togolana* soup, which is one of the least that has the least *L. togolana* content. The result may be because *L. togolana* is not as common as melon soup, and people taking it for the first time, regardless of how quickly they adopt the soup, are unlikely to choose it over melon, which they are used

to taking. The finding agrees with Asante-Kwatia and colleagues who found that the powder from the root of *L. owariensis* was sweet, aromatic, yellowish brown and smooth (Asante-Kwatia et al., 2019). However, it was evidenced that the aroma of *L. owariensis* is odourless at room temperature (Akubugwo & Ugbogu, 2007), which is in contrast to the findings from this study. The acceptance of a food is determined by how well it responds to consumer wants and how much enjoyment it can bring (Costell et al., 2010). Furthermore, some have reported the responses of two taste and two odour stimuli at unimodally or in various combinations. The findings demonstrated that some brain areas respond only to taste only retronasal olfactory inputs, while others respond to both (Rolls, 2005). There was a significant difference in terms of level of acceptance of the formulated soup for functional food. This is consistent with the report of Pestorić and colleagues where the authors affirmed an overall acceptance for cookies made from medicinal products (Pestorić et al., 2017). The null hypothesis was accepted in this study for the formulated soup containing 20% *L. togolana* for food thickening in terms of their level of general acceptability. For numerous reasons, consumer adoption of plant-based foods has risen dramatically. They are suitable for vegan and vegetarian diets, have the potential for a health-promoting composition, and are produced in a more sustainable manner than comparable animal products (M. Zeece, 2020). Although *L. togolana* species are neglected and under-utilized, their nutritional and medicinal values are high in carbohydrates, vitamins and minerals, phytochemicals, and antioxidants (Opaleke et al., 2022). The anti-oxidative abilities of the plant extract could be attributed to the presence of phytochemicals (Lee et al., 2017; Yu et al., 2021). In the present study, the methanol extract of *L. togolana* root exhibited a high antioxidant capacity.

The DPPH radical assay is employed as a substrate to evaluate the antioxidant activity of methanol extract of *L. togolana* root. In this study, the methanol extract exhibited highest percentage (100.2%) of inhibition in a concentration-dependent manner and compared favorably with ascorbic acid (98.53%). This is similar to the observation of Chauke et al where it was reported that, with an IC₅₀ value of 30 g/ml, acetone extracts of *Flueggea virosa* demonstrated the highest antioxidant activity, almost matching ascorbic acid with an IC₅₀ value of 25 g/ml (Chauke et al., 2012). Similarly, Olugbami et al. reported that ethanol extracted stem bark of *Terminalia glaucescens* maintained a high level of activity (83.77%) compared to 92.80% for the conventional compound (Olugbami et al., 2015). All these evidences suggest the high concentration of antioxidants in plants foods which could be utilized as a free radical potential boost the immune systems of human body against any form of disease.

Conclusion

The root of *L. togolana* can be used to formulate functional foods which can fight and prevent several chronic diseases such as diet-related, noncommunicable diseases such as obesity, diabetes, hypertension, cancer, and cardiovascular diseases that are viable during retirement because of their high number of phytochemical-antioxidant properties that are excellent in fighting and preventing a set of diseases, maintaining well-being and securing the family future for sustainability in retirement.

Recommendations

Based on the conclusion of the study, the following recommendations were made:

1. To prevent the onset of future diseases, the addition of a 20% level of formulated sample of togolana root to household feeding should be encouraged earlier, particularly at retirement.
2. Home economists should emphasize the health benefits and potential of *L. togolana* as a cost-effective medicinal plant with appealing culinary characteristics.

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