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Effect of Chemical Preservative and Packaging Material during Storage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Antinutritional properties of yam flour treated with chemical preservatives during six months of storage were carried out. Yam samples were purchased from *the wurukum* market, processed to obtain yam flour treated with chemical preservatives and packaged in plastic and low-density polyethene. About 100 grams of each of the different samples were separated into five portions. The first portion (sample A) was treated in a water bath with 250 ml of water with 0.5% of sodium metabisulphite for 15 minutes, drained and dried in an automated drier at about 70°C until dried to brittleness, Second portion (Sample B) was immersed in a solution of 0.5% Ascorbic acid for 15 minutes respectively, Third portion(Sample C) was immersed in a solution of 0.5% of Citric acid for 15 minutes, Fourth portion (Sample D) was immersed in a solution of 0.5% of Ascorbic and Citric Acid, Fifth portion was blanched at 70°C for 5 minutes respectively. The yam slices were dried to brittleness and milled separately with a laboratory hammer mill and sieved using a 250-um mesh to obtain yam flour referred to as high–quality yam flour. The flour samples were analyzed for antinutritional using standard laboratory procedures. The anti-nutritional factors in the high-quality

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yam flour were significantly different ($p \leq 0.05$) from each other in terms of pretreatment but there was no significant difference in packaging material across storage. Antinutritional factors of yam flour samples decreased as storage progressed. The alkaloid contents of the different yam flour samples ranged from 0.17mg/100 g before storage to 0.39mg/100 g two months after storage, The Tannin contents of the different yam flour samples ranged from 0.32–0.68 mg/100 g (month 0), 0.04–0.64 mg/100 g (month 2), 0.31–0.58 mg/100 g (month 4), and 0.28–0.52mg/100 g (month 6) and The saponnin contents of the different yam flour samples ranged from 0.21–0.39 mg/100 g (month 0), 0.20–0.34 mg/100 g (month 2), 0.19–0.35 mg/100 g (month 4), and 0.21–0.32 mg/100 g (month 6). The anti-nutritional factors in the treated and untreated yam flour samples were significantly ($p < .05$) affected by pretreatment, storage and packaging materials. Chemical preservatives used in yam processing makes treated yam flour safe for consumption after six months of storage.

Keywords: Antinutritional composition; yam flour; chemical preservatives; packaging materials.

1. INTRODUCTION

"Yams (*Dioscorea spp*) constitute an important staple food in tropical and sub-tropical regions of the world. Yam tubers have high carbohydrate content" [1] and are also sources of protein, fats, vitamins and minerals for many people.

Over 600 species of yam out of which only a few are cultivated for food have been reported by IITA, [2]. Bhandari et al*.,* [3] reported that "there are several different edible yam species available in different tropical regions, which differ in their chemical composition and nutritional importance". "Many species and cultivars of edible yams are not consumed raw because of itchiness, bitterness, or toxicity" [4].

"So far the antinutrient compositions of the economically important species of yam have not been widely reported. Antinutritional factors when present in a food system lower the bioavailability of protein and minerals" [5].

Some researchers (Okeola and Machuka, 2001): [6,7] identified "the presence of some antinutritional factors in the seed of the African Yam Bean. These are alkaloids, flavonoids, saponins, trypsin inhibitors, phytate, tannin and oxalate", while Nwinuka et al. [8] identified some "gassy factors like sucrose, raffinose and stachyose". Betche et al. (2005), identified "amylase as the notable anti–nutrient in African Yam Bean. These anti-nutritional factors can be reduced by using efficient processing techniques and proper cooking [9].

2. MATERIALS AND METHODS

Yam tubers of specie *Dioscorea rotundata* used during the cause of this research work were bought in Wurukum market, Makurdi area of Benue State. The yam tubers were selected by their shape and size without any external damage or blemish. Untreated yam flour and high-quality ponded yam flour (HQPYF) was bought from a store and the Wadata market. All samples were packaged in sterile bags and transported to the laboratory of the university for processing.

2.1 Processing of Yam Flour

Following the steps outlined by Omohimi et al., [10], premium yam flour was prepared. To get rid of sand and other dirt particles, the yam tubers that had been collected were thoroughly cleaned. A stainless steel knife was used to peel the washed tubers, and a stainless steel vegetable slicer was used to cut them into 1 mm pieces. The slices were washed in distilled water and divided into five equal portions, each of them was weighed using an electronic scale. About 100 grams of each of the different samples were separated into five portions. The first portion (Sample A) was treated in a water bath with 250 ml of water with 0.5% of sodium metabisulphite for 15 minutes, drained and dried in an automated drier at about 70 ^{o}C until dried to brittleness, Second portion (Sample B) was immersed in a solution of 0.5% Ascorbic acid for 15 minutes respectively. Third, the portion (Sample C) was immersed in a solution of 0.5% of Citric acid for 15 minutes. Fourth, portion (Sample D) was immersed in a solution of 0.5% of Ascorbic and Citric Acid. The fifth portion was blanched at 70^{o}C for 5 minutes respectively. The yam slices were dried to brittleness and milled separately with a laboratory hammer mill and sieved using a 250-um mesh to obtain yam flour referred to as high–quality yam flour. The flour samples were analysed and packaged in airtight plastic and low-density polyethene materials and stored for further analysis.

2.2 Test for Alkaloids

Tannin, Saponin and Alkaloid were conducted on both untreated and treated flour samples. Phytochemical screenings were done using the method of (AOAC, [11]).

2.3 Statistical Analysis

The means of the data that was obtained for treated, untreated and market-purchased yam flour were subjected to analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

The Alkaloid contents of the different yam flour samples ranged from 0.17mg/100 g before storage to 0.39 mg/100 g two months after storage as shown in Table 1. The Alkaloid contents of flour samples decreased as storage progressed from month 0 to month 6, while the other samples varied haphazardly. The Alkaloid content was significantly different ($p < 0.05$) from each other. Table 1 on the main effect of treatment, packaging materials and storage period indicated that there were no significant differences ($p > 0.05$) in Alkaloid content in different packaging materials during storage; but showed significant differences ($p \leq 0.05$) in the treatment and storage period The presence of antinutritional factors may adversely affect the nutritive value of foods (McAnuff et al.,2005). The presence of alkaloids in the yam tubers of the Dioscoresa species suggests that they shouldn't be consumed fresh. Comparatively speaking to research by Okwu and Ndu [4] on several yam cultivars, this study's alkaloids content is lower. When taken, alkaloids can lead to a variety of physiological changes in the body and are harmful (Awa and Chinedum, 2015). Alkaloids are present in the majority of farmed species of yams, although basic processing like cooking eliminates them [12].

The saponnin contents of the different yam flour samples ranged from 0.21–0.39 mg/100 g (month 0), 0.20–0.34 mg/100 g (month 2), 0.19–0.35 mg/100 g (month 4), and 0.21–0.32 mg/100 g (month 6) as shown in Table 3 The saponnin contents of flour samples decreased as storage progressed from month 0 to month 6, Saponnin content of flour samples was ranged from 0.18 mg/100 g – 0.36 mg/100 g while the other samples varied haphazardly. The Saponin content was significantly different ($p < 0.05$) from each other. Table 3 on the main effect of treatment, packaging materials and storage period indicated that there were no significant differences in saponnin content in different packaging materials during storage; but showed significant differences ($p \leq 0.05$) in the treatment and storage period.

Table 1. Alkaloids content of treated and untreated yam flour samples (Main effect)

Packaging material	Alkaloids (%)			
	0	2	4	6
Plastic	0.25^{a}	0.36^{a}	0.27^{a}	0.36^{a}
LDPE	0.35^{a}	0.39^{a}	0.35^{a}	0.38^{a}
FLSD{0.05}				
P-value				
Treatments				
A	0.21^{e}	0.37^{e}	0.27^{f}	0.26^{e}
B	0.18^{f}	0.39^{d}	0.30^{e}	0.28^{de}
C	0.15^{h}	0.43^{b}	0.26^{g}	0.31^{cd}
D	0.29^{c}	0.36^{f}	0.33^{d}	0.30^{b}
E	0.38^{a}	0.21^{g}	0.20^{h}	0.19^{f}
F	0.17^{g}	0.45^{a}	0.38^{b}	0.36^{b}
G	0.36^{b}	0.41^{c}	0.40^{a}	0.38^{a}
H	0.24^{d}	0.40^{c}	0.35^{c}	0.33^{cd}
FLSD				
P-VALUE{0.05}				

Values are means of duplicate sample ± SD. Values with different superscripts in the same column are significantly different at (p<0.05).

Key:

A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated nor Blanched
H= High-quality pounded yam flour bought from a store

Table 2. Alkaloids content of treated and untreated yam flour samples (Interactive effect)

	Alkaloids (%)			
Packaging materials	0	2	4	6
Plastic				
A	0.21^{e}	0.36^{fg}	0.25^{j}	0.25^{ef}
B	0.18^{f}	6.36^{fe}	0.28^{i}	0.26^{ef}
C	0.15^{h}	0.43^{c}	0.20^{k}	0.30^{cde}
D	0.29^{c}	0.35^{g}	0.32^{g}	0.30^{cde}
E	0.38^{a}	0.21^{i}	0.20^{k}	0.18^{g}
F	0.17^{g}	0.45^{b}	0.35^{e}	0.35^{bc}
G	0.36^{b}	0.39^{d}	0.38^{d}	0.32^{a}
H	0.24^{d}	0.35^{g}	0.35^{j}	0.25^{bc}
LDPE				
A	0.21^{e}	0.39^{d}	0.29^{h}	0.28^{de}
B	0.18^{f}	0.42^{c}	0.32^{g}	0.30^{cde}
C	0.15^{h}	0.43^{c}	0.33^{f}	0.32^{cde}
D	0.29^{c}	0.37^{e}	0.35^{e}	0.42^{a}
E	0.38^{a}	0.22^{h}	0.20^{k}	0.20^{fg}
F	0.17^{g}	0.45^{b}	0.42^{c}	0.37^{ab}
G	0.36^{b}	0.43^{c}	0.43^{b}	0.36^{a}
H	0.24^{d}	0.46^{a}	0.5^{a}	0.32^{bcd}

Values are means of duplicate sample ± SD. Values with different superscripts in the same column are significantly different at ($p<0.05$).
Key:
A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated nor Blanched
H= High-quality pounded yam flour bought from a store

Table 3. Saponin content of treated and untreated yam flour samples (Main effect)

Packaging materials	**Saponin (%)**			
	0	**2**	**4**	**6**
Plastic	0.25^{a}	0.29^{a}	0.39^{a}	0.24^{a}
LDPE	0.25^{a}	0.31^{a}	0.28^{a}	0.26^{a}
FLSD				
P-VALUE{0.05}				
Treatments				
A	0.24^{d}	0.30^{d}	0.31^{a}	0.21^{d}
B	0.26^{c}	0.26^{e}	0.23^{a}	0.22^{d}
C	0.22^{e}	0.39^{a}	0.35^{a}	0.28^{b}
D	0.24^{d}	0.26^{f}	0.22^{a}	0.25^{c}
E	0.22^{e}	0.24^{g}	0.54^{a}	0.21^{d}
F	0.20^{f}	0.33^{c}	0.19^{a}	0.22^{d}
G	0.34^{a}	0.33^{c}	0.31^{a}	0.30^{a}
H	0.32^{b}	0.36^{b}	0.33^{a}	0.32^{a}

Values are means of duplicate sample ± SD. Values with different superscripts in the same column are significantly different at ($p<0.05$).
Key:
A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated nor Blanched
H= High-quality pounded yam flour bought from a store

Table 4. Saponin content of treated and untreated yam flour samples (Interactive effect saponin)

Packaging materials	Saponin (%)			
	0	2	4	6
Plastic				
A	0.24^{d}	0.28^{g}	0.31^{b}	6.18^{i}
B	0.26^{c}	0.26^{h}	0.22^{b}	0.21^{gh}
C	0.22^{e}	0.38^{b}	0.35^{b}	0.21^{gh}
D	0.24^{d}	0.24^{i}	0.18^{b}	0.27^{d}
E	0.22^{e}	0.18^{j}	0.184^{a}	0.20^{h}
F	0.20^{f}	0.36^{c}	0.18^{b}	0.28^{f}
G	0.34^{a}	0.32^{e}	0.30^{b}	0.25^{bc}
H	0.32^{b}	0.36^{c}	0.34^{b}	0.30^{a}
LDPE				
A	0.24^{d}	0.32^{e}	0.31^{b}	0.25^{e}
B	0.26^{c}	0.27^{g}	0.25^{b}	0.23^{ef}
C	0.22^{e}	0.40^{a}	0.35^{b}	0.36^{a}
D	0.24^{d}	0.28^{g}	0.26^{b}	0.22^{fg}
E	0.22^{e}	0.24^{i}	0.23^{b}	0.22^{fg}
F	0.20^{f}	0.30^{f}	0.20^{b}	0.22^{fg}
G	0.34^{a}	0.34^{d}	0.32^{b}	0.32^{b}
H	0.32^{b}	0.36^{c}	0.33^{b}	0.30^{c}

Values are means of duplicate sample ± SD. Values with different superscripts in the same column are significantly different at (p<0.05).
Key:
A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated nor Blanched
H= High-quality pounded yam flour bought from a store

Table 5. Tannin content of treated and untreated yam flour samples (Main Effect)

	Tannin (%)			
Packaging materials	**0**	**2**	**4**	**6**
Plastic	0.51^{a}	0.45a	0.45a	0.38a
Polytene	0.51^{a}	0.56a	0.53a	0.47a
Flsd value{0.0}				
Treatment				
A	0.52^{d}	0.32^{g}	0.47^{cd}	0.41^{c}
B	0.47^{e}	0.41^{f}	0.47^{d}	0.40^{c}
C	0.43^{f}	0.63^{b}	0.60^{a}	0.54^{a}
D	0.64^{b}	0.60^{c}	0.55^{b}	0.36^{ds}
E	0.43^{f}	0.66^{a}	0.56^{b}	0.51^{b}
F	0.40^{g}	0.46^{e}	0.43^{e}	0.39^{c}
G	0.68^{a}	0.51^{d}	0.49^{c}	0.40^{c}
H	0.56^{c}	0.46^{e}	0.38^{f}	0.39^{c}

Values are means of duplicate sample ± SD. Values with different superscript in the same column are significantly different at (p<0.05).
Key:
A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated or Blanched
H= High quality pounded yam flour bought from a store

Table 6. Tannin content of treated and untreated yam flour samples (Interactive Effect)

Packaging materials	Tannin			
	0	**2**	**4**	**6**
Plastic				
A	0.32d	0.04^{j}	0.46^{gh}	0.34^{j}
B	0.47^{e}	0.35^{i}	0.47^{fg}	0.36^{hi}
C	0.43^{f}	0.62^{d}	0.58^{c}	0.47^{de}
D	0.64^{b}	0.58^{e}	0.50^{e}	0.28^{k}
E	0.43^{f}	0.64^{bc}	0.47^{f}	0.52^{b}
F	0.40^{g}	0.48^{g}	0.42^{i}	0.35^{hij}
G	0.68^{a}	0.48^{g}	0.46^{gh}	0.33^{j}
H	0.56^{c}	0.45^{h}	0.31^{j}	0.22^{g}
LDPE				
A	0.52^{d}	0.61^{d}	0.49^{ef}	0.48^{cd}
B	0.47^{e}	0.47^{g}	0.45^{gh}	0.44^{ef}
C	0.43^{f}	0.65^{b}	0.63^{b}	0.61^{a}
D	0.64^{b}	0.62^{d}	0.60^{b}	0.45^{ef}
E	0.43^{f}	0.68^{a}	0.65^{a}	0.50^{bc}
F	0.40^{g}	0.45^{h}	0.44^{hi}	0.43^{fg}
G	0.68^{a}	0.54^{f}	0.52^{d}	0.47^{de}
H	0.56^{c}	0.48^{g}	0.46^{gh}	0.37^{h}

Values are means of duplicate sample ± SD. Values with different superscript in the same column are significantly different at ($p<0.05$).
Key:
A= Flour sample treated with 0.5% of Sodium metabisulphite.
B = Flour sample treated with 0.5% of Ascorbic Acid
C= Flour sample treated with 0.5% of Citric Acid
D=Flour sample treated with 0.5% of Ascorbic and Citric Acid.
E= Flour sample bought from a local market exposed
F= Blanched flour samples
G= Flour samples neither treated or Blanched
H= High quality pounded yam flour bought from a store

Saponins are considered important due to their toxicity in yams [4]. This toxic metabolite occurs in varying concentrations in yam tubers. The saponin contents of yam in this research was lower than 2.98-19.5 mg/100 g reported by Okwu and Ndu [4].

High levels of saponin in yam are responsible for its bitter characteristic taste. Saponins natural tendency to ward off microbes makes them good candidates for treating fungal infections [4].

These compounds have been reported to serve as natural antibiotics, which help the body fight infections and microbial invassions [13].

3.1 Tannin

The Tannin contents of the different yam flour samples ranged from 0.32–0.68 mg/100 g (month 0), 0.04–0.64 mg/100 g (month 2), 0.31–0.58 mg/100 g (month 4), and 0.28–0.52mg/100 g (month 6) as shown in Table 4, 3 respectively, The Tannin contents of flour samples decreased as storage progressed from month 0 to month 6, while the other samples varied haphazardly. The Tannin content was significant different ($p < 0.05$) from each other. The Table 4 on the main effect of treatment, packaging materials and storage period indicated that there was no significant differences ($p > 0.05$) in tannin content in different packaging materials during storage; but showed significant differences ($p \leq 0.05$) in the treatment and storage period.

The tannin concentration in flour samples was relatively lower when compared with values reported for D. *rotundata* reported by Uka [14].

Since a human should consume a maximum of 560 mg of tannic acid daily, according to Anonymous (1973), the toxicity effects of the tannin may not be considerable. Additionally, the tannin content of the wheat samples used in this study is quite low in comparison to its significant toxicity effect. As a result, even at raw levels, the tannin contents of the current study posed no substantial health risk.

It's possible that D. dumetorum's high tannin content explains its bitter flavor. According to Okwu and Ndu [4], the small amounts of tannin present in yam tubers serve as a deterrent against rot in yams. However, heating, soaking, and drying could reduce antinutrients in general, according to FAO (1999).

According to Afiukwa et al. [15], tannin complexes with proteins diminish the digestibility and palatability of the protein. Cooking is known to reduce food's content, nevertheless [16-19].

4. CONCLUSION

Antinutritional properties of flour samples treated with chemical preservatives were reduced as storage progressed. The presence of antinutritional factors can adversely affect the nutritive value of foods. Antinutritional components of yam such as Tannins, Alkaloids and saponins can be inactivated or reduced through heat treatments such as Blanching or cooking before consumption.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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