Original Research Article

Chemical composition of serendipity berry *(Dioscoreophyllum cumminsii)* and miracle fruit (*Thaumatococcus daniellii*)

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ABSTRACT

Aims: To determine the chemical composition of serendipity berry *(Dioscoreophyllum cumminsii)* and miracle fruit (*Thaumatococcus daniellii*)
Study design:
Place and Duration of Study: Samples were prepared in Department of Food Science and Technology, Osun State Polytechnic, between November 2018 and December 2019.
Methodology: Chemical properties of two natural sweeteners namely the miracle fruit (*Thaumatococcus danielli*) and serendipity berry (*Dioscoreophyllum cumminsii*) were studied in this work. The fresh fruits were obtained from a farm, sorted, washed and the tissues were scraped, dried in the oven at 45 ^{o}C for 12 hrs, milled and packed in airtight plastic containers. Proximate, vitamins and amino acid contents of the sweeteners were determined.
Results: The results revealed that the protein contents of miracle fruit and serendipity berry were 75.57% and 62.54% respectively. Moisture contents of the sweeteners ranged from 56.95-58.33% while ash contents ranged from 19.33-22.90%. The sweeteners had low carbohydrate and lipid contents. Crude fiber was not detected in miracle fruit but serendipity berry had crude fibre of 5.38%. The fruits had β-carotene contents ranging from 8.44 mg/100 g and 23.00 mg/100 g, vitamin C (20.40 mg/100 g and 22.01mg/100 g) and vitamin D (17.02 mg/100 g and 19.02 mg/100 g) in miracle fruit and serendipity berry respectively. However, low values were recorded for vitamin E 0.55 mg/100 g and 0.89 mg/100 g in miracle fruit and serendipity berry respectively. The fruits had appreciable amount of essential amino acid which was above 50% of the total amino acid content. Miracle fruit had 51.96% and serendipity berry had 58.07% of the essential amino acid. Aromatic essential amino were 10.78 and 12.79 % in miracle fruits and serendipity respectively.
Conclusion: This study showed that the two natural sweeteners are good source of essential nutrients and could be used as food supplements in our diet

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Keywords: [Sweetener, miracle fruit, serendipity berry, Amino acid, proximate composition}

1. INTRODUCTION

Intake of high caloric food causes obesity and related problems mainly due to consumption of refined sugars, which ultimately leads to higher probability of heart diseases, type II diabetes, sleep apnoea, certain types of cancer and osteoarthritis. The primary sources of these extra carbohydrates are sweetened beverages and other carbohydrate-rich foods. Although addition of artificial sugar-free sweeteners may replace sugar, they still have some side effects. As a consequence, using monellin and thaumatin a low-calorie, carbohydrate-free protein as natural sweeteners, would be an ideal option [1]. Sweet proteins have the potential to replace these artificial sweeteners, by acting as natural, good, low calorie sweeteners, as weknow that proteins do not trigger a demand for insulin in these patients whereas sucrose does. There are seven known sweet and taste-modifying proteins, namely Brazzein,Thaumatin , Monelin , Curculin , Mabinlin , Miraculin and Pentadin [2]. Monellin was found to be 10,000 times sweeter than sucrose on a molar basis, followed by Thaumatin which is 3,000 times sweeter than sucrose. These proteins have been isolated from plants that grow in tropical rainforests. Although most of them share no sequence homology or structural similarity, Thaumatin shares extensive homology with certain non-sweet proteins found in other plants .The potential industrial applications of these proteins are the low calorie sweetener industry and the beverage, snacks, food and chocolate industries [3].
Thaumatins are a class of intensely sweet proteins isolated from the fruit of the tropical plant *Thaumatococcus danielli*. The protein crystallizes in a hexagonal lattice after a temperature shift from 293 to 277 K. The structure has been solved at 1.6 Å resolutions. Its fold was found to be identical to that found in three other crystal forms grown in the presence of crystallizing agents of differing chemical natures [4]. It consists of 207 amino acid residues with eight intra-molecular disulfide bonds and contains no free cysteine residues. It aggregates upon heating at pH 7.0 above 70 ^{o}C, whereupon its sweetness disappears [4, 5]. The protein is approximately 10,000 times sweeter than sugar on a molar basis [6]. It is a protein that tastes intensely sweet only to Old World monkeys and to higher primates, including man, as it has been found that the protein binds to certain elements in taste pores of Rhesus monkey foliate papillae [7, 8]. Thaumatin has been approved for use in many countries as both a flavour enhancer and a high-intensity sweetener [9].Monellin, a sweet protein, consists of two non covalently associated polypeptide chains, an A chain of 44 amino acid residues and a B chain of 50 amino acid residues [10]. The protein can be purified from the fruit of *Dioscoreophyllum cumminsii* grown in West Africa and is approximately 10,000 times sweeter than sugar on a molar basis and several thousand times sweeter on a weight basis [2]. Single-chain monellin (SCM), which is an engineered 94-residue polypeptide, has proven to be as sweet as native two. The main objective of this present study is to evaluate the nutritional qualities of two natural sweeteners (miracle fruit and serendipity berry).
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2. MATERIAL AND METHODS

2.1 Materials

Miracle fruit (*Thaumatococcus danielli*) and serendipity berry (*Dioscoreophyllum cumminsii)* were obtained from a farm in Esa-Odo, osun state, Nigeria. The pods of miracle fruit were opened and the sweetener at the arils of the seeds were carefully scraped, dried and milled. Also for serendipity berry, the tissue around the seed was scraped, dried and milled.

2.2 Analyses

Proximate analysis such as moisture, ash, fat, and protein contents of the samples was carried out using the AOAC methods [11]. Carbohydrate was determined by difference. Vitamin C was determined using 2.6 dichlophenol visual titration method while vitamin D and E were done using AOAC methods [11]. β-carotene was carried out using Batool et al. [12] method.

2.3 Statistical analysis

Data were subjected to Analysis of Variance (ANOVA) and differences between means were evaluated by Duncan's multiple range tests using SPSS (version 17.0). Significant differences were expressed at $P<0.05$.

3. RESULTS AND DISCUSSION

Proximate compositions of two natural sweeteners, miracle fruit and serendipity berry are presented in Table 1. The moisture contents of miracle fruit and serendipity berry are 5.33% and 6.95% respectively. Moisture content is a measure of water content in the fruit sample [13]. The values were low compared to 30.21% reported for canarim schweinfurthii seed pulp by Ayoade *et al*. [14] and lower than 78.00% and 64.00% of the pulp and peel recorded for pear fruits by Mohammed *et al*. [15].The moisture contents of the sweeteners compared favourably with other vegetables (72-92%) reported by Ogoloma *et al.* [16]. The ash content is an index of the total mineral content of food. The samples had values of 22.90% and 19.33% for miracle fruit and serendipity berry. These values were higher than three dates varieties Dagalla, Dan-mali and Fari of 3.00%, 3.33% and 3.17% reported by Uba *et al.* [17]. The crude fiber contents for miracle fruit and serendipity berry were 0.00% and 5.35%. These values were lower compared to the results recorded by Omowunmi and Ayoade [18] for wild date palm with 12.55%. The fat contents of miracle fruit 0.48% and 5.58% for serendipity berry is lower to the value obtained for the pulp 5.60% for pear fruit reported by Mohammad et al. [15]. The crude protein contents of the two sweeteners 73.57% for miracle fruit and 62.54% for serendipity berry. This is an indication that these two sweeteners are good source of protein, thus can be a replacement for sugar and as well enrich food, since proteins are essential component of diet which supplies adequate amount of amino acids [19]. Carbohydrate composition was lower for both the sweeteners 2.14% miracle fruit and 7.44% serendipity berry. The values of carbohydrate make it safe for human consumption since people are avoiding food with high calories. Carbohydrate provide calories in diet [17]

Table 1. Proximate composition of miracle fruit and serendipity berry (% dry weight)

Parameter	Miracle fruit	Serendipity berry
Moisture %	5.33±0.98	6.95±0.13
Crude protein %	70.24±0.54	55.59±0.23
Crude fiber %	0.00±0.00	5.35±0.14
Lipid %	0.48±0.01	5.58±0.42

Ash %	21.81±0.72	19.33±0.14
Carbohydrate %	2.14± 0.00	7.20±0.24

Mean ± standard deviation

Table 2 shows the vitamin contents of two sweeteners miracle fruit and serendipity berry. Vitamins are accessory factors, which must be presented in the food in minute amounts to enable growth, health and life to be maintained [20]. The carotene contents miracle fruit and serendipity berry are as follows 8.44mg/100g and 23.00mg/ 100g. The vitamin A reported in this study is lower than the vitamin A (57.25mg/100g) of the dried pulp of watermelon [21] but higher than the vitamin A of three varieties of date fruits: Trounja, Lagou and Gounla 0.7mg/100g, 1.2mg/100g and 0.9mg/100mg reported by Kumar [22]. The relatively high vitamin A content in the sweeteners indicated that it can play a vital role in bone growth and healthy vision [20]. Vitamin C contents of miracle fruit 20.40 mg/100g and serendipity berry 22.01mg/100g. These results showed that the two sweeteners had higher values of vitamin C. Vitamin C have high antioxidant activity and it helps in maintaining the cellular membrane integrity. Also vitamin C has been reported to prevent formation of cancer [23]. The values of vitamin D obtained in this present work were high for the two sweeteners 17.02mg/100g for miracle fruit and 19.02mg/100g for serendipity berry. This implies that the fruits are a good source of vitamin D and underline their significance nutritionally in the diet. However, low values were recorded for vitamin E 0.55mg/100g for miracle fruit and 0.89mg/100g for serendipity berry.

Table 2: Vitamin contents of miracle fruit and serendipity berry (mg/100 g)

Parameter	Miracle fruit	Serendipity berry
Carotene	8.44±0.02	23.00±4.24
Vitamin C	20.40±0.18	22.01±5.08
Vitamin D	17.02±1.42	19.02±1.41
Vitamin E	0.55±0.07	0.89±0.02

Mean ± standard deviation

Table 3 shows eighteen amino acid determined in the profile of miracle fruit and serendipity berry with highly remarkable concentrations when compared with the FAO/WHO [24] reference values for humans of all ages. The most dominant amino acids in the two sweeteners were glutamic acid miracle fruit 10.61 g /100 g and serendipity berry 10.37 g/100 g followed by aspartic acid (8.86 g/100 g and 7.74 g/100 g) then arginine (6.09 g/100 g and 5.28 g/100 g) for non essential amino acids, this was close to (13.19 g /100 g, 11.67 g/100 g and 6.09 g/100 g) reported for canarium schweinfurthii seed pulp by Ayoade *et al*. [14]. Glutamic acid and aspartic acid are precursor from which the backbones of amino acid are formed and they are storage forms of nitrogen [15] Also Arginine is necessary for human life especially in children's growth [23]. However, higher values were observed for miracle fruit and serendipity berry for phenylalanine (6.40 g/100 g and 6.48 g/100 g), tryptophan (3.18

g/100 g and 3.30 g/100 g), tyrosine (4.58 g/100 g and 6.31 g/100g), leucine (7.15 g/100 g and 8.35 g/100 g) , threonine (8.98 g/100 g and 8.35 g/100 g), isoleucine (4.27 g/100 g and 6.50 g/100 g) and valine (5.58 g/100 g and 7.40 g/100 g). cystine (1.47 g/100 g and 1.12 g/100 g) and histidine (0.26 g/100 g and 0.31 g/100 g) had low values. When compared with the FAO/WHO reference pattern miracle fruit and serendipity berry are sources of essential amino acids. These results showed that the total amino acids for miracle fruit and serendipity berry are (90.35g/100g and 97.27g/100 g). The total essential amino acids are 46.95 and 56.50g/100g at 51.96% and 58.09% respectively while the non essential amino acids are (43.40g/100g and 40.77g/100g) at 48.03% and 41.91%. This revealed that these fruits contained above 50% concentration of nutritionally useful essential amino acids which implies that the fruits could be used as supplement. The sulphur containing amino acids (methionine and cystine) are (2.11g/100g and 7.42g/100g) and aromatic essential amino acids (phenylalanine and tyrosine) are (10.78g/100g and 12.79g/100g) respectively.

Table 3: classification of Amino acid composition of miracle fruit and serendipity berry

Amino acid	Miracle fruit	Serendipity berry	FAO/WHO reference pattern (1991)
*Lysine	4.70±0.64	5.31±0.01	5.80
*Histidine	0.26±0.06	0.31±0.01	2.50
**Arginine	6.09±0.78	5.28±0.06	5.20
**Aspartic acid	8.86±0.21	7.74±0.57	7.70
**Threonine	8.98±0.04	8.35±0.49	3.40
Serine	3.65±0.07	3.14±0.07	7.00
Glutamic acid	10.61±0.56	10.37±0.05	14.70
Proline	4.26±0.15	4.26±0.15	10.70
**Glycine	5.87±0.07	5.87±0.07	2.20
Alanine	3.80±0.17	3.80±0.17	6.10
*Cystine	1.47±0.64	1.12±0.13	3.00
**Valine	5.58±0.04	7.40±0.01	5.00
**Methionine	0.64±0.05	6.30±0.01	2.50
**Isoleucine	4.27±0.38	6.50±0.07	2.80
**Leucine	7.15±0.38	6.01±0.09	1.10
**Tyrosine	4.56±0.12	6.31±0.26	1.10
**Phenylalanine	6.40±0.28	6.48±0.01	6.30
*Tryptophan	3.18±0.23	3.36±0.21	4.00

*Essential Amino acid
**Values higher than FAO/WHO reference pattern
Mean ± standard deviation

4. CONCLUSION

The proximate composition of the two sweeteners revealed that protein was high. The fruits had low values for lipid, crude fiber and carbohydrate. The values of vitamins obtained in this investigation showed that these fruits are good sources of vitamins A, C and D however, low values were recorded for vitamin E. The fruits contained appreciable amount of essential amino acid contents which was more than fifty percent of total amino acid. Moreover, miracle fruit and serendipity berry are good protein sources as they contained essential amino acid and nonessential amino acid thus, could be used as food supplement and good replacement for sugar.

REFERENCES

1. Reddy CS,Vijayalakshmi, M, Kaul T, Islam T and Reddy MK. Quality of Tomatoes by Expression of Synthetic Gene Encoding Sweet Protein Monellin. Molecular Biotechnology Research Gate, 2015; Doi:10.1007Is 12033-015-9838-5
2. Ravi K. Sweet Protein –Potential Replacement for Artificial Low Calories Sweeteners. *Nutr.* 2005; *J*4:5 1-2
3. Charon C Gioge R and Lorber B. Struture of Thaumatin in a hexagonal Space Group: Comparison of Packing Contacts in Four Crystal Lattices. Acta Crystallogr.2004; 60(pt1) :8 3-5
4. McPerson A, Meickmann J. X-Ray Analysis of New Crystal Forms of the Sweet Protein Thaumatin*. J. Biomol. Struct. Dyn*. 1990; 7(5): 1053-55.
5. Kaneko R, Kitabatake N. Heat t- Induced Formation of Internolecular Disulfide Linkages between Thaumatin Molecules that do not Cysteine Resdues. *J. Agric. Food Chem*. 1990; 49(12): 4950-3
6. Ogta C, Hatada M, Tomlinson G, Shin WC, Kim H. Crystal Structure of the Intensely Sweet Protein Monellin. *Nature.* 1987; 328(6132) : 739-40
7. Menco BP, Hellekant G. Ultrastructural Evidence for a binding Substance to the Sweet –Tasting Protein Thaumatin inside Taste Bud of Rhesus Monkey Foliate Papillae. Micsc. Res Tech. 1993; 26(2):133-39.
8. Farbman AL, Ogden-Ogie CK, Hellekant G, Simmons SR, Albrecht RM, Van Der Wel H. Labeling of Sweet Taste Binding Sites Using a Colloidal Gold- Label Sweet Protein, Thaumatin, *Scanning Micrsc*. 1987; 1 (1): 351-6
9. Zemanek C, Wasserman BP. Issues and Advances in the use of Transgenic Organisms for the Production Thaumatin, the Intensely Sweet Protein from *Thaumatococcus danielli. Crit Rev Food SciNutr*. 1995; 35 (5):455-60
10. Ota M, Sawa A, Nio N, Ariyoshi Y. Enzymatic Ligation for Synthesis of Single-Chain Analogue of Monellin by Transglutaminase. Biopolymers. 1990; 50 (2) :193-6.
11. AOAC (2010) Official Methods of Analysis. 16TH Edition, Association of Official Analytical Chemist. Washington. D.C.
12. Batool F, Sabir SM, Rocha J, Shah AH, Saify ZS, Ahmed SD . Evaluation of antioxidant and free radical scavenging activities of fruit extract from Zanthoxylum alatum: a commonly used spice from Pakistan. Pakistan Journal of Botany, 2010; 42:4299-4311.
13. Umar KJ, Hassan LG, Ado Y. Mineral Composition of Detarium MicroCarpum Grown in Kwatar Kwashi, Zamfara State. *Nigerian Int. J. of Pure Appl. Sci.* 2007; 9120 : 42.
14. Ayoade GW, Amoo IA, Jabar JM, Ojo AM, Maduewuchi CO. Proximate, Minerals and Amino Profile of (*Canarium schweinfuerthii*) Seed pulp. *Int, J. Sci. Tech.* 2017; 6:(1) 658- 660.
15. Mahammed, MU, Kamba AS, Abubakar L, Bagna EA (2010) Nutritional Composition of Pear Fruits (*Pyruscommunis*) *Afr. J. Fd. Sci. Tech*. 2010; 1(3): 78-80
16. Ogoloma UJ, Nkpan KW, Akaninwor JO, Uwakwe, AA. Proximate, Phytochemical and Minerals Elements Composition of Some Edible Fruits Grown in Oil Producing State, Nigeria. *J. Envir. Sci. Tech. Fd. Tech*. 2013; 5(2): 40-43.
17. Uba A, Abdullahi MI, Yusuf AJ, Ibrahim ZYY, Lawal M, Nasir I, Abudullahi FT. Mineral Profile, Proximate and Amino acid Composition of three Dates Varieties *(Phoenix dactylifera. L*.) Scholars Research Library. Der Pharma Chem. 2015; 7 (5) 51-52.

18. Omowunmi SA and Ayoade LA. Nutritional Composition of the Fruit of the Nigerian Wild Date Palm, *Phoenix dactylifera*. *World J. Dairy Fd. Sci*. 8(2) 197-198.
19. Pugatenthi,M., Vadivel, V.A. and Gurumoortyi, P. (2004) Comparative Nutritional Evaluation of Little Known Legumes, *Tamarindus. Indica, Erythima* and *Sesbania.* Tropical Subtropical Agro ecosyst. 2013: 4: 120-2
20. Johnson JI, Lennox JA, Ujong UP, Odey MO, Fila WO, Edem PN, Dasofunjo K. Comparative Vitamins Content of Pulp, Seed and Rind of Fresh and Dried Watermelon (*Citrullus lanatus*). *Int. J Sci Tech.* 2013; 2 (1) 101
21. Sultana P, Dilruba E, Afzal S, Mrityunjoy B, Subed C, Sharma, Golam SJ, Amirul I, Narayan R, Mohammad SS. Nutritional Analysis of Date Fruits (*Phoenix dactylifera* L.) in Perspective of Bangladesh. *American J. Life Sci*. 2015;3 (4) 274-7
22. Kumar D, Paul and Ranajit, Shama K. Nutrients, Vitamins and Mineral Content in Common Citrus Fruits in the Northern Region of Bangladesh. *Pakistan J. Biol. Sci*. 2004; 7 (2) : 240-1
23. Ashakumar A, Parida K, Jaykumar R, Ashok P. Antioxidant Activities, Metabolic Profiling, Proximate Analysis, Mineral Nutrient Composition of *Salvadorapersica* Fruit Unravel a Potential Functional Food and a Natural Source of Pharmacuticals. Frontiers in Pharmacology Ethnopharmacology. 2017; 19-20
24. FOA/ WHO/ UNU. Protein Quality Evaluation. Food and Agricultural Organisation of the United Nation Rome, Italy. 1991
25. Abudayeh ZHM, Lamazian HR, Sereda P, Chekman I, Al-Khaldun II, Azzam MA, and Hassouneh LKM. Comparative Study of Amino acid Composition in the Seed, Pulp and Rind from *Citurllus colocynthis* Fruits. *Int. J. Pharm. Phyt. Reser*. 2016; 8(3); 433-6.