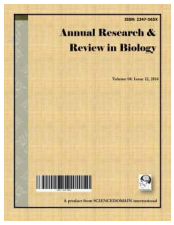

Annual Research & Review in Biology
8(3): 1-6, 2015, Article no.ARRB.19290
ISSN: 2347-565X, NLM ID: 101632869

SCIENCEDOMAIN *international*
www.sciencedomain.org

Bioconversion of Sweet Potato Leaves to Animal Feed

I. A. Onyimba[1*], A. I. Ogbonna[2], J. O. Egbere[3], H. L. Njila[1] and C. I. C. Ogbonna[2]

[1]Department of Science Laboratory Technology, University of Jos, P.M.B. 2084, Jos, Nigeria.
[2]Department of Plant Science and Technology, University of Jos, P.M.B. 2084, Jos, Nigeria.
[3]Department of Microbiology, University of Jos, P.M.B. 2084, Jos, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author IAO initiated and designed the study. Authors IAO and CICO wrote the protocol. Authors AIO, JOE and IAO managed the literature searches while authors HLN and IAO performed the statistical analysis. Authors IAO and AIO produced the initial draft while authors CICO and JOE read the initial draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2015/19290
Editor(s):
(1) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
Reviewers:
(1) Luis Quihui Cota, Centro de Investigación en Alimentación y Desarrollo, Mexico.
(2) Klara Kosova, Crop research Institute, Prague, Czech Republic.
(3) Mugdha Ambatkar, University of Mumbai, India.
(4) Anonymous, University of Ghana, Ghana.
Complete Peer review History: http://sciencedomain.org/review-history/11361

Original Research Article

Received 1st June 2015
Accepted 6th July 2015
Published 12th September 2015

ABSTRACT

Background: The high cost of conventional animal feed ingredients in Nigeria has made it necessary to search for alternative local sources of feed. Crop residues including sweet potato leaves abound in Nigeria. These have been explored as feed sources. The ability of microorganisms to convert agricultural wastes to more useful products could be harnessed to produce feed from sweet potato leaves which can be obtained in high abundance at low cost.
Aim: To examine the possibility of converting sweet potato leaves to animal feed through fermentation with a co-culture of *Chaetomium globosum* and *Saccharomyces cerevisiae*.
Materials and Methods: Triplicate samples of sweet potato leaves were fermented with a co-culture of *C. globosum* and *S. cerevisiae* for 21 days at 25±2℃ and the effects of fermentatio n on

**Corresponding author: E-mail: am_isaac2002@yahoo.com;*

nutrient composition were determined. Fermentation and control samples were analysed for proximate, amino acids, and elemental contents.
Results: Crude protein, crude fat and ash contents increased by 97.5%, 265.3% and 12.3%, respectively, while crude fibre and nitrogen free extract values decreased by 22.7% and 61.4% respectively. Energy content increased by 14.5%. The observed changes in the values of these nutritional components were significant (P = 0.05). The percentage dry matter values of all the amino acids analyzed (lysine, histidine, arginine, aspartic acid, threonine, glutamic acid, proline, glycine, alanine, cystine, valine, methionine, isoleucine, leucine tyrosine and phenylalanine) were found to increase, with the contents of seven of the amino acids increasing significantly. Calcium, phosphorus, potassium and magnesium contents increased significantly while those of copper and iron decreased.
Conclusion: Fermentation of sweet potato leaves with a co-culture of *C. globosum* and *S. cerevisiae* enhanced the feed potential of the leaves. With mineral supplementation, energy enhancement, and further crude fibre reduction, fermented sweet potato leaves could serve as feed for some animals.

Keywords: Fermentation; sweet potato; leaves; animal feed; bioconversion.

1. INTRODUCTION

Conventional ingredients for feed production like cereal grains and legumes are in short supply in Nigeria [1]. The cost of finished feed is therefore higher. In view of this, alternative indigenous raw materials have to be found. Traditionally, animal farmers allow their livestock to graze as additional means of meeting the animals' nutritional requirements. The grazing animals usually select and feed on plant materials that are nutritious, non toxic and organoleptically attractive. Among these forages are sweet potato leaves which are available in Nigeria.

The feeding value of sweet potato leaves for livestock is well documented [2,3,4]. Sweet potato leaves are, however, high in crude fibre content [5], and this limits their potential for maximal use as animal feedstuff, especially for monogastric animals. Microorganisms have been used successfully as tools for enhancing the feed value of fibrous agricultural residues [6]. Such microorganisms possess the prerequisite enzymes for breakdown of complex polysaccharide components of the agricultural residues to sugars. This brings about an increase in the energy value of the materials. Also, specific microorganisms are able, by fermentation, to convert some of the resultant sugars to other required nutrients such as proteins and fats, leading to increases in the values of the nutrients [7]. This increases the feed potential of the resultant product. The aim of this research work was to determine the ability of a co-culture of *Chaetomium globosum* and *Saccharomyces cerevisiae* to upgrade sweet potato leaves to animal feed. This derives from the drive to produce affordable animal feed from cheap and easily sourced indigenous raw materials.

2. MATERIALS AND METHODS

2.1 Collection and Processing of Sweet Potato Leaves

The sweet potato leaves used in the experiment were obtained from a sweet potato farm in Jos North Local Government Area of Plateau State, Nigeria. The leaves (without petioles) were taken from the sweet potato vines by hand, packed into clean polythene bags, and transported to the laboratory. At the laboratory the leaves were dried at 60℃ in a hot air oven after which they were pulverized and stored in sterile dry bottles.

2.2 Experimental Microorganisms

The test microorganisms, *Chaetomium globosum*, and *Saccharomyces cerevisiae* used in the fermentation studies were isolated from naturally fermenting sweet potato leaves. The isolates were characterized and identified using identification manuals including [8,9,10].

2.3 Experimental Procedure

Twenty-gram weights of dried, pulverized sweet potato leaves (SPL) were transferred into each of six conical flasks. The content of each flask was moistened by adding 35 ml of water. A spatula was used to thoroughly mix the contents of the flasks. The mouth of each flask was fitted with an

aeration apparatus which consisted of a rubber cork with two glass tubes running through its middle. The outer ends of the glass tubes were plugged with cotton wool and then covered with aluminum foil. The flasks, together with aeration apparatus, were autoclaved for 15 minutes at 121℃ and 15 kg/cm^2 after which they were allowed to cool. Three of the sterilized flasks were each inoculated with 3 ml of inoculum containing 1.5 ml of *C. globosum* spores (3.51 x 10^6 spores) and 1.5 ml of *S. cerevisiae* cells (3.96 x 10^6 cells). The other three flasks were not inoculated and served as the controls. Inoculation was done by spreading the inoculum all over the surface of the substrate with the help of sterile pipettes. The inoculated substrate was mixed thoroughly with a sterile spatula. The pieces of aluminum foil covering the outer ends of the glass tubes were removed to allow aerobic fermentation to take place. The leaf substrate was allowed to ferment for 21 days at room temperature (25±2℃). After the fermentation period, the fermented material was sterilized by tyndalization, dried in a hot air oven at 60℃, blended using a domestic dry blender and then stored in sterile air tight bottles. Both fermented and control samples were analysed in triplicates for proximate nutrient composition (crude protein, crude fat, crude fibre, ash and nitrogen free extract), gross energy, amino acid profile and elemental composition. Proximate analysis was by the method of AOAC [11]. Energy values were calculated using general energy conversion factors for food energy (4, 4, 9 Kcal/g for protein, carbohydrate and fat, respectively) [12]. The amino acid profile was determined using a Technichon Sequential Multi-sample (TSM) amino acid analyzer after prior defatting and hydrolysis of sample. Elemental analysis was carried out using a MiniPAL 4 model Energy Dispersive X-Ray Fluorescence Spectrometry (ED-XRFS). Statistical analyses of the results were carried out manually using student t-test at 5% significance level.

3. RESULTS

The results of the proximate analysis of the fermented and non fermented sweet potato leaves (SPL) (Table 1) showed that fermentation of SPL with the co-culture of *C. globosum* and *S. cerevisiae* brought about significant increases (P = 0.05) in crude protein (97.5%), crude fat (265.3%) and ash (12.3%) contents. There were reductions in the crude fibre (22.7%) and nitrogen free extract values (61.4%). Energy content increased by 10.2%.

Fermentation with the co-culture of *C. globosum* and *S. cerevisiae* brought about increases in the values of all the amino acids analysed. Significant increases (P = .05) were recorded for seven of the sixteen amino acids analyzed (Table 2).

Elemental analysis revealed increases in the values of calcium (1168.5 to 1225.5 mg/kg), phosphorus (39 to 69 mg/kg), potassium (1079 to 1170.5 mg/kg) and magnesium (60.5 to 90.5 mg/kg). The values of manganese (25 mg/kg) and zinc (2.5 mg/kg) were unaltered. Copper content decreased from 13.5 to 11 mg/kg while the content of iron decreased from 206.5 to 198.5 mg/kg. The recorded increases were significant at P = .05.

4. DISCUSSION

The observed increase in crude protein content (Table 1) was due to bioconversion of simple products of polysaccharide breakdown into protein. The high protein content (40.20%) of the fermented leaves compares favourably with the protein content (44-48%) of soy bean meal, a conventional source of protein for animal feeds. This means that the fermented leaves could meet the protein requirements of animals, especially monogastrics. [13] reported a similar protein enrichment in cassava by-products as a result of solid state fermentation by fungi.

The fat content (8.95%) of the fermented material is adequate for chickens of different types and ages [14]. The observed increase in fat content could mean an increase in the energy content of the fermented substrate. This increase in fat content could be as a result of conversion of fermentable sugars into fat. This finding is in conformity with that of [7] who reported that the fat content of hawaijar an indigenous fermented soya product was higher than that of the unfermented soya.

Enzymatic hydrolysis of polysaccharides especially cellulose by *C. globosum* is probably responsible for the observed reduction in the crude fibre content of the leaves. This reduction in the crude fibre content of the leaves increases the feed potential of the fermented product as excessively high fibre contents lead to digestion problems. Similar reduction in crude fibre content has been reported by [15] in biodegraded maize straw. The final crude fibre value of 19.40% was, however, still higher than the maximum 4% requirement for broilers [16] and 5% for mice [17].

Table 1. Nutrient compositions of non fermented sweet potato leaves and sweet potato leaves fermented with a co-culture of *C. globosum* and *S. cerevisiae*

Nutrient	Non fermented	Fermented
Crude protein (%)	20.35±0.05[a]	40.20±0.07[b]
Crude fibre (%)	25.10±0.07[a]	19.40±0.05[b]
Fat (%)	2.45±0.07[a]	8.95±0.05[b]
Ash (%)	15.42±0.09[a]	17.32±0.05[b]
Nitrogen free extract (%)	36.68±0.09[a]	14.13±0.14[b]
Energy (kcal/100 g)	260.17±0.30[a]	297.87±0.30[b]

Means on same row with different superscripts are significantly different at P = .05, student t- test. Data are means ± SD (n = 3).

Table 2. Amino acids compositions of non fermented sweet potato leaves and sweet potato leaves fermented with a co-culture of *C. globosum* and *S. cerevisiae*

Amino acids	Non fermented (g/100 g protein)	Fermented (g/100 g protein)
Lysine	0.6±0.05[a]	1.33±0.04[a]
Histidine	0.43±0.03[a]	0.68±0.02[a]
Arginine	0.92±0.04[a]	2.02±0.04[a]
Aspartic acid	1.96±0.02[a]	3.30±0.10[a]
Threonine	0.52±0.02[a]	1.33±0.03[b]
Glutamic acid	1.87±0.03[a]	3.90±0.03[b]
Proline	0.31±0.02[a]	1.05±0.01[b]
Glycine	0.05±0.02[a]	1.02±0.03[b]
Alanine	0.80±0.05[a]	1.43±0.03[a]
Cystine	0.06±0.02[a]	0.47±0.01[b]
Valine	0.92±0.03[a]	1.49±0.03[a]
Methionine	0.29±0.01[a]	0.45±0.03[a]
Isoleucine	0.93±0.02[a]	1.29±0.02[a]
Leucine	1.65±0.01[a]	2.91±0.03[b]
Tyrosine	0.81±0.02[a]	1.25±0.02[a]
Phenylalanine	0.89±0.03[a]	1.75±0.01[b]

Means on same row with different superscripts are significantly different at P = .05, student t- test. Data are means ± SD (n = 3)

The decrease in the nitrogen free extract value of the fermented sweet potato leaves is similar to the findings of [18]. The authors reported that the soluble carbohydrate content of agro-industrial byproducts fermented with species of *Aspergillus* and *Penicilium* decreased after 14 days.

The observed increase in the ash content due to fermentation may imply increases in the values of some of the elemental components of the substrates. This may be an advantage as it may ensure the availability of adequate minerals required for healthy growth in animals.

Though fermentation raised the gross energy content of the leaves to 297 kcal/100 g, the energy value was still not adequate for most animals including chickens which have an energy requirement of 300 kcal/100 g [19] and mice which have an energy requirement of 390 kcal/100 g [20].

The fermented leaves were found to be richer than the non fermented substrate in all the amino acids analyzed (Table 2). The essential amino acids contents of the fermented product compared well to the [21] recommended values for amino acids (g/100 g of protein) even though there were deficiencies in lysine and methionine contents. The essential amino acid composition of fermented sweet potato leaves meets the requirements of these amino acids for most animals, including laboratory animals such as mice and rats [20] and also chickens [19]. The increases observed in the amino acid values were due to the synthesis of amino acids by the microorganisms, especially, *S. cerevisiae* during the fermentation process. The result is comparable to the finding of [22] who reported increases in the amino acids content of *Ogiri* as a result of fermentation.

The observed increases in the contents of some of the minerals could have resulted from the

degradation of antinutritional compounds which often bind mineral elements, thus making the minerals more available. Mohite et al. [23] reported a similar increase in the iron, zinc, calcium, and magnesium contents of foods subjected to fermentation. Despite increases in the contents of minerals like calcium, phosphorus, potassium and magnesium, their values were still below the recommended values for birds [19].

5. CONCLUSION

Fermentation of sweet potato leaves with a co-culture of *C. globosum* and *S. cerevisiae* improved the nutrient composition of the leaves. Mineral supplementation, energy enhancement, and further crude fibre reduction will increase the potential of the fermented leaves for use as feed for some animals including mice and rats. Inclusion of a lignolytic fungus in the co-culture used for the fermentation may help in further reducing the crude fibre content to levels required in quality feeds. Hydrolysis of the lignin component of the leaves is likely to increase the availability of carbohydrates in the leaves thereby increasing the energy content. The use of other microorganisms with high enzymatic potentials could also be explored in the bioconversion of sweet potato leaves to animal feed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iyayi EA. Changes in the cellulose, sugar and crude protein contents of agro-industrial by-products fermented with *Aspergillus niger*, *Aspergillus flavus* and *Penicillium* sp. Afr. J. Biotechnol. 2004; 3(3):18-188.
2. Adewolu MA. Potentials of sweet potato (*Ipomoea batatas*) leaf meal as dietary ingredient for *Tilapia zilli* fingerlings. Pakistan J Nutr. 2008;7(3):444-449.
3. Mora L, Dominguez PL, Calderon R, Quintano J. Notes on the use of sweet potato (*Ipomoea batatas*) in diets of weaned pigs. Zootechnia de Cuba. 1992; 2:85-90.
4. Abonyi FO, Iyi EO, Machebe NS. Effects of feeding sweet potato (*Ipomoea batatas*) leaves on growth performance and nutrient digestibility of rabbits. Afri. J. Biotecnol. 2012;11(15):3709-3712. DOI: 10.5897/AJB11.3103.
5. Woolfe JA. Sweet potato: An untapped food resource. Cambridge: Cambridge University Press; 1992.
6. Mahesh MS, Madhu M. Biological treatment of crop residues for ruminant feeding: A review. Afr. J. Biotechnol. 2013; 12(27):4221-4231. DOI: 105897/AJB2012.2940.
7. Keishing S, Banu T, Umadevi M. Effect of fermentation on the nutrient content, antioxidant and antidiabetic activities of *Hawaijar*, an indigenous fermented soya of Manipur, India. J Hum Nutr Food Sci. 2015;3(3):1066.
8. Domsch KH, Gams W, Anderson T. Compendium of soil fungi. London: Academic Press Limited; 1980.
9. Samson RA, Hoekstra ES, Van Oorschot CA. Introduction to food–borne fungi. Netherlands: Institute of the Royal Netherlands Academy of Arts and Sciences; 1984.
10. Kreger-van Rij NJ. The yeasts: A taxonomic study. Amsterdam: Elsevier-North; 1984.
11. Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. Arlington; 1980.
12. Food and Agricultural Organisation. Food energy – methods of analysis and conversion factors. Rome; 2003.
13. Iyayi EA, Losel DM. Protein enrichment of cassava by-products through solid state fermentation by fungi. The Journal of Food Technology in Africa. 2001;6(4):116-118.
14. Chinke LG. Some agricultural investment opportunities in Nigeria (A practical guide). Jos; 2000.
15. Ogbonna CIC, Popoola AR. Biodegradation of maize straw by fungi for use as ruminant feed. Nig J Biotechnol. 1997;8(1):46-56.
16. Smith AJ. The tropical agriculturist. R. Coste ed. London: Macmillan Publishers; 1990.
17. Mckeown C. Mouse diets in Laboratories. Available:http://www.fancymice.info/labdiets.htm (Accessed 10 January 2015).
18. Iyayi EA, Aderolu ZA. Enhancement of the feeding value of some agro-industrial by-products for laying hens after their solid state fermentation with *Trichoderma viride*. Afr. J. Biotechnol. 2004;3(3):182-185.

19. Food and Agricultural Organisation. Poultry feeding in tropical and sub-tropical Countries. Rome; 1965.
20. Institute for Laboratory Animal Research. Nutrient requirements of laboratory animals 4th ed. Washington D. C.; 1995.
21. Food and Agricultural Organisation. Energy requirements and protein requirements. Rome; 1973.
22. Ojinaka MC, Ojimelukwe PC. Effect of fermentation period on the organic acid and amino acid contents of *Ogiri* from *Ricunus communis*. J Food Technol. 2012;10:140-150.
DOI: 103923/jftech.2012.140.150
23. Mohite BV, Chaudhari GA, Ingale HS, Mahajan VN. Effect of fermentation and processing on in vitro mineral estimation of selected fermented foods. International Food Research Journal. 2013;3: 1373-1377.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/11361