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Research Article
Antioxidant Properties of Steamed Paste (Moin-Moin) Made from Sprouted Pigeon Pea Flour as Influenced by Heat Treatment

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Abstract

Background and Objective: Phytochemicals act as antioxidant in the body thereby playing a role in the prevention of some degenerative diseases like type II diabetes. Pigeon pea contains some polyphenols, such as flavonoids which plays an important role in the prevention of diseases such as cancer, diabetes and heart disease because of their actions. Effect of heat on phenol, flavonoid, antioxidant activities and sensory qualities of moin-moin produced from sprouted and unsprouted pigeon pea flour were evaluated in this study. **Materials and Methods:** Moin-moin was produced from sprouted and unsprouted pigeon pea flour. The flours (sprouted and unsprouted pigeon pea) and the moin-moin were evaluated for phenol, flavonoid, 1, 1, Diphenyl-2-Picrylhydrazy, reducing power and ferric reducing antioxidant power to assess the effect of heat on them. Sensory properties of the moin-moin were measured. **Results:** The evaluation showed that phenol, flavonoid and their antioxidant activities in sprouted pigeon pea flour were significantly ($p \leq 0.05$) higher than that of unsprouted pigeon pea flour. Moin-moin made from sprouted pigeon pea flour exhibited higher phenol, flavonoid and antioxidant activities than moin-moin that was produced from unsprouted pigeon pea flour. The moin-moin exhibited acceptable sensory qualities. Steaming affected the phenolic contents because the antioxidant and its activities were lower in the steamed paste than that in the flour samples. However, moin-moin made from sprouted pigeon pea still exhibited considerable high quantities of phenol, flavonoid and antioxidant activity that were higher than the conventional plant product used in producing moin-moin. **Conclusion:** Based on the experiment, moin-moin produced from sprouted pigeon pea flour is a potential source of antioxidants of plant origin which could lead to the reduction of certain degenerative ailment like diabetes and cancer.

Key words: Antioxidant, sprouting, moin-moin, pigeon pea, diabetes, steamed paste, degenerative ailment

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Legumes are the edible seeds of leguminous plants. They are indispensable in human nutrition. They are good and affordable sources of protein especially in developing countries where the prevalence of malnutrition is high[1]. Legumes are not only good sources of protein but contain health-promoting phytochemicals like phenols and flavonoids. These phytochemicals act as antioxidant in the body thereby playing a role in the prevention of some degenerative diseases. Studies showed that high intake of legumes protects the human body from developing type II diabetes and also acts as protective factors against oxidative damage[2]. Many developing countries that have recorded increased occurrence of malnutrition which can be linked to decreasing levels of protein in food consumed has once again emphasized the prime place and relevance of legumes as good and affordable especially when complemented with cereal grains.

Primarily pigeon pea is used as a legume food crop. The seeds are eaten fresh as vegetable, dried, flour form and the leaf can be used as forage for livestock. It is one of the most effective medicinal plants categorized to fabaceae family[3]. In Africa, pigeon pea seeds are widely applied in treating hepatitis and measles while in China, they are used in stopping bleeding, relieve pain and as an expectorant[4]. Nutritionally, pigeon pea seeds have been reported to have high protein content that ranges [5] from 21-28% and some amino acids like tryptophan, lysine and methionine. The protein content is comparable with those in cowpea and soybean. It has high mineral quality and fibre content[6]. Research has shown that pigeon pea contains some polyphenols, such as flavonoids which plays an important role in the prevention of diseases such as cancer, diabetes and heart disease because of their actions[7]. Polyphenols are secondary metabolites that are found in plant. Research has indicated that phenolics consisting of anthocyanins, phenols and flavonoids have a wide range of biochemical activities like anticarcinogenic and antioxidant. Antioxidants posses the ability to scavenge free radicals, act as hydrogen donor, chelating agents or quench singlet oxygen. The reaction of these free radicals leads to causation of some degenerative diseases. Hence natural antioxidants that can protect the human body against these damages by reactive oxygen species are being investigated.

Some processes and methods like germination are regarded economical to enhance the nutritional value of legumes by causing anticipated changes in the nutrients availability and organoleptic features. Secondary compounds such as antioxidants at times change during the germination[8]. Germination processes usually increase the functionality of the seeds due to the successive increase in the bioactive compounds such as polyphenols which protect the cell membrane against the damages induced by reactive free radical[9]. Therefore, consumption of food that contains high phenolic content leads to reduced cancer mortality, inflammation, heart disease and diabetics[10].

Moin-moin is a common food which can be consumed as breakfast by most Nigerians. It is enjoyed by majority especially in combination with cereal based dishes such as maize gruel (akamu), maize gelled products (agidi) and rice. It is a steamed gelled product made from a mixture of either wet or dry milled dehulled beans especially cowpea, crayfish, onions, oil and ground peppers and other ingredients, the formed homogenous paste is wrapped with local leaves or aluminum foil and cooked in steam or boiling water until it solidifies into a irreversible gel at a temperature of 80°C [11]. Moin-moin is rich in phyto-protein, vitamins and other nutrients and it is a perfect weight losing meal with good filling effect and a food that can be consumed by people suffering from type II diabetes because of its low glycemic index. Nigerians are not accustomed with moin-moin made from pigeon pea. Pigeon pea is still an under-utilized legume crop in Nigeria, thus there is necessity for another crop which can be alternated with the utility of cowpea in some areas of food processing, reducing monotony and cost.

The aim of this study was to determine the antioxidant properties of sprouted and unsprouted pigeon pea flour, the effect of heat on the antioxidant and antioxidant activity of pigeon pea based moin-moin and their possible potentials in the production of moin-moin.

MATERIALS AND METHODS

Dry white variety of pigeon peas (*Cajanus cajan*) were obtained from Ogbete Market in Enugu State, Nigeria. After due identification by the department of Botany, University of Nigeria Nsukka, they were sorted and stored in plastic airtight containers at 4°C until needed.

Steeping and germination procedures: This was done by sterilizing the sample (500g) using 1% sodium hypochlorite for 20 min followed by washing and steeping in water for 15 h. The steeped grains were allowed to sprout at ambient temperature (28±2°C) for 56 h by spreading them on a wet jute bag and covered with cotton cloth. This was followed by drying in an oven (Gallenkamp) set at 50°C for 24 h. The grain sprouts were separated from kernel by rubbing the

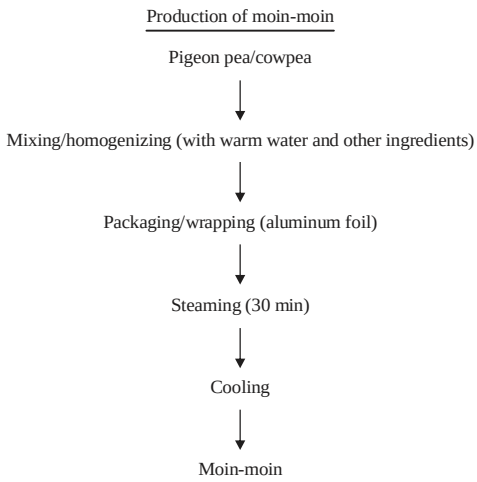

Fig. 1: Moin-moin production

germinated grain prior to milling. The milled sample was then sieved through a 100 m mesh sieve size. The ungerminated pigeon pea and cowpea (control) were given the same treatment.

Three different samples of flour were obtained:

1A : Germinated pigeon pea flour
1B : Ungerminated pigeon pea flour
1C : Ungerminated cowpea flour (control)

Preparation of moin-moin from germinated and ungerminated pigeon pea and cowpea flour: Moin-moin was produced from the germinated pigeon pea flour by mixing 200 g of the flour in a bowl with 552 mL of warm water with other ingredients (tin tomato: 25 g, 1 bouillon cube, ground red pepper: 25 g, onion slices: 20 g, vegetable oil: 100 mL, crayfish: 2 g, smoked fish: 18.1 g, mixed spices: 0.5 g, salt: 5.5 g and curry powder-0.5 g). The ingredients were mixed manually and the mixed slurry was packaged with aluminum foil and allowed to cook by steaming for 30 min[11]. A step by step presentation of moin-moin production process was shown in Fig. 1. The same ingredients measurements and cooking time were used for ungerminated pigeon pea and cowpea flour which served as control.

Three different samples of moin-moin were prepared, as fellows:

2A : Moin-moin prepared from germinated pigeon pea flour
2B : Moin-moin prepared from ungerminated pigeon pea flour
2C : Moin-moin prepared from ungerminated cowpea flour (control)

Analytical methods: The total phenol was determined using the method described by Makkar *et al.*[12], total flavonoid by Chang *et al.*[13], 1,1, Diphenyl-2-Picrylhydrazyl (DPPH) free radical scavenging activity by Blois[14] reducing power assay by Duh *et al.*[15] and ferric reducing/antioxidant power (FRAP) by Benzie and Strain[16], assay were carried out on the ungerminated and germinated pigeon pea flour and moin-moin samples produced. All analyses were done in triplicates.

Sensory evaluation of moin-moin: Sensory evaluation was conducted on moin-moin produced from 3 different flour samples. Fifteen semi trained panelists were selected randomly from IMT polytechnic community, Enugu, Nigeria. The samples were coded and presented to the panelists. Water was provided for rinsing the mouth in between evaluations. The panelist rated the samples for overall acceptability, sensory attributes of color, aroma, taste, texture and mouth feel. A 9-point Hedonic scale was used for rating where, 9 = Like extremely, 5 = Neither like nor dislike, 1 = Dislike extremely[17].

Statistical analysis: A one-way analysis of variance (ANOVA) was carried out on the polyphenols and antioxidant activities data followed by Tukey's test (SPSS v. 20 for windows, SPSS Inc., Illinois, USA) to determine differences in the means.

RESULTS AND DISCUSSION

Antioxidant and antioxidant activities of germinated and ungerminated pigeon pea flour and cooked moin-moin samples: It was observed from Table 1 that the polyphenol and antioxidant activity of germinated pigeon pea were higher than that of ungerminated pigeon pea. Polyphenols are a group of antioxidant agents that act as terminators and free radical scavenger[18] and most of them play a role in the prevention of degenerative diseases[19]. This rise in the quantity of phenolic compound after germination is in agreement with the study done by Lopez-Amoros *et al.*[9] which revealed that germination alters the number and quality of polyphenol compounds in legumes. Antioxidant activities checked revealed that the germinated pigeon pea had a higher scavenging properties and higher levels of free radical inhibition activity against 1,1,Diphenyl-2-Picrylhydrazyl (DPPH), higher hydrogen donor and ferric reducing antioxidant power when compared to the ungerminated sample[20]. Thus germinated pigeon pea might contain some compounds which are electron donors that might have

Table 1: Antioxidant and antioxidant activities of germinated and ungerminated pigeon pea and cowpea flour

Samples	Phenol (mg/100 g dry weight)	Flavonoid (mg/100 g dry weight)	DPPH (μg mL^{-1})	Reducing power (μg mL^{-1})	FRAP (μmol g^{-1})
1A	52.14±0.06^{a}	16.00±0.11^{a}	69.11±0.72^{a}	0.55±0.47^{a}	66.00±2.01^{a}
1B	20.62±0.13^{b}	8.11±0.25^{b}	49.00±0.34^{b}	0.31^{b}±0.81^{b}	47.81±1.03^{b}
1C	13.01±1.01^{c}	3.11±0.43^{c}	12.20±0.01^{c}	0.19±0.00^{c}	15.30±1.10^{c}

Means of triplicate determinations±SD. Means within a column with the same superscript are not significantly different ($p \geq 0.05$)

Table 2: Antioxidant and antioxidant activities of moin-moin prepared from germinated and ungerminated pigeon pea and cowpea flour

Moin-moin sample	Phenol (mg/100 g dry weight)	Flavonoid (mg/100 g dry weight)	DPPH (μg mL^{-1})	Reducing power (μg mL^{-1})	FRAP (μmol g^{-1})
2A	40.32±1.86^{a}	6.19±1.10^{a}	41.24±0.60^{a}	0.45±0.21^{a}	36.21± 0.00^{a}
2B	14.44±1.51^{b}	2.73±1.51^{b}	21.30±0.51^{b}	0.22±0.01^{b}	19.14±0.12^{b}
2C	12.33±0.10^{c}	1.49±0.05^{c}	10.11±0.00^{c}	0.10±0.04^{c}	13.34±0.60^{c}

Means of triplicate determinations ±SD. Means within a column with the same superscript are not significantly different ($p \geq 0.05$)

reacted with free radicals to change them to more stable products and blocked the free radical chain reactions[21]. It was also observed that antioxidant and antioxidant activities in both germinated and ungerminated pigeon pea flour were higher than those in ungerminated cowpea flour. The results of phenol, flavonoid and antioxidant activity of moin-moin made from germinated pigeon pea, ungerminated pigeon pea and cowpea are presented in Table 2. There was significant ($p \leq 0.05$) difference in all the parameters, with the germinated pigeon pea flour based moin-moin having the highest value and the cowpea flour based moin-moin with the least value.

Since the germinated seed had higher phenol, flavonoid and antioxidant activities than the ungerminated seed, it is therefore not too surprising that the moin-moin produced showed the same trend. Pasko *et al.*[22] reported higher total phenolic content in sprouts compared to seeds, suggesting that synthesis of phenolic antioxidants during germination may occur, also the highest flavonoids content in germinated pigeon pea flour based moin-moin over the other flour was in accordance with the results of Kim *et al.*[23]. These authors found that germination of mung bean increased (nearly three times) the flavonoid level, compared to the ungerminated seed. An increase in phenolic compounds content along with the seed germination may influence their free scavenging activity. This might be due to hydroxyl groups existing in the chemical structure of the phenolic compounds which can provide the component that acts as a radical scavenger. Germinated pigeon pea flour based moin-moin had the highest antioxidant activity. The increment of antioxidant activity values in product from germinated seeds seems to be related to the rise in the content of antioxidant compounds such as polyphenols.

The lower residual phenolic compounds and antioxidant activity content in moin-moin from germinated pigeon pea flour sample relative to the raw sample could be as a result of dilution effect of cooking oil and other ingredients used in the preparation of moin-moin. Again the decrease in the phenolic content could be due to heat or changes in the association between the protein in the germinated pigeon pea and the phenolic compounds. It was likely that the alliance between the pigeon pea proteins and the phenolic compounds could influence the extractability of the phenolic compounds. The alliance might be due to the chemical interaction between the pigeon pea proteins and phenolic compounds or that the phenolic compounds might be trapped in the gelled network structure formed by denatured pigeon pea protein. However, the moin-moin samples contained appreciable residual amounts of phenolic compounds.

Sensory properties of the moin-moin: Results obtained from the sensory evaluation as shown in bar diagram which Fig. 2 revealed slight difference among the germinated pigeon pea, ungerminated pigeon pea and cowpea used in the moin-moin production. The colors did not differ significantly ($p \geq 0.05$). The germinated pigeon pea rated the best in terms of aroma (7.5) but it did not differ significantly ($p \geq 0.05$) from the score of cowpea (6.9). The taste of moin-moin from the germinated pigeon pea was rated highest (7.9), followed by cowpea (7.1) but there was no significant ($p \geq 0.05$) difference between them, while the ungerminated pigeon pea had the least rating (6.2). In terms of mouth feel, both the germinated pigeon pea and cowpea flour scored high values. The texture of the moin-moin samples differed significantly ($p \leq 0.05$). However cowpea flour was rated highest (7.3), followed by ungerminated pigeon pea (6.8), while that of germinated pigeon pea flour was rated the least (6.2). There were no significant ($p \geq 0.05$) difference among germinated pigeon pea and cowpea in overall acceptability.

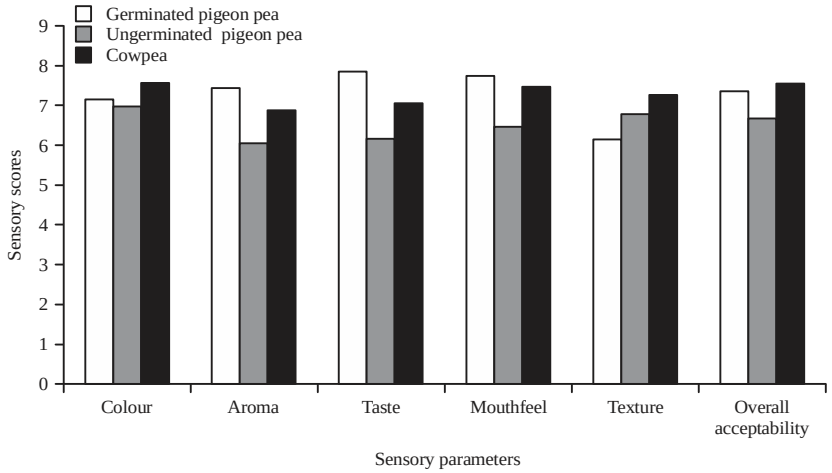

Fig. 2: Mean sensory score of parameters of moin-moin prepared from the flours of germinated and ungerminated pigeon pea and cowpea flour

The relative high acceptability scores of aroma and taste of moin-moin prepared from germinated pigeon pea samples, compared with ungerminated pigeon pea may have been due to the reduction of the beany flavor of pigeon pea by the sprouting treatment. This is in agreement with that work done by Rekha *et al.*[24] which revealed that steeping and germination reduced the undesired flavors such as beany and grassy flavor to a minimum and maximize total acceptability for the soy curd prepared from soybeans germinated for 2 days[25]. These results suggested that steeping and germination of pigeon pea could be done to reduce beany flavor in the final flour. The presence of such beany flavor in legumes had been shown to be offensive to most consumers[25].

One key attribute desired for moin-moin is good mouth feel. In terms of mouth feel, the moin-moin produced from germinated pigeon pea compared favorably with moin-moin produced from cowpea. The relatively low mean score for texture obtained for samples prepared from germinated pigeon pea flour was most probably as a result of the modification and reduction in starch component brought about by germination. The starch component is mostly responsible for the firm texture in flour gels. Sensory evaluation results showed that moin-moin of good sensory quality can be produced from pigeon pea by steeping and germinating the seed, since the product from germinated pigeon pea was not significantly ($p \geq 0.05$) different from cowpea in overall acceptability. Fasoyiro *et al.*[26] reported that pigeon pea moin-moin was acceptable in terms of flavor, mouth feel and overall acceptability when compared with cowpea moin-moin.

CONCLUSION

The study showed that steeping and germination led to increase in some of the bioactive compounds like total phenol and total flavonoid with subsequent increase in antioxidant activity like DPPH, reducing power and FRAP. Moin-moin produced from germinated and ungerminated pigeon pea flour had lower antioxidants and antioxidant activity than were observed in their corresponding flours. The products also had acceptable sensory quality. However, the phenolic content and antioxidant activity in the moin-moin decreased, but it still contained appreciable amount of phenolic compound. As a result of the good functionality of the germinated pigeon pea seeds, the seeds would be very good in composite flours or even used alone depending on the product. Its use in food products will not only increase the nutritional intake of individuals, but also reduce the risk of developing certain degenerative diseases such as cancer, diabetes, high blood pressure.

SIGNIFICANCE STATEMENT

This study discovered that pigeon pea based moin-moin is a novel product that contain natural antioxidant that will eliminate the risk associated with consumption of synthetic antioxidant. The findings in this research are unique in their nature because it has been able to reveal that germination increases the antioxidant in pigeon pea and that other than cowpea, pigeon pea can be used to produce natural antioxidant rich moin-moin which can be consumed by people suffering from type-II diabetes.

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