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Study of physicochemical and functional properties of *Dioscorea bulbifera* (tuber) chips and their characterizations

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Abstract
Fresh Aerial yam was purchased from local market of Bilaspur, Chhattisgarh. After the tubers were washed, peeled, sliced they were subjected to two processing methods i.e. Un-blanched Air-frying (UBAF) and Blanching with Air-frying (BAF). Functional and physicochemical properties for Un-blanched Air-fried (UBAF) and Blanched Air-fried (BAF) chips were determined. The chips were grinded, powdered and sieved through 2mm sieve. The Water Absorption Capacity **(**WAC-235.00%), Water Solubility Index (WSI-20.25%),), Oil Absorption Capacity (OAC-46.00%),) and Foam Capacity (FC-25.67%),) was observed higher for flour of BAF chips in comparison to the flour of UBAF chips **(**WAC-167.00%, WSI-18.20%, OAC-44.00%, FC-21.16%). While low Bulk Density (BD) was observed for BAF chips (0.74%) in comparison to the UBAF (0.76%). The values of Carbohydrate, fat, moisture and ash were higher in UBAF chips (78.70%, 1.24%, 50.62%, and 2.10%) in comparison to the BAF (77.50%, 1.41%, 1.80% and 48.78%). On the other hand the values of protein and fibre were observed fairly higher in BAF chips (4.74, 8.54%) than in UBAF chips (4.19, 7.62%). In the present study it was found that the treatment given to chips (BAF) with blanching and Air Frying was very effective and useful in comparison to other treatments as it alters the nutrients in a way that the product becomes more nutritive and tasty.

Keywords: Air fried chips, aerial yam, carbohydrate, moisture content

Introduction
Root and tubers are the most important food crops since time immemorial in the tropics and subtropics. They are herbaceous plants with twine. Approximately 600 *Dioscorea* species are eaten in various parts of the world (Ojinnaka 2017) [16].
Dioscorea bulbifera L. also known as aerial yam, air potato, bulbil bearing yam, turkey liver yam is an under-utilized yam variety. The edible species of *D. bulbifera* are grown in West Africa, the Carribean Islands, South East Asia, South Pacific, Florida, India and West Indies.
Yam (Family – Dioscoreaceae) is found commonly in India. The tubers are crushed and decoction is emulsified into oil, which is used in infected ulcers and sinus. *Dioscorea bulbifera* is a large vine, 6 meters (20ft) or more in length. It produces tubers; the bulbils which grow at the base of its leaves are the important food product. They are about the size of potatoes, weighing from 0.5 to 2kg (1 to 5 lbs). The common names for *Dioscorea bulbifera* are air potato, air yam and bitter yam (Suriyavathana 2011) [21]. The bulbils are brown in colour, hard with yellow mucilaginous flesh; some varieties may need detoxification by soaking or boiling before they are eaten. *Dioscorea bulbifera* is used as food and is a good source of iron, phosphorous and calcium (Ezeocha 2014) [12].
Aerial yam is considered as world's fourth important crop next to potato, cassava and sweet potato. They are herbaceous twining plants belonging to *Dioscoreaceae* and are suggested to have nutritional superiority when compared with other tropical root crops. Presence of resistant starch and absence of gluten makes them good alternative in composite flours with reduced risk of obesity, diabetes or any other allergic diseases like celiac disease (Aathira 2017) [1]. Tubers are also used for the treatment of purgative, deflatulent, aphrodisiac, rejuvenating and tonic anthelmentic, haemorrhoids, scrofula, worm infestations, and general debility and polyuric (Dutta 2015). Dietary PEs (plant estrogens) of *Dioscorea* can provide wide range of health benefits including protection against development of some cancers, osteoporosis, cardiovascular disease, and nephritis, and asthma, used in Preparation of contraceptives and in the treatment of various genetic disorders (Sheikh *et al.*, 2013) [22].
Development of snacks from aerial yam root and tuber crops has become attractive in the light of a search for alternative uses. Root crops are not easily digested in their natural state and should be cooked before they are eaten.

Cooking improves their digestibility, promotes palatability and improves their keeping quality as well as making the roots safer to eat. However, cooking may affect the nutritional composition and phytoconstituents in food (Ezeocha 2012) [11].

Material and Methods

Raw Material and Sample Preparation

Fresh aerial yam *(Dioscorea bulbifera)* was purchased from local market of Bilaspur, Chhattisgarh. After purchasing yam, the material was washed thoroughly in running tap water to remove the adhering soil and extraneous matters. Then some of the tubers were blanched and some were remained unblanched then processed into two types of chips Un-blanched Air-frying (UBAF) and Blanching with Air-frying (BAF) using Air fryer (Fig-1).

Air frying equipment with a nominal power of 1425W was used for frying of aerial yam. A constant frying temperature was confirmed by means of two PT-100 temperature sensors located at the top and the bottom of each fryer. Samples were brushed in the oil on surface of foods in air frying when the initial frying temperature of 120ºC was achieved (Shaker 2015) [20].

Fig 1: Air fryer during frying process

Physicochemical Analysis

The aerial yam chips were powdered and stored under refrigerated condition for physicochemical analysis. Physicochemical analysis for moisture and ash was carried out following the procedures of AOAC (Anonymous 2005) [5], carbohydrate by sulphuric acid phenol method using UV VIS Spectrophotometer, fat content was determined by Soxhlet method (AOAC 1998) [6], and crude fibre was determined by the Weende method as described by James and protein by micro-Kjeldahl method.

Evaluation of Functional Properties

Water Absorption Capacity (WAC) and Water Solubility Index (WSI): The water absorption capacity and solubility index of UBAF and BAF chips flours of *Dioscorea bulbifera* were evaluated according to Phillips *et al.* (1988) [19] and Anderson *et al.* (1969) [4] methods respectively.

Oil Absorption Capacity (OAC): The oil absorption capacity of UBAF and BAF chips flours from *Dioscorea bulbifera* was evaluated according to Eke and Akobundu (1993) [10] methods.

Foam Capacity (FC) and Foam Stability (FS): The foam capacity and stability of UBAF and BAF chips flour from *Dioscorea bulbifera* were studied by the method of Coffman and Garcia (1977) [7].

Bulk density (BD): The method described by Oladele and Ainaby (2007) was used for the determination of bulk density.

Textural analysis

The aerial yam chips samples were subjected to textural analysis using Testometric Universal Testing Machine (Serial No. 500 – 689; Capacity – 25KN). They were fractured to complete failure in the three-point bending as described by Vincent. Specifically, parameters such as force at peak, energy at peak, deformation at peak and deformation at break were determined (Oluwole *et al.*, 2014) [18].

Colour analysis

The organic filtrate obtained was used to determine color by taking the absorbance at wavelength of 520 nm on a spectrophotometer (Obadina *et al.*, 2014) [15].

Sensory evaluation

The processed aerial yam chips were subjected to sensory evaluation. Scoring difference test and hedonic scale test was used in measuring the overall acceptability of the aerial yam chips colour, taste and texture. As described by Ihekoronye and Ngoddy, (1985) [13].

Statistical analysis

All analyses were carried out in triplicates and the data were subjected to one-way analysis of variance (ANOVA).

Result and Discussions

Table 1: Physico-chemical characteristics of differently treated chips of Dioscorea bulbifera i.e. Un-blanched Air-fried (UBAF) and Blanched Air-fried (BAF).

Proximate analysis (%)						
Treatments	**Moisture**	**Ash**	**Carbohydrate**	**Protein**	**Fat**	**Fibre**
UBAF	50.62 ± 0.09	02.10 ± 0.33	78.70 ± 0.09	4.19 ± 0.18	1.24 ± 0.01	7.62 ± 0.26
BAF	48.78 ± 0.09	01.80 ± 0.36	77.50 ± 0.13	4.74 ± 0.29	1.41 ± 0.01	8.54 ± 0.23
Mean ± SD	49.70± 0.75	1.95 ± 0.12	78.10 ± 0.48	4.46 ± 0.22	1.32 ± 0.06	8.08 ± 0.37
F - Value	352.73	1.44	104.48	4.90	78.83	13.68
C. D.	0.27	N/A	0.33	N/A	0.05	0.70
SE(m)	0.06	0.17	0.08	0.15	0.01	0.17

The UBAF chips had the higher values for moisture (50.62%), followed by BAF (48.78%). The moisture content reflects the quantity of solid matter present and the rate of spoilage is also closely related to the amount of moisture present (Sanfal *et al*., 2013), thereby showing that the BAF chips has low spoilage capacity owing to its low moisture content. Ash, which reflects the mineral content in food, differed for the treatments given to the Aerial yam chips and

was highest in UBAF (2.10%) than BAF (1.8%) (Table 1). The levels of ash in these chips indicated that they could serve as a fairly good source of dietary minerals. Methods adopted in present study have not much effect on the level of carbohydrate. Blanching has reduced the carbohydrate and fat content more in BAF (77.5%, 1.41%) than UBAF (78.7%, 1.24%). Higher protein and fibre in BAF chips (4.74, 8.54%) in comparison to UBAF chips (4.19, 7.62%) also indicates the enhancement of nutritive properties of the BAF chips.

Table 2: Sensory Evaluation of differently treated chips of Dioscorea bulbifera i.e. Un-blanched Air-fried (UBAF) and Blanched Air-fried (BAF).

Sensory Evaluation %				
Treatments	**Texture**	**Colour**	**Crispness**	**Overall acceptability**
UBAF	8.10 ± 0.14	6.87 ± 0.19	8.50 ± 0.26	7.82 ± 0.69
BAF	7.60 ± 0.14	8.95 ± 0.15	8.99 ± 0.18	8.51 ± 0.64
Mean ± SD	7.85 ± 0.20	7.91 ± 0.84	8.74 ± 0.20	8.16 ± 0.28
F-Value	11.14	139.85	4.68	1.06
C.D.	0.42	0.50	N/A	N/A
SE(m)	0.10	0.12	0.16	0.47

For overall acceptance of the Air fryer chips products, the panellists ranked the blanched aerial yam air fryer chips as the most preferred product with a score of 8.51. This was however not statistically different from the 50% UBAF aerial yam chips which were scored an average of 7.82. Development of a crispy, crunchy and crackly texture is one of the distinct properties of fried food products and considerably affects overall acceptability. Results showed that crispness is higher for flour of BAF chips (8.99%) in comparison to UBAF (8.50%) chips.

Table 3: Functional properties of flour made-up of differently treated chips of *Discorea bulbifera* i.e. Un-blanched Air-fried (UBAF) and Blanched Air-fried (BAF).

Functional Properties (%)					
Treatments	**WAC**	**WSI**	**OAC**	**FC**	**BD**
UBAF	167 ± 0.17	18.20 ± 0.18	44 ± 0.21	21.16 ± 0.25	0.76 ± 0.02
BAF	235 ± 0.28	20.25 ± 0.14	46 ± 0.24	25.67 ± 0.55	0.74 ± 0.02
Mean ± SD	201 ± 27.76	19.22± 0.83	45 ± 0.81	23.41 ± 1.84	0.75 ± 0.00
F - Value	81,601.75	148.19	75.00	110.08	0.85
C. D.	0.67	0.48	0.65	1.22	N/A
SE(m)	0.16	0.11	0.16	0.30	0.01

*WAC- Water absorption capacity
*WSI- Water solubility index
*OAC- Oil absorption capacity
*FC- Foaming capacity
*BD- Bulk density

The WAC is the ability to absorb or retain water. The WAC was observed higher for flour of BAF chips (235.00%) in comparison to the flour of UBAF chips. The water solubility index (WSI) reflects the extent of starch degradation (Diosady *et al.,* 1985) [8]. The WSI is observed high for flour of BAF chips (20.25%) in comparison to UBAF chips (18.20%). The OAC is an important property in food formulation because fats improve the flavor and mouth feel of foods (Kinsella, 1976). The OAC is observed high for flour of BAF chips (46.00%) in comparison to UBAF chips (44.00%). Foams are used to improve texture, consistency and appearance of foods (Akubor, 2007). Results showed that foam capacity (FC) is higher for flour of BAF (25.67%) in comparison to UBAF chips (21.16%). Bulk Density gives an indication of the relative volume of packaging material required. In the present research BD determined for UBAF and BAF chips is 0.76 and 0.74%. Low BD of flours are good physical attributes when determining transportation and storability since the products could be easily transported and distributed to required locations.

Conclusions

The result of this study indicated that blanching and air frying affected significantly the functional properties of aerial yam chips (*Dioscorea bulbifera*). Blanching and air frying has reduced the carbohydrate content in both UBAF (78.7%) and BAF chips (77.5%). In this study it was found that the treatment given to chips (BAF) with blanching and Air Frying was very effective and useful in comparison to other treatments because it alters the nutrients in the way that the product become more nutritive and tasty. The processed aerial yam chips have a lot of potential in ready to eat foods. The high WAC of the processed yam chips was good providing agent and can thus be used as a thickener or gelling agent in various food products. The comparatively low values of carbohydrate, sodium, bulk densities as well as the high water solubility of the chips (BAF) are indicative of highly digestive nature of the product. So, aerial yam chips, aerial yam chips (BAF) would be very digestive and useful for kids and for every age people. However blanching ameliorates better functional properties of aerial yam chips than un-blanched plus air fried chips. The surpassed of air-fried potato strips in hardness and oiliness may be due to low oil uptake that improve the taste, colour, crispness and overall acceptability of aerial yam chips. Tubers are reported to possess a good source of starch, high protein digestibility, physico-chemicals, and other nutrients. Processing helps to enhance the acceptance of the tubers. Converting these tubers into other value added products may add to the best utilization of tubers as functional and health foods (Aigal SS *et al.,* 2017) [2].

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