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Sensory characteristics and acceptability of air potato *Dioscorea bulbifera* L. bulbils products

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Abstract

Air potato, *Dioscorea bulbifera* L., bulbils are known to contain primary metabolites such as ash, carbohydrates, crude fiber, lipid, moisture and protein. It also exhibited secondary metabolites: anthrones, anthraquinones, coumarins, essential oils, fatty acids, flavonoids, phenols, steroids, tannins and triterpenes. Cytotoxicity analyses also revealed its non-toxic nature and thus, safe to be consumed. These scientific data were the bases for developing products for maximum utilization of the crop for household consumption and additional income generation through cultivation. This study focused on the sensory characteristics and acceptability of the identified products of air potato (AP) bulbils for consumption and adoption by farmers. It used the descriptive research design. A researcher-made questionnaire was used as the instrument for gathering the data needed. The data were analyzed using the Hedonic scale, frequency count and mean. The findings showed that air potato halaya (jam) and ice cream were liked and accepted extremely; air potato polvoron and maja (white pudding) were liked and accepted very much; air potato chips and flour were liked and accepted moderately. Air potato flour, mainly the ingredient for polvoron and maja, was slightly liked and accepted due to its bitterness. These evaluations revealed that air potato bulbils when adequately nurtured and prepared can be a vital aid for family consumption, additional livelihood and a cheap rich nutritious source of raw materials. Thus, these significant results strongly recommend air potatoes for cultivation and promotion of the diversity and conservation of their species.

Keywords

Air potato products, flour, general acceptability, ice cream, sensory evaluation

Introduction

Air potato, *Dioscorea bulbifera* L., belongs to the family Dioscoreaceae. It is an herbaceous vine that sprouts from underground or aerial stems/ tubers/ bulbils. The stem of the plant grows up to 70 feet in length and is round or slightly angled in cross-section and counter-clockwise formation (1). The heart-shaped leaves are alternately arranged along the stem which is attached to long stalks and can grow at least 8" long. It fruits robustly in a ruggedly round shape. It has aerial bulbils of 10-15 pieces per vine with 5 cm to 30 cm width and height. Its fruit can weigh more than 50 g to 1 kg. Its tubers are known to be bitter and poisonous (2, 3). Species of the *Dioscorea* genus are twinning herbaceous to woody edible single or clustered tubers called yams (4, 5). This crop is widely naturalized and cultivated in tropical and

subtropical areas in America, West Indies and the Pacific Islands. But other authors believed it is a native of Asia and subsequently introduced in Africa (6-8). Aerial yam is bitter but edible sweet, pungent, slimy and greenish when peeled, which gives a non-appealing appearance that led to the belief of being toxic ((9-12). The tropical yam family requires less management and input once grown (13).

Scientific analyses showed air potato bulbils contain primary metabolites such as total ash, moisture, carbohydrates, fibers, lipids and proteins (14-18). These primary metabolites are required for the growth and maintenance of cellular functions. The extraction of these primary metabolites is much easier than secondary metabolites (19, 20). They are important constituents of daily diet both for plants and animals because of their involvement in maintaining normal and essential physiological processes for proper growth, development and reproduction. But deficiency of one constituent may lead to abnormalities.

Air potato (AP) bulbils also exhibited some secondary metabolites such as anthrones, anthraquinones, coumarins, essential oils, fatty acids, flavonoids, phenols, steroids, tannins and triterpenes (21, 22). It also contains some minerals and elements (23, 24). Secondary metabolites are not required for cellular functions but are the by-products of primary metabolism for the ecological and other activities of the cell. These substances increase the fitness of the producing organisms and decrease the fitness of the surrounding organism. However, some of these are poisonous to animals, plants and microorganisms.

Studies also showed that air potato bulbils were not toxic (25-30). However, the presence of alkaloids, oxalates and saponins at high concentrations in yam, makes it poisonous and inedible. Emphasis on the manner of cooking this species would reduce its characteristics to be toxic. Scientifically, the absences of these in the samples contribute to their edibility and non-poisonousness.

Air potato has been known to produce a volume of aerial bulbils and ground tubers. These tubers contain nutrients and secondary metabolites and are edible with proper preparation. Thus, this study was conceptualized based on the above background. The results of the study served as baseline data to widen the awareness of this resilient crop as a good source of raw material for product development. Hence, farmers and the community must adopt the crop for cultivation.

The main objective of this project was to develop food products from analyzed air potatoes in Quirino, Nueva Vizcaya and nearby provinces in the country for cultivation and consumption. It aimed to determine the sensory characteristics and level of acceptability of air potato chips, flour, halaya, ice cream, maja and polvoron, in terms of appearance, taste, texture, mouth feel, aroma and general acceptability.

Materials and Methods

This study used descriptive research. It described the present status of the sensory characteristics and acceptability of air potato products. Some of the data used were based on the results of interviews with the individuals who had encountered air potato as an underutilized backyard crop and the documented laboratory analyses found in the Introduction part, paragraphs 2-4 supported by published research. There was a need to use this information as it was a localized material within the locale of the study and even in other parts of the Philippines. The conceptual process and determination of results is given in Fig. 1. The images of the raw material is also provided (Fig. 3).

Research Environment

The samples were gathered from Nueva Vizcaya and Quirino. The product development procedures were conducted at the

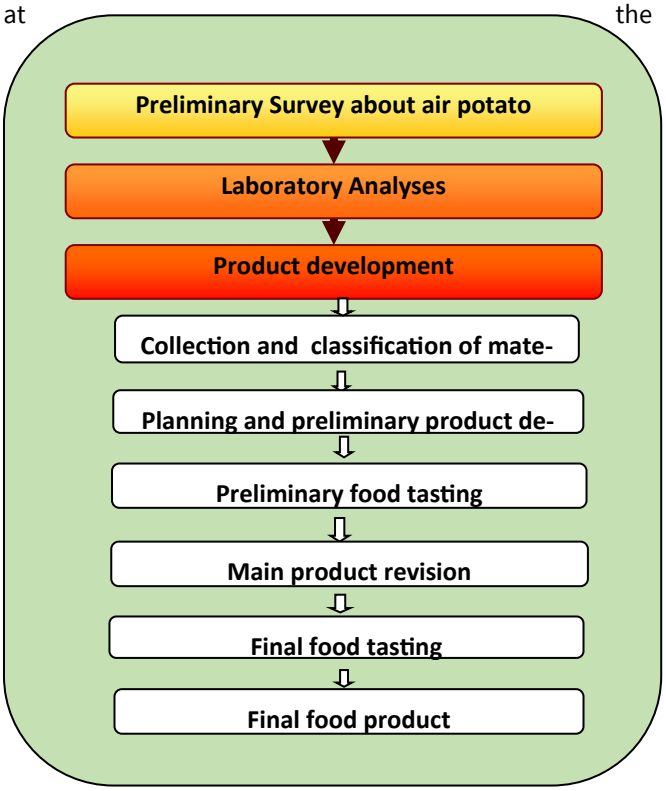


Fig. 1. Conceptual process of the study.

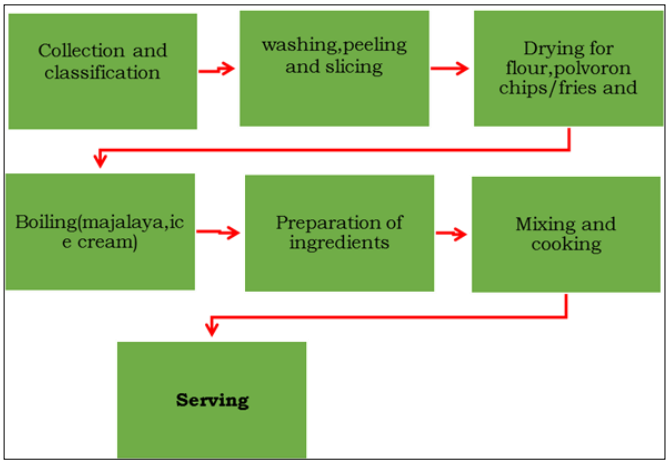
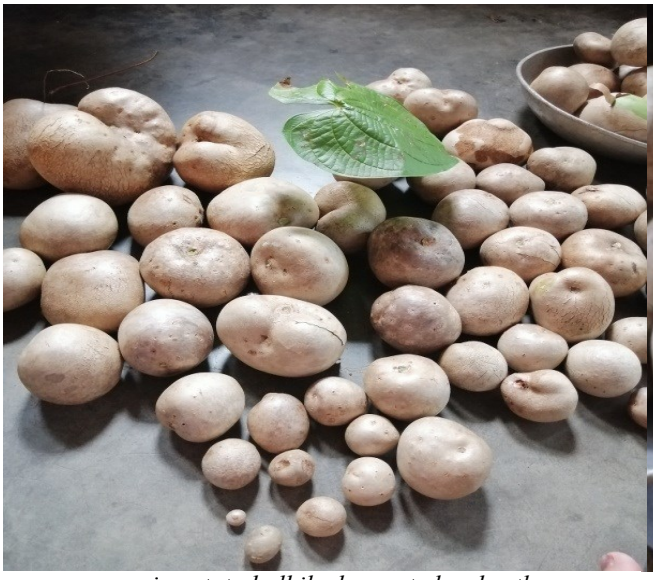


Fig. 2. General flowchart of procedure for each product.

College of Agriculture, Forestry and Engineering, Chemistry Laboratory, Diffun, Quirino. It was done within

heart shaped leaves of air potato

air potato bulbil growing



air potato bulbils harvested robustly

air potato bulbils when mature

air potato bulbil sprout

air potato bulbils ready for planting

Fig. 3. Images of air potato, *D. bulbifera* L. bulbils.

the bounds of the protocols of sensory analyses.

Research Instrument

A researcher-made questionnaire was used as the instrument for gathering the data needed. The data were analyzed using the Hedonic scale, frequency count and mean.

Data Gathering Procedure and Analyses

The respondents were students and faculty members from the different departments of the college. Among the 171 evaluators, there were professional and trained food tasters. The following considerations were followed for the selection of an evaluator.

Prior to evaluation, the taster a) must not be a smoker; b) must not be chewing for at least 2 hrs; c) must not have artificial teeth, and d) must not be using perfumes and smelling spicy ingredients. It was ensured that the principles of sensory evaluation for food were followed. The panel of tasters underwent a short briefing about the research prior to evaluation. The general flowchart of the procedure for the development of each product is given in Fig. 2.

Hedonic scale

The 9-point Hedonic scale (31) was modified and used to determine the degree of likeness and general acceptability of the products (Table 1).

The preparation and evaluation followed the procedures as a) collection and classification of the bulbils in terms of the same size and weight; b) planning for the preliminary formulation of the products including the ingredients and materials needed; c) preliminary food tasting which included the freshness of the materials, the product developed, the evaluator's readiness and testing area; d) main product revision, the results of treatments/variations were the bases for the final food tasting; e) final tasting included the final food tests to determine the sensory characteristics and general acceptability of the products; and f) formulation of the final food product after the analyses.

Table 1. Hedonic Scale

Scale	Range	Description	
		Sensory Evaluation	General Acceptability
9	7.89-8.72	Like extremely	Extremely acceptable
8	7.02-7.87	Like very much	Accepted very much
7	6.16-7.01	Like moderately	Moderately accepted
6	5.30-6.15	Like slightly	Accepted slightly
5	4.44-5.29	Neither like nor dislike	Neither accepted nor accepted
4	3.58-4.43	Dislike slightly	Slightly not accepted
3	2.72-3.57	Dislike moderately	Not accepted slightly
2	1.86-2.71	Dislike very much	Not accepted very much
1	1.00-1.85	Dislike extremely	Extremely not accepted

Results and Discussion

Sensory Evaluation of air potato chips and flour

This part presented the data gathered in tabular and textual form, the analysis and interpretation of the data were based on the results of the evaluation. Table 2 showed the mean distribution of the sensory characteristics and acceptability of air potato chips and flour.

It was shown that air potato chips' sensory characteristics such as appearance (mean=6.95), texture(6.83), aroma (6.56), mouth feel(6.37) and taste (6.35) were liked moderately and accepted moderately (6.71). The light yellow appearance was common for chips. Its aroma was likened to freshly baked bread with a soft powdery texture.

For air potato flour, its golden brown appearance (7.44) and smooth texture (7.07) were liked very much. Its aroma (6.05), mouth feel (5.91) and taste (5.81) were liked slightly because of the bitter taste and were accepted moderately (6.49). This flour was used in the maja and polvoron products also. But the mouth feel and taste left a bitter taste which was liked the least. The bitterness of the bulbils when not boiled was a common taste for all the air potato yams being studied today.

Although, various types of research showed that air potatoes are best suited for cooked applications such as frying, sautéing and roasting it should be treated and prepared like a yam. It carries a bitter flavor and slimy texture when raw. Therefore, it is recommended to boil the bulbils for 15 min until tender to reduce their bitterness (32).

Soaking the bulbils with brine solution for five minutes minimize the sliminess. But did not totally remove its bitterness. It even added to the saltiness of the product. Because of this, it was recommended by a trained evaluator not to totally soak instead just rinse with the brine to prevent the salty after taste. Nevertheless, the bitterness was acceptable for some evaluators.

In Florida, USA, there were some wild, uncultivated varieties of air potato that cannot be consumed due to their toxic nature. So, caution and research should be taken into consideration prior to consumption. In contrast, cultivated air potatoes, from Asia like in Japan, are popular for making Okonomiyaki, a Japanese-style pancake that uses a variety of ingredients. Additionally, air potatoes were added to miso soups, curry, tempura and Nimono, which is a Japanese-style simmered dish. This can be because air potatoes stay fresh for a couple of weeks when loosely wrapped and stored in a cool, dry and dark place.

Air potato flour's ash content (2.51%) was highest among wheat and cassava, in terms of fat (1.90%), fiber (1.80%) and protein content (3.09%). It was second to wheat; highest in calcium (52.40 ppm) and sodium (29.81 ppm); potassium (32.21 ppm), second to wheat (33-36). The flours were generally less than 2.0 ppm in Manganese and Zinc contents. This revealed the suitability of air potato to be an accepted ingredient for bread as composite flour (37-48).

It must be noted also that specific volume, elasticity, texture, and starch digestibility in the bread depends on the flour variety mixture. Like for chips, in different potato cultivars, the moisture content, oil uptake, fracture force and processes of blanching and frying temperature

Table 2. Mean distribution of the acceptability of the sensory characteristics of air potato chips and flour

Treatment	Chips						Flour					
	App	Tas	Tex	Mf	Aro	GA	App	Tas	Tex	Mf	Aro	GA
T1 Unsoaked with brine	6.95	6.35	6.83	6.36	6.56	6.71	7.44	5.80	7.07	5.91	6.05	6.45
T2 Soaked with-brine	6.95	6.35	6.84	6.37	6.56	6.71	7.44	5.81	7.07	5.92	6.05	6.45
Grand Mean	6.95	6.35	6.83	6.37	6.56	6.71	7.44	5.81	7.07	5.91	6.05	6.45
Qualitative De-scription	Like Moder-ately	Like Moder-ately	Like Moder-ately	Like Moder-ately	Like Moder-ately	Accept Moder-ately	Like Very Much	Like Slight-ly	Like Moder-ately	Like Slight-ly	Like Slight-ly	Accept Moder-ately

Appearance—Ap, Taste - Tas, Texture - Tex, Mouth feel - MF, Aroma—Ar, General Acceptability - GA

affect its quality (49-51). AP then is another cheap and good source for these industries.

Sensory Evaluation of air potato halaya (jam) and ice cream

Table 3 revealed that air potatoes when made into halaya (jam) and ice cream were liked extremely. In terms of its taste (mean=8.37), appearance (8.23), mouth feel (8.18), aroma (8.12), and texture (7.91). With the change in the amount of sweetener (cream) in treatment 2, it showed that it was better to reduce the sweets so that the air potato component would be more elaborated. Air potato when freshly boiled was milky in texture and its sliminess and bitter taste would be removed. Although, during the preliminary preparation, AP bulbils were boiled and smashed while in the final stage, they were boiled and ground, it was still accepted extremely.

For the AP ice cream, the taste (8.49), mouth feel (8.40), texture (8.35), appearance (8.31), and aroma (8.28), were liked extremely and accepted extremely. To maintain its best sensory characteristics then, it was recommended that it should be kept at a temperature that would balance all the components.

The most widely used raw materials for producing jams and ice creams were sweet potatoes. Organoleptic studies showed that ice cream batata products were acceptable with consistent colors. Studies showed that sweet potatoes contained high anthocyanin compounds by steaming (52-55). Ingredients ratio and type of stabilizers affect the texture, viscosity, aroma and acceptability of ice cream products. Fortunately, this was also true for air potato jam and ice cream too (56).

With this regard, there were no published studies yet regarding this type of food application of air potato as far as the researcher was concerned at the moment of study.

Sensory Evaluation of air maja (white pudding) and polvoron

Table 4 showed that air potato maja (white pudding) was liked very much of taste (mean=7.79); mouth feel (7.70), aroma (7.64), texture (7.30) and appearance (7.07). Since the bulbils were boiled, the bitterness was removed and blended evenly with the ingredients. The consistency of its appearance and texture was attributed with the added starch which served as a binder for all the ingredients (57).

The study also revealed that air potato polvoron was liked extremely in terms of its golden brown appearance (8.08). Its aroma (7.61), texture (7.47), taste (7.37) and mouth feel (7.29) which blended nicely with the butter were liked very much. Although, there was the presence of a bitter end taste, it was still very much accepted. To emphasize the air potato content, an additional cup of AP potato was added, as per recommendation by the evaluators.

Table 3. Mean distribution of the acceptability of the sensory characteristics of air potato halaya and ice cream

Treatments	Halaya						Ice cream					
	App	Tas	Tex	Mf	Aro	GA	App	Tas	Tex	Mf	Aro	GA
T1												
500g air potato and 4 nestle cream	8.22	8.37	7.91	8.18	8.11	8.23	8.30	8.491	8.35	8.40	8.27	8.39
T2												
500g air potato and 3 nestle cream	8.24	8.38	7.92	8.19	8.14	8.25	8.32	8.50	8.36	8.41	8.28	8.34
Grand Mean	8.23	8.37	7.91	8.18	8.12	8.24	8.31	8.49	8.35	8.40	8.28	8.39
Qualitative Description	Like Extreme-ly	Like Ex-tremely	Like Ex-tremely	Like Ex-tremely	Like Ex-tremely	Accept Ex-tremely	Like ex-tremely	Like Extreme-ly	Like Extreme-ly	Like Ex-tremely	Like Ex-tremely	Accept Ex-tremely

Appearance—Ap, Taste - Tas, Texture - Tex, Mouth feel - MF, Aroma—Ar, General Acceptability - GA

Table 4. Mean distribution of the acceptability of the sensory characteristics of air potato maja and polvoron

Treatments	Maja						Treatments	Polvoron					
	App	Tas	Tex	MF	Aro	GA		App	Tas	Tex	MF	Aro	GA
T1 5og cornstarch	7.06	7.79	7.30	7.70	7.64	7.59	T1 1 cup air potato	8.08	7.37	7.47	7.28	7.60	7.46
T2 100g cornstarch	7.08	7.80	7.30	7.70	7.64	7.59	T2 2 cups air potato	8.08	7.37	7.48	7.29	7.61	7.47
Grand Mean	Like Very Much	Like very much	Like very much	Like very much	Like very much	Accept very much	Grand Mean	8.08	7.37	7.47	7.29	7.61	7.47
Qualitative Description	Like Very Much	Like very much	Like very much	Like very much	Like very much	Accept very much		Like extremely	Like very much	Like very much	Like very much	Like very much	Accept very much

Appearance—Ap, Taste - Tas, Texture - Tex, Mouth feel - MF, Aroma—Ar, General Acceptability - GA

Potato flavor results from the combination of taste, aroma and texture. Flavor precursors synthesized by the plant are present in raw potatoes which consist mainly of sugars, amino acids, RNA and lipids. Plant genotype, production and storage environment influence the levels of these compounds and the enzymes that react with them to produce flavor compounds.

During cooking, flavor precursors react to produce the Maillard reaction compounds that contribute to flavor. The identification of major flavor compounds is important for breeders to make gains in the selection of enhanced flavors (58-59).

Because of air potato's low dependence on external supplies, high plasticity, resistance to pests and diseases and high durability in stock, it has attributes to become a plant resource that can contribute to improving the food security of communities (60).

As to the researcher's knowledge and time of study was concerned, there were no published studies yet regarding this type of food application of air potatoes.

Conclusion

Air potato bulbil products such as halaya (jam) and ice cream were liked and accepted extremely. While AP maja (white pudding) and polovoron, were liked and accepted very much. Moreover, AP chips were liked and accepted moderately while AP flour was liked slightly and accepted moderately. The products were evaluated according to sensory characteristics: appearance, taste, texture, mouth feel and aroma. As for air potato chips and flour, there were no initially published studies as to their food applications. Further, air potato halaya, ice cream, maja and polvoron there were no conducted studies published yet as far as the researcher's knowledge was concerned up to this time.

With the above significant findings that this crop must be cultivated and adopted. This indigenous crop is a rich and cheap alternative source of food nutrients for human consumption. These findings are bases for farmers' search for alternative crops for additional income generation through product development and in its humblest way, aid in the world's food crisis.

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Compliance with ethical standards

Conflict of interest: The author does not have any conflict of interest to declare.

Ethical issues: None.

References

1. Plants. Air potato facts. [Internet] [cited 2019 Aug 11]. Available from: https://www.softschools.com/facts/plants/air_potato_facts/2647/
2. Stuart G. Philippine Alternative Medicine (PAM).Updated 2014. [Internet]. [cited 2019 Aug 15]. Available from: http://stuartxchange.com/AltMed.html
3. Center for Aquatic and Invasive Plants Archive. Florida Invasive Plant Education Initiative, University of Florida. *Dioscorea bulbifera*. [Internet]. [cited 2019 Sept 18]. Available from: https://plants-archive.ifas.ufl.edu/plant-directory/dioscorea-bulbifera/
4. Air Potato Task Force Florida Exotic Pest Plant Council. Air potato management plan. Biology of air potato. [Internet].2008 [cited 2019 Aug 11]. Available from: https://www.fleppc.org/Manage_Plans/AirpotatoManagementPlan_Final.pdf
5. Acevedo-Rodriguez P. [Internet]. 2005. [cited 2021 October 20].Vines and climbing plants of Puerto Rico and the Virgin Islands. Smithsonian Inst., Contr. US Nat. Herb., 51: 1-483. Available from: http://botany.si.edu/antilles/westindies/catalog.htm
6. Sandoval JR, Ackerman JD, Tremblay RL et al. Island biogeography of native and alien plant species: contrasting drivers of diver-

sity across the Lesser Antilles. Diversity and Distribution. 2020;26 (11):1539-50. [Internet]. [cited 2021 Oct 8]. Available from: https://onlinelibrary.wiley.com/doi/10.1111/ddi.13139

7. Overholt WA, Hughes C. Wallace C, Morgan EC. Origin of air potato identified [Internet]. 2003.[cited 23 October 2021]. (PDF | 99 KB) Wildlands Weeds 7:9. Available from: https://www.invasivespeciesinfo.gov/terrestrial/plants/air-potato; https://www.se-eppc.org/pubs/ww/airpotatoWinter2003.pdf

8. Invasive Species Specialist Group. *Dioscorea bulbifera* L. Global Invasive Species Data Base. University of Auckland. 2012 [cited 2019 Aug 11]. Available from: http://issg.org/database/species/ecology.asp?si=1220&ver=print

9. Wheeler G, Pemberton R, Raz L. A biological control feasibility study of the invasive weed-air potato, *Dioscorea bulbifera* L. (Dioscoreaceae): an Effort to Increase Biological Control Transparency and Safety. [Internet]. 2009. [cited 2021 October 5]. Available from: Natural Areas Journal 27 (Jul 2007):269-279. https://doi.org/10.3375/0885-8608(2007)27 269:ABCFSO]2.0.CO;2

10. Gucker CL. *Dioscorea* spp. In: Fire Effects Information System. 2009. [Internet]. [cited 2021 October 10]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available from: https://www.fs.fed.us/database/feis/plants/vine/diospp/all.html

11. Rayamajhi MB, Pratt PD, Tipping PW, Lake E, Smith M , Rohrig E, Dray FA, Center TD. Seasonal growth, biomass allocation and invasive attributes manifested by *Dioscorea bulbifera* L. (Air-potato) plants generated from bulbils in Florida. 2016. [Internet]. [cited 2021 September 25]. Invasive Plant Science and Management, 9(3):195-204. Published By: Weed Science Society of America Available from: https://doi.org/10.1614/IPSM-D-16-00022.1

12. Toensmeier E.Perennial vegetables./air potato.[Internet].[cited 2019 Sept 23].Available from: https//:www.chelseagreen.com

13. Butangon RA, Ehhal EB, Padayao OP. Evaluation of nutritional composition, secondary metabolites and cytotoxicity of air potato (*Dioscorea bulbifera*) bulbils. 2017.[thesis]. Bambang: Nueva Vizcaya State University

14. Wekesa MN, Okoth M, Abong G, Muthoni J. Effect of soil characteristics on potato tuber minerals composition of selected Kenyan varieties. 2014. [Internet]. Journal of Agricultural Science 6(12). Available from: https://doi.org/10.5539/jas.v6n12p163

15. Achy JY, Koffi PKB, Ekissi GSE, Konan HK, Koaume LP. Assessment of physico-chemical properties and anti-nutritional factors of flour from yam (*Dioscorea bulbfera*) bulbils in Southeast Cote D' Ivoire. [Internet]. 2016 [cited 2019 Nov 5]; 12:871-887. Available from: https://doi.org/10.21474/IJAR01/2468

16. Adeosun OM, Arotupin DJ, Toba OA, Adebayo AA. Antibacterial activities and phytochemical properties of extracts of *Dioscorea bulbifera* Linn. (Air potatoe) tubers and peels against some pathogenic bacteria. [Internet]. 2016 [cited 2019 October 11]; 5(105)21-26. Available from: http://www.phytopharmajournal.com/Vol5_Issue1_05.pdf

17. Ojinnaka MC, Okudo H, Uzusike F. Nutrient composition and functional properties of major cultivars of aerial yam (*Dioscorea bulbifera*) in Nigeria. Food Science and Quality Management. [Internet].2017[cited 2019 October 25]. Available from: https://core.ac.uk/download/pdf/234684562.pdf

18. Oden C. Nutritional value of *Dioscorea bulbifera* (aerial yam). [Internet].[cited Aug 2019 25]. Available from: https://www.projecttopics.org/nutritional-value-dioscorea-bulbifera-aerial-yam.html

19. Khan Arifa, Erum Shazia, Riaz Naveeda, Ghafoor Abdul, Khan Farhat Ali. Evaluation of potato genotypes for yield, baked and organoleptic quality. 2019. [Internet]. [cited 25 Sept 2021]. Sarhad Journal of Agriculture. Dec 2019; Vol. 35(4):1215-23. 9p. Knowledge Bylanes. Available from: https://web.p.ebscohost.com/abstract

20. Bolaniran T, Ogidi CO, Akinyele BJ. Nutritional value and safety of air potato *Dioscorea bulbifera* L. fermented with *Pleurotus ostreatus* and *Calocybe indica*. [Internet]. 2019. [cited 2021 October 10];6(13) p.467. Available from: https://doi.org/10.21472/bjbs.061314

21. Center for Agriculture and Bioscience International. Herbs: treat and tastier potatoes (*Dioscorea bulbifera*) information: health benefits and uses of air potatoes. [Internet]. 2019. [cited 18 Sept 2019]. Available from: https://www.cabi.org/tag/centre-for-agriculture-and-biosciences-international

22. Ogbuagu MN. Nutritive and anti-nutritive composition of the wild (in-edible) species of *Dioscorea bulbifera* (potato yam) and *Dioscorea dumentutorum* (bitter yam). [Internet]. 2008 [cited 2019 October 30]; 6:224-26. Available from: https://medwelljournals.com/abstract/?doi=jftech.2008.224.226

23. Subramanian NK, White PJ, Broadley MR, Ramsay G. The three-dimensional distribution of minerals in potato tubers. 2011. [Internet]. [cited 2021 August 29]. Available from107(4): 681 https://doi.org/10.1093/aob/mcr009

24. Osukoya OA, Kuku A. Physicochemical, enzymatic and molecular characterisation of the storage protein of aerial tuber, *Dioscorea bulbifera* Linn. 2020. [Internet] [cited 2021 August 30]. Available from: https://doi.org/10.1186/s43141-020-00040-y

25. Gutierrez RV. 2021. Nutritional, phytochemical and cytotoxicity analyses of air potato *Dioscorea bulbifera* L. bulbils. [Internet] [cited 29 August 2021]. Available from: https://doi.org/10.14719/pst.2021.8.2.1064

26. Salem SJ. Sensory Characteristics and acceptability of banana Pseudo stem sisig in varying amount of coconut milk. QSU. unpublished. 2018.

27. Bishwa B, Kundu KV, Ayesha F, Devendra KP, Vijay K. *Dioscorea bulbifera* L. (Dioscoreaceae): A review of its ethnobotany, pharmacology and conservation needs. [Internet]. 2020. [cited 30 Oct 2020]. Available from: https://doi.org/10.1016/j.sajb.2020.07.028

28. Adeosun OM, Arotupin DJ, Toba OA, Adebayo AA. Antibacterial activities and phytochemical properties of extracts of *Dioscorea bulbifera* Linn. (Air potatoe) tubers and peels against some pathogenic bacteria. [Internet]. 2016 [cited 2019 October 11];5(105)21. Available from: http://www.phytopharmajournal.com/Vol5_Issue1_05.pdf

29. Butangon RA, Ehhal EB, Padayao OP. Evaluation of nutritional composition, secondary metabolites and cytotoxicity of air potato (*Dioscorea bulbifera*) bulbils. [thesis]. Bambang: Nueva Vizcaya State University; 2017.

30. Afiukwa CA, Igwe OD. Comparative nutritional and phytochemical evaluation of aerial and underground tubers of air potato (*Dioscorea bulbifera*) available in Abakaliki, Ebonyi State, Nigeria. [Internet]. 2015 [cited 2019 Aug 20]. Available from: https://doi.org/10.9734/BJAST/2015/20249

31. Lim J. Hedonic scaling: A review of methods and theory. 2011. [Internet]. 2015 [cited 2021 Aug 20]. Available from https://doi.org/10.1016/j.foodqual.2011.05.008

32. Bolaniran T et al. Sensory evaluation of bread produced with composite flour fermented by Baker's yeast in Akure, Nigeria. Asian Journal in Agricultural Research. 2017;ISSN:2456-8864.

33. Jimenez-Mo M, Martinez A. Morpho-agronomic evaluation of air potato (*Diosocrea bulbifera* L.) in Panamaa. 2016;37:14-21.

34. Kumar S, Das G, Shin HS, Patra JK. *Dioscorea* spp. (A wild edible tuber): A study on its ethnopharmacological potential and traditional use by the local people of Similipal Biosphere Reserve, India. [Internet]. 2017. [cited 20 Sept 2019];8:52. Available from: https://doi.org/10.3389/fphar.2017.00052

35. Guevarra BQ, Claustro AD, Madulid RS, Aguinaldo AM, Espeso EI, Nonato MG et al. A guidebook to plant screening: phytochemical and biological. Research Center for the Natural Sciences. Univer-

sity of Santo Tomas. 2005.

36. McClements DJ. How modern science is transforming the way we eat. [Internet]. [cited 2019 October 20]. Available from: https://www.springer.com/gp/about-springer/media/press-releases/corporate/serving-the-future/16505332

37. Bolaniran T, Ogidi CO, Juliet AB. Nutritional value and safety of air potato *Dioscorea bulbifera* L. fermented with *Pleurotus ostreatus* and *Calocybe indica*. [Internet]. 2019. [cited 2019 October 21];6 (13)p.467. Available from: https://doi.org/10.21472/bjbs.061314

38. Karenlampi SO, White PJ. Potato proteins, lipids and minerals. Advances in potato chemistry and technology[e-book]. 2009. [cited 2019 Aug 20]; pp 99-125.Available from: https://doi.org/10.1016/B978-0-12-374349-7.00005-2

39. Ogbuagu MN. Nutritive and anti-nutritive composition of the wild (in-edible) species of *Dioscorea bulbifera* (potato yam) and *Disocorea dumentutorum* (bitter yam). [Internet]. 2008 [cited 2019 October 30].Available from: https://medwelljournals.com/abstract/?doi=jftech.2008.224.226

40. Olatoye KK, Arueya GL. Nutrient and phytochemical composition of flour made from selected cultivars of Aerial yam (*Dioscorea bulbifera*) in Nigeria. [Internet]. 2019 [cited 2019 Aug 23];79:pp 23-27. Available from: https://doi.org/10.1016/j.jfca.2018.12.007

41. Arbuckle C. Secondary metabolites and human health. 2016. [Internet]. [cited 2019 Oct 5] Available from: https://sites.psu.edu/carolyn/2016/03/24/secondary-metabolites-and-human-health/

42. Verena S, Lorenz M, Stangl K. The role of tea and tea flavonoids in cardiovascular health. [Internet]. 2006. [cited 2019 October 23];50:218-28. Available from: https://doi.org/10.1002/mnfr.200500118

43. Mbiantcha M, Kamanyi A, Teponno RB, Watcho P, Nguelefack TB. Analgesic and ant inflammatory properties of extracts from the bulbils of *Dioscorea bulbifera* L. in mice and rats. Evidence Based Complementary and Alternative Medicine. [Internet]. 2011. [cited 2019 Oct 2019]. Available from: https://doi.org/10.1155/2011/912935

44. Sougata G, Mehul A, Sumersing P, Amit J, Meenakshi BD, Bimba N et al. Antidiabetic activity of *Gnidia glauca* and *Dioscorea bulbifera*: potent amylase and glucosidase inhibitors. [Internet]. 2012; [cited 2019 October 23](1741-427X). Available from: https://www.researchgate/publication/51517931

45. Achy JY, Koffi PKB, Ekissi GSE, Konan HK, Koaume LP. Assessment of physico-chemical properties and anti-nutritional factors of flour from yam (*Dioscorea bulbfera*) bulbils in Southeast Cote D' Ivoire. [Internet]. 2016 [cited 2019 Nov 5];12:871-87. Available from: https://doi.org/10.21474/IJAR01/2468

46. Adeosun OM, Arotupin DJ, Toba OA, Adebayo AA. Antibacterial activities and phytochemical properties of extracts of *Dioscorea bulbifera* Linn. (Air potatoe) tubers and peels against some pathogenic bacteria. [Internet]. 2016 [cited 2019 October 11]; 5(105)21-26. Available from: http://www.phytopharmajournal.com/Vol5_Issue1_05.pdf

47. Hajšlová J, Schulzová V, Slanina P, Janné K, Hellenäs KE, Andersson CH. Quality of organically and conventionally grown potatoes: four year study of micronutrients, metals, secondary metabolites, enzymic browning and organoleptic properties. Additives and Contaminants. [Internet]. 2005 [cited 25 Sept 2019];22(6):514-34. Available from: https://doi.org/10.1080/02652030500137827

48. Center for Agriculture and Bioscience International. Herbs: treat and tastier potatoes (*Dioscorea bulbifera*) information: health benefits and uses of air potatoes. [Internet]. 2019. [cited 18 Sept 2019]. Available from: https://www.cabi.org/tag/centre-for-agriculture-and-biosciences-international

49. Rodriguez-Sandoval E,Fernández-Quintero A, Sandoval AP, Quicazán AC. Effect of cooking time and storage temperature on the textural properties of Cassava Dough. 2008. [Internet] [cited 2021 October 5]. Journal of texture studies. 39(1):68-82. Available from: https://doi.org/10.1111/j.1745-4603.2007.00131.x

50. Rudito NM, Suwarto N, Witono JY, Saragih B, Arung ET. Physical and chemical characteristics of fermented 'Dayak' wild Yam (*Dioscorea hispida* Dennst), Purple Yam (*Dioscorea alata* var. purpurea) and Air Potato (*Dioscorea bulbifera* L.) Flour as Food. 2018. International Journal of ChemTech Research. 2018;11(11): 369-78. [Internet]. [cited 18 August 2021]. Available from: http://dx.doi.org/10.20902/IJCTR.2018.111142

51. ES Venetcianskij AS, Mordvinkin, SA KuznetsovaE A. Research on possibilities of non-traditional flour types use in baking industry. 2021. [Internet] [cited 2021 September 24]. Available from: https://doi.org/10.1088/1755-1315/640/2/022067

52. International Potato Center. Sweet potato jams and juices contribute to forest conservation in the Philippines. 2019. [Internet]. [cited 2021 August 22]. Available from: www.agrilinks.org/post/sweetpotato-jams-and-juices-contribute-forest-conservation-philippines

53. Sherif RHB. Utilization of sweet potato roots in jam production. 2008. [Internet] [cited 15 September 2021]. Available from: http://repository.sustech.edu/bitstream/handle/123456789/21579/Utilization%20of%20Sweet%20Potato%20.pdf?sequence=3

54. Dhilipkumar M, Ragaventhira V, Manikandan J, Karthika R, Vaishnavi N, Balasubramani V. Development and quality evaluation of sweet potato jam blended with *Cucumis sativus* and *Beta vulgaris*. 2020. [Internet]. [cited 10 September 2021]. Available from: https://journals.grdpublications.com/index.php/ijprse/article/view/169

55. Wijaya1 H, Slay A and Abdullah N. Ice cream products made from processed purple sweet potatoes: a product organoleptic study. 2021. [Internet] [cited 2021 September 20].IOP Conf. Series: Earth and Environmental Science 807 (2021) 042074 IOP Publishing. Available from: https://doi:10.1088/1755-1315/807/4/042074

56. Weenuttranon J. Product development of purple sweet potato ice cream. International Journal of Advances in Science Engineering and Technology, ISSN(p): 2321 –8991, ISSN(e): 2321 –9009. 2018;6 (2). [Internet]. [cited 27 August 2021]. Available from: http://www.iraj.in/journal/journal_file/journal_pdf/6-462-153026384933-36.pdf

57. Draženka Dite Hunjek,Tanja Pranjić,Maja Repajić,Branka Levaj. Fresh-cut potato quality and sensory: Effect of cultivar, age, processing and cooking during storage. 23 July 2020. Available from: https://doi.org/10.1111/1750-3841.15353

58. Jnasky SH. Potato Flavor. 2010.[Internet].[cited 30 September 2021].Available from: https//: https://doi.org/10.1007/s12230-010-9127-6

59. Bello-Pérez LA, Sáyago-Ayerdi SG, Méndez-Montealvo G and Tovar J. *In vitro* digestibility of banana starch cookies. 2004. [Internet] [cited 5 October 2021]. Available from: https://link.springer.com/article/10.1007/s11130-004-0026-1

60. Jimenez-Mo M, Martinez A. Morpho-agronomic evaluation of air potato (*Diosocrea bulbifera* L.) in Panama. 2016;37:14-21. Available from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0258-59362016000100002