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Original Article

Potential Relevance of *Allium sativum, Psidium Guajava Linn* & *Brassica oleracea Var. Capitata* Formulations in the Management of Diabetes Mellitus

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ABSTRACT

Background and aims. *Diabetes mellitus (DM) is a significant global health concern and a leading contributor to mortality. It is characterized by both macrovascular and microvascular complications. Preventing the onset of diabetes and managing its associated complications are of utmost importance. In recent times, there has been a growing inclination towards the consumption of certain foods, driven by their recognized biological properties. The study aimed to evaluate the proximate composition and antioxidant vitamin content of formulations containing Allium sativum (garlic), Psidium guajava Linn (guava), and Brassica oleracea Var. Capitata (cabbage) and explore their potential relevance in diabetes management.* ***Methods***. *Phytochemical analysis and proximate composition of different formulations were conducted. The formulations were assessed for protein, carbohydrate, moisture, fat, crude fiber, and ash content. The antioxidant vitamin content, including vitamins A, C, and E, was also measured.* ***Results***. *The garlic-containing formulations exhibited the highest protein content), while the garlic-cabbage formulation had the highest carbohydrate content. Guava-containing formulations were rich in crude fiber, and the cabbage formulation had the highest ash content. The garlic:cabbage: guava formulation demonstrated the highest vitamin A and E content, while the garlic: cabbage formulation exhibited the highest vitamin C content.* ***Conclusion***. *The formulations containing garlic, cabbage, and guava leaves displayed diverse proximate compositions and antioxidant vitamin profiles. The high protein content in garlic formulations suggests their potential benefits in diabetes management, while the lower carbohydrate and fat content in garlic: cabbage: guava formulations may be suitable for blood sugar and weight control. The presence of fiber and essential minerals in these formulations further supports their potential relevance in diabetes management. Incorporating these formulations into the diet may contribute to glycemic control, reduce oxidative stress, and support overall health in individuals with diabetes.*

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INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to insufficient insulin production or impaired insulin function. It is a major global health concern affecting millions of individuals worldwide. The elevated blood glucose levels observed in individuals with type 2 diabetes are attributed to a combination of factors, including an unhealthy diet, lack of physical activity, impaired insulin secretion in response to food, and decreased responsiveness of target tissues to insulin's effects [1]. The prevalence of a persistent metabolic disorder, which impacts approximately 150 million individuals globally, is projected to double and reach 300 million by the year 2025. This alarming trend highlights the significant growth of this chronic condition and its potential to affect a larger population in the near future [2].

Diabetes management typically involves a combination of lifestyle changes, medication, and dietary adjustments. However, there has been a growing interest in recent years regarding the use of natural products and plant-based feed formulations as complementary treatments for diabetes. Although synthetic oral anti-diabetic drugs and insulin are effective in controlling high blood glucose levels, they often come with side effects and may not effectively address diabetes-related complications [1]. Traditional medicinal plants have been utilized globally for managing various diabetic complications, with ancient literature highlighting the use of herbal drugs and minerals for treating diabetes mellitus. Notably, herbal drugs are generally considered safer and have fewer side effects compared to their synthetic counterparts. [3].

This study focuses on investigating the proximate and phytochemical composition of a feed formulation containing three plant species known for their potential anti-diabetic properties: *Allium sativum* (garlic), *Psidium guajava Linn* (guava), and *Brassica oleracea var. capitata* (cabbage). These plants have been traditionally used in various medicinal practices and have shown promising effects in the management of diabetes [4-5].

Garlic (*Allium sativum*) is known for its high content of bioactive compounds, including allicin, flavonoids, and organosulfur compounds. These compounds have been shown to possess anti-diabetic properties by improving insulin secretion, increasing insulin sensitivity, and regulating glucose metabolism [4,6]. Guava (*Psidium guajava Linn*) is a tropical fruit known for its high content of dietary fiber, antioxidants, and polyphenols. These bioactive constituents have been shown to possess anti-hyperglycemic properties by modulating glucose absorption and improving insulin resistance [4,6]. Cabbage (*Brassica oleracea var. capitata*), belonging to the cruciferous vegetable family, contains glucosinolates and phenolic compounds that exhibit anti-diabetic effects through mechanisms such as insulin secretion stimulation and inhibition of glucose absorption [7-8].

By incorporating these plant-based ingredients into the feed formulation, it is expected that the resulting feed will offer not only essential nutrients but also bioactive compounds that can positively impact human health, performance, and disease resistance [3]. Therefore, assessing the proximate composition, which includes evaluating the levels of protein, fat, fiber, carbohydrates, and vitamins, as well as the phytochemical composition of the polyherbal formulation is crucial to understanding its nutritional value and potential benefits as a dietary intervention for diabetes management. Understanding the nutritional and phytochemical profiles of this feed formulation can contribute to the development of functional foods and supplements that may help regulate blood glucose levels, improve insulin sensitivity, and mitigate the complications associated with diabetes.

METHODS

Chemical and Reagents

All chemicals and reagents used for the research work were of analytical grade.

Plant Material

The matured leaves of *Psidium guajava linn and Brassica oleracea var. capitata* were collected from a farm in Karkarku village while *Allium sativum* was purchased from a local market in Daura, Katsina state, Nigeria. The plants were botanically authenticated by a Botanist at the herbarium unit, Department of Plant Sciences, Bayero University Kano, Nigeria, and voucher specimens were deposited.

Preparation of Plant Samples

The plants *Allium sativum, Psidium guajava linn and Brassica oleracea var. capitata* were washed and air dried at room temperature. The samples were powdered using laboratory mortar and pestle. The powdered sample was bagged and stored in desiccator until when needed.

Phytochemical Analysis

The phytochemical constituent of the *Allium sativum*, *Psidium guajava linn* and *Brassica oleracea var. capitata* were determined following the method described for alkaloids [9]; phenolics, flavonoids and cardiac glycosides [10-11] (Awe and Sodipo, 2001), tannins, terpenoids and triterpenes [12] and Carotenoids [13], steroids, anthraquinones, [14].

Proximate and Mineral Analysis

The proximate analysis was conducted following the established protocols of the Association of Analytical Chemist [15]. The determination of vitamin C content in the formulation was carried out using the method described by [16]. Additionally, the analysis of vitamin E content was performed according to the methodology outlined by [17]), while the assessment of vitamin A content followed the procedure described by [18]. All analyses were conducted in triplicate to ensure the accuracy and reproducibility of the results.

Moisture content

The moisture content of each of the formulations was determined using the oven method. Initially, 2 g of the fresh sample was weighed and placed in an oven at 105°C for 24 hours. The dried sample was then reweighed until a consistent weight was obtained. The percentage moisture content was calculated using the following formula:

$$\%\ \text{Moisture} = \frac{W_1 - W_2}{\text{Weight of sample}} \text{ x } 100$$

Where: W1 represents the initial weight of the crucible plus the sample,
W2 represents the final weight of the crucible plus the sample.

Ash Content

The ash content of each of the formulations was determined by incinerating 2 g of the fresh sample in a muffle furnace at 600°C for 3 hours. After incineration, the resulting ash was weighed, and the percentage ash content was calculated using the following formula:

$$\%\ \text{Ash} = \frac{\text{Difference in Wt. of Ash}}{\text{Weight of sample}} \text{ x } 100$$

The difference in the weight of ash is determined by subtracting the initial weight of the sample (W1) from the weight of the obtained ash (W3).

Crude Lipid

Two grams (2g) of the sample were added to petroleum ether and stirred. After the sample particles settled at the bottom of the container, the mixture was decanted. The liquid portion was taken in a crucible and placed in the oven for evaporating the petroleum ether, while the lipid residue that remained in the crucible was weighed and the percentage crude lipid was calculated from it.

$$\%\ \text{Crude lipid} = \frac{\text{Difference in Wt. of Ash}}{\text{Weight of sample}} \text{ x } 100$$

Crude Protein

The crude protein content of the sample was determined using the Kjeldahl method. First, the nitrogen content of the sample was measured. The percentage of nitrogen was then used to calculate the crude protein by multiplying it with the conversion factor of 6.25 (i.e., % N × 6.25).

$$\%\ \text{Crude Protein} = 6.25 * \text{ x } \%\ \text{N} \ (*.\text{Correction factor})$$

$$\%\ \text{Crude Protein} = \frac{(\text{S} - \text{B}) \text{ x N x } 0.014 \text{ x D}}{\text{Weight of sample x V}} \text{ x } 100$$

Where
S = Sample titration reading
B = Blank titration reading
N = Normality of HCl
D = Dilution of the sample after digestion
V = Volume taken for distillation
0.14 Milli equivalent weight of Nitrogen

Crude Fiber

The crude fiber of the formulations was analyzed using an acid-base digestion method. The residue obtained after lipid extraction was subjected to the following treatment: 20 mL of a 10% H_2SO_4 solution was added, and the mixture was then boiled for a duration of 30 minutes. Afterward, the solution was filtered. To the filtrate, 20 mL of a 10% NaOH solution was added and heated for an additional 30 minutes, followed by filtration. The resulting residue was then transferred to a crucible and dried in a furnace. The dried ash obtained was weighed, and the percentage of fiber was calculated based on this measurement as depicted in the formula below:

$$\% \text{ Crude fiber } = \frac{W_1 - W_2}{W_0} \text{x } 100$$

Where,

W_1 = weight of digested sample + crucible before ash

W_2 = weight of crucible + ash

W_0 = weight of sample used

Total Carbohydrates

This was determined by a difference between 100 and the sum of the percentage of other contents excluding moisture.

100 – (Weight in grams [Crude Protein + Fat + Moisture content + ash + Crude fibre] in 100 g of food)

Data Analysis

All the analyses were performed using SPSS v.20 (for Windows) software. The results were expressed as mean ± Standard Error of the Mean (SEM) of triplicate determinations. Statistical analysis was conducted using one-way ANOVA, and a significance level of $p<0.05$ was considered statistically significant. In instances where applicable, the statistical significance was compared between the formulations using the Tukey Kramer multiple comparison test.

RESULTS

Phytochemical screening

Qualitative phytochemical screening of garlic, cabbage, and guava leaves was presented in Table 1. The phytochemical screening of individual plants revealed the presence of alkaloids, Flavonoids, saponin, steroids, terpenoids, Carotenoids, and phenols in all the plants, Tannins and Glycosides in Garlic and Guava leaves, and Anthraquinones in Garlic.

Table 1: Phytochemical analysis of Garlic, Cabbage, and Guava

Phytochemicals	Samples		
	Garlic	Cabbage	Guava
Alkaloids	+	+	+
Flavonoids	+	+	+
Glycosides	+	+	-
Saponins	+	+	+
Steroids	+	+	+
Phenols	+	+	+
Terpenoids	+	+	+
Anthraquinones	+	-	-
Tannins	+	+	-
Carotenoids	+	+	+

Key: + = present - = absent

Proximate composition of different formulations

The proximate composition (moisture, ash, protein, fat, crude fiber, and carbohydrates) of garlic, cabbage, guava leaves, as well as various formulations combining these ingredients is presented in Table 2. The compositions are expressed as percentages. The data highlights variations in nutritional content among the individual ingredients and their combinations, providing insights into potential dietary and health implications.

Table 2. Proximate composition of different formulations containing garlic, cabbage, and guava leaves.

Formulations	Proximate composition					
	MOISTURE	ASH	PROTEIN	FAT	C.FIBRE	CHO
Garlic	5.52±3.01[a]	4.85±1.23[b]	17.23±0.21[a]	1.24±0.58[a]	4.16±0.83[a]	66.99±2.99[c]
Cabbage	62.02±2.32[b]	1.67±0.02[a]	1.20±0.41[a]	4.69±0.03[b]	8.12±0.06[b]	22.30±0.01[a]
Guava leaves	27.67±2.16[a]	3.80±0.01[b]	16.68±0.01[b]	1.89±0.01[a]	12.98±0.01[a]	36.98±2.02[a]
Garlic: Cabbage	34.80±1.86[b]	3.92±0.08[b]	16.93±0.92[b]	4.31±1.32[b]	7.32±0.36[a]	67.36±0.06[c]
Garlic: Guava	21.21±0.86[a]	4.91±1.51[b]	14.07±0.31[a]	3.43±0.36[a]	9.61±0.56[b]	46.77±0.09[b]
Guava: Cabbage	36.52±0.93[b]	3.10±1.32[b]	9.81±1.32[b]	3.91±0.03[b]	11.68±0.41[b]	34.98±0.11[a]
Garlic:Cabbage:Guava	12.77±1.44[a]	4.10±0.02[b]	15.40±1.32a	4.72±1.23b	13.56±0.02b	51.45±0.34b

The values are presented as mean ± S.E.M of triplicate determinations. Different letters in the same column indicate significant differences (p<0.05).

The antioxidant vitamin content of the formulations

The results presented in Table 3 demonstrate variations in the antioxidant vitamin (Vitamin A, C, and E) content among different formulations containing garlic, cabbage, and guava leaves. These variations have implications for the potential use of these formulations in the management of diabetes.

Table 2: Antioxidant Vitamin Content of Different Formulations

Formulations	Vitamin Content		
	VIT. A (µmol/L)	VIT. C (mg/dl)	VIT. E (mg/dl)
Garlic	3.72±0.02[a,b]	23.27±2.02[c]	11.04±0[a]
Cabbage	3.083±0.07[a]	9.357±1.19[a]	10.83±0.12[a]
Guava leaves	5.34±0.02[c]	18.57±0.92[b]	13.27±0.04[b]
Garlic: Cabbage	4.087±0.02[b]	22.93±0.09[c]	14.53±0.02[b]
Garlic: Guava	4.307±0.92[a, b]	20.77±0.04[b,c]	11.75±0.02[a,b]
Guava: Cabbage	3.23±0.02[a]	23.527±0.02[c]	14.23±0.91[b]
Garlic:Cabbage:Guava	4.69±0.04[c]	24.57±1.03[c]	15.21±2.01[c]

The values are presented as mean ± S.E.M of triplicate determinations; Different letters in the same column indicate significant differences (p<0.05).

DISCUSSION

The proximate composition of different formulations containing garlic, cabbage, and guava leaves is presented in Table 2. From Table 2, it can be observed that the formulations containing garlic have the highest protein content, ranging from 14.07±0.31 to 17.23±0.21 (g/100g). The highest carbohydrate content was observed in the garlic-cabbage formulation, ranging from 67.36±0.06 to 66.99±2.99 (g/100g), whereas the formulations containing cabbage were found to be highest in moisture content, ranging from 62.02±2.32 to 36.52±0.93 (g/100g). The high protein content of the garlic-containing formulations suggests that they could be useful in the management of diabetes as a source of the necessary amino acids for the body to build and repair tissues. They could also help maintain satiety and aid in weight management, which is important for individuals with diabetes [19]. The high carbohydrate content in the garlic-cabbage formulation could also be beneficial for individuals with diabetes as carbohydrates are the main macronutrient responsible for raising blood sugar levels.

Furthermore, the formulations containing guava leaves were found to be high in crude fiber, which is a type of dietary fiber that has been shown to improve blood glucose control in individuals with diabetes [20]. Cabbage-containing formulation was found to have the highest ash content, which suggests that the formulation is rich in essential minerals that could be beneficial for individuals with diabetes [21].

Carbohydrates are much higher in garlic: cabbage formulation (67.36%) and garlic formulation (66.98%) which are significantly higher (p> 0.05) than all other formulations, cabbage formulation has the least value of carbohydrates (52.00%) compared to other formulations. Similarly, the result shows that the cabbage formulation had the highest value of moisture content (62.02) followed by garlic: cabbage formulation (34.80%) which is significantly higher (p<0.05) compared to other formulations, while garlic formulation appears to have the least moisture content of 5.52%.

Garlic: Cabbage: Guava formulation has the highest value of Fat content (4.72%) followed by cabbage formulation (4.69%) and significantly different (P<0.05) from the fat content of garlic with the lowest (1.24%) compared with other formulations. Similarly, the garlic formulation had the highest protein content (17.23%), followed by Garlic: Cabbage (16.93%) formulation and guava (16.68%), While the cabbage formulation had the least value of 1.20 (Table 2) which was significantly low compared to the other formulation.

Crude fiber is significantly high (p<0.05) in all mixture formulations compared to all individual plants formulations, except the guava formulation. Guava: Cabbage: Garlic:Guava formulation contain the highest crude fiber content of about 13.56% while Garlic has the least with 4.16%. On the other hand, garlic: Guava formulation had the Ash content at (4.91%), follow by garlic formulation (4.85%) while the leas ash content was observed cabbage formulation which was significantly lower (P<0.05) compared to all other formulations.

The proximate composition of these formulations provides valuable insights into their nutritional profiles, which can be relevant for use in the management of diabetes. Diabetes management often requires careful consideration of nutrient intake, including controlling carbohydrate and fat consumption while ensuring adequate protein and fiber intake. The formulations with lower carbohydrate and fat content, such as garlic:cabbage: Guava, may be suitable for individuals with diabetes who need to manage their blood sugar levels and weight [22-23].

Additionally, the presence of protein and fiber in the formulations can contribute to glycemic control and satiety. Protein helps in stabilizing blood sugar levels, while fiber aids in digestion and slows down the release of glucose into the bloodstream [24]. The formulations with higher protein and fiber content, such as garlic: Cabbage, may be beneficial in diabetes management [20, 24].

The antioxidant vitamin (vitamins A, C, and E) content in different formulations containing garlic, cabbage, and guava leaves varies, as shown in Table 3. These variations have important implications for the potential application of these formulations in diabetes management

In terms of vitamin A content, guava leaves exhibited the highest concentration (5.34±0.02 µmol/L), followed by the garlic:cabbage: guava formulation (4.69±0.04 µmol/L). Garlic and cabbage showed relatively lower levels of vitamin A compared to guava leaves. Adequate levels of vitamin A are important for maintaining overall health, supporting immune system function, and contributing to vision health. These findings suggest that the inclusion of guava leaves and the garlic:cabbage: guava formulation in the diet may provide beneficial vitamin A levels for individuals with diabetes [25-27].

Regarding vitamin C content, the garlic: cabbage formulation demonstrated the highest concentration (24.57±1.03 mg/dl), closely followed by guava: cabbage (23.527±0.02 mg/dl) and garlic (23.27±2.02 mg/dl). Vitamin C is a potent antioxidant that helps reduce oxidative stress, enhances immune function, and improves wound healing. Elevated blood glucose levels in diabetes can lead to increased oxidative stress, and adequate vitamin C levels may help combat this damage. Therefore, the formulations containing garlic, cabbage, and guava leaves may be beneficial for individuals with diabetes due to their high vitamin C content [24, 28].

In terms of vitamin E content, the garlic:cabbage: guava formulation displayed the highest concentration (15.21±2.01 mg/dl), followed by guava: cabbage (14.23±0.91 mg/dl). Vitamin E is a powerful antioxidant that protects cell membranes from oxidative damage. It also plays a role in regulating glucose metabolism and improving insulin sensitivity. Adequate levels of vitamin E can contribute to the management of diabetes by reducing oxidative stress and supporting cellular health. The higher vitamin E content in the garlic: cabbage: guava formulation and guava: cabbage formulation suggests their potential relevance in diabetes management [24, 30-31].

The active ingredients present in the studied plants play a crucial role in the observed phytochemical and antioxidant properties of the formulations. For instance, garlic contains bioactive compounds like allicin, which have been associated with antioxidant, anti-inflammatory, and anti-diabetic effects [29, 30, and 31]. Cabbage is rich in glucosinolates, sulfur-containing compounds that exhibit antioxidant and anti-cancer properties [32, 33]. Guava leaves, on the other hand, are abundant in flavonoids and polyphenols, contributing to their high antioxidant capacity [34].

These active compounds offer potential health benefits, particularly for individuals with diabetes. Allicin from garlic and glucosinolates from cabbage may help reduce oxidative stress and inflammation, while the flavonoids and polyphenols in guava leaves could contribute to improved glycemic control and overall health [33, 34, and 35]. The combination of these ingredients in the formulations may have synergistic effects on the overall antioxidant capacity of the feed formulation, making them valuable in diabetes management [30, 31].

By highlighting the presence of these active ingredients in the studied plants, we gain valuable insights into the nutritional profiles of the formulations and their potential application in diabetes management. Incorporating these formulations into the diet of individuals with diabetes may provide them with the antioxidant properties of the vitamins present [36, 37, 38, 39]. Consequently, this could lead to a reduction in oxidative damage and support overall health and glycemic control. Thus, the discovery of these active ingredients in the studied plants holds promising implications for improving the well-being of individuals with diabetes through dietary interventions.

CONCLUSION

In conclusion, the proximate composition of the feed formulation containing garlic, cabbage, and guava leaves presents a potential for use in the management of diabetes. The protein content is high, while the carbohydrate content varies depending on the combination of ingredients. Additionally, the formulations contain dietary fiber and essential minerals which can aid in blood glucose regulation. The high levels of antioxidant vitamins in the feed formulation containing garlic, cabbage, and guava leaves indicate its potential as a functional food for use in the management of diabetes. However, further animal and human studies are necessary to determine the efficacy and safety of these formulations for the management of diabetes.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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ملاءمة Allium sativum و Psidium Guajava Linn & Brassica oleracea Var. Capitata تركيبات في علاج مرض السكري

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المستخلص

الخلفية والأهداف. مرض السكري (DM) هو مصدر قلق كبير للصحة العالمية ومساهم رئيسي في الوفيات. يتميز بمضاعفات الأوعية الدموية الكبيرة والأوعية الدموية الدقيقة. إن منع ظهور مرض السكري وعلاج المضاعفات المرتبطة به أمران في غاية الأهمية. في الآونة الأخيرة ، كان هناك ميل متزايد نحو استهلاك بعض الأطعمة ، مدفوعًا بخصائصها البيولوجية المعترف بها. هدفت الدراسة إلى تقييم التركيب التقريبي ومحتوى الفيتامينات المضادة للأكسدة للتركيبات المحتوية على Allium sativum (الثوم) و Psidium guajava Linn (guava) و Brassica oleracea Var. Capitata (الملفوف) واستكشاف أهميتها المحتملة في علاج مرض السكري. **طُرق الدراسة**. تم إجراء التحليل الكيميائي النباتي والتركيب التقريبي للصيغ المختلفة. تم تقييم التركيبات لمحتوى البروتين والكربوهيدرات والرطوبة والدهون والألياف الخام والرماد. تم أيضًا قياس محتوى الفيتامينات المضادة للأكسدة ، بما في ذلك الفيتامينات A و C و E. **النتائج**. أظهرت التركيبات المحتوية على الثوم أعلى محتوى بروتين) ، بينما احتوت تركيبة الثوم والملفوف على أعلى محتوى من الكربوهيدرات. كانت التركيبات المحتوية على الجوافة غنية بالألياف الخام ، وكانت تركيبة الملفوف تحتوي على أعلى محتوى من الرماد. الثوم: الملفوف: أظهرت تركيبة الجوافة أعلى محتوى من فيتامين أ و هـــ ، بينما أظهرت تركيبة الكرنب والثوم أعلى محتوى من فيتامين ج. **الخاتمة**. أظهرت التركيبات التي تحتوي على أوراق الثوم والملفوف والجوافة تركيبات قريبة متنوعة وملامح فيتامين مضادة للأكسدة. يشير المحتوى العالي من البروتين في تركيبات الثوم إلى فوائدها المحتملة في علاج مرض السكري ، في حين أن محتوى الكربوهيدرات والدهون المنخفض في الثوم: الكرنب: تركيبات الجوافة قد تكون مناسبة لسكر الدم والتحكم في الوزن. إن وجود الألياف والمعادن الأساسية في هذه التركيبات يدعم أيضًا أهميتها المحتملة في علاج مرض السكري. قد يساهم دمج هذه التركيبات في النظام الغذائي في التحكم في نسبة السكر في الدم وتقليل الإجهاد التأكسدي ودعم الصحة العامة للأفراد المصابين بداء السكري.

الكلمات الدالة. التركيب التقريبي ، الفيتامينات المضادة للأكسدة ، Allium sativum، Psidium guajava Linn، Brassica oleracea Var. Capitata ، علاج مرض السكري