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(RESEARCH ARTICLE)

Microbial evaluation of hydrocolloids from flesh and peel of tuber crops flour and sensory attributes of ice cream produced from it

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Abstract

This study assessed the microbial evaluation of hydrocolloids from fresh and peel of tuber crops flour and sensory attributes of ice cream produced from it. White flesh sweet potato and cocoyam were purchased from Ubani market Umuahia, trifoliate yam was purchased from Orie-Ntigha in Isi-alaNgwa North of Abia State and aerial yam from the Abakiliki main market in Ebonyi State. Ice cream ingredients were purchased from Ubani Market in Umuahia of Abia State. Each of the tuber samples (Sweet potato, yams and cocoyam) were washed, peeled and chopped into smaller units of about 5-6 cm long. The peels and flesh were divided into three (3) portions each and were dried to constant weight using sun, air and oven drying methods respectively to obtain chips, followed by grinding into flour samples separately. The flour samples obtained were defatted. The extracts produced were purified and kept in plastic bag and stored in air-tight plastic container prior to analysis. Bacterial and fungal loads in the samples were determined using standard methods. The sensory evaluation of homemade vanilla ice cream was determined based on the method of Iwe (2010). Results obtained showed that the total bacterial count for sun dried and air dried samples ranged from 3.12x 10^3 to 3.69 x 10^3 CFU/g, while fungi count ranged from 4.21 x 10^3 to 4.68 x 10^3 CFU/g. Four species of bacteria (*Micrococcus*, *E. coli*, *Salmonella* and *Staphylococcus aureus*) were identified in the sun-dried and air-dried samples, while 2 species of fungi (yeast and mould) were also detected in the sun-dried and air-dried samples. The oven-dried samples had no microbial growth. Sensory evaluation results showed that ice cream sample produced with oven dried white flesh sweet potato peel hydrocolloids was most preferred.

Keywords: Microbial Evaluation; Hydrocolloids; Tuber Crops Flour; Sensory Attributes; Ice Cream

1 Introduction

Root and tuber crops produce a substantial part of the world's food supply. On global basis, approximately 45 percent of root and tuber crops production are consumed as food (FAO, 2014), with the remainder used as animal feed or for industrial processing for products of such as starch, distilled spirit and range of minor product (David,2005). Root and tuber crops are Africa's main staple foods such as sweet potato (*Ipomoea batatas)*, yam (*Dioscorea* Spp.), cocoyam (*Colocasia esculenta*) etc. They contribute significantly to income generation, sustainable development and household food security especially in low income countries which are, namely located in the tropical regions (IHC, 2014).

Nigeria is the largest producer of yam and cocoyam in the world and the largest producer of sweet potato in sub-Sahara Africa (Amadi *et al*., 2011). Tuber crops are produced in large quantities in Nigeria; crop losses of between 30 to 50 percent are common shortly after harvest (Taiwo, 2014). The high moisture content of the crops renders them perishable but processing transforms them into value added products with enhanced shelf life. Post-harvest losses of tuber crops mostly due to the high moisture content of the crops that renders them perishable is a very crucial setback

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in the storage of these crops. This makes them unavailable during the off season. Also in the peeling of the tubers of these crops there is much peeling loss which results to reduced flour yield. However, processing fresh and peels of these tuber crops into hydrocolloids, using it in food formulation such as ice cream is one way of preventing post-harvest waste of these crops (Ohuoba and Onwuka, 2016). Hydrocolloids are added to control the functional properties of aqueous foodstuff (Ohuoba *et al.,* 2019a, Phillip and Williams, 2009). Most importantly include viscosity, prevention of ice recrystallization and organoleptic properties (Ferry *et al*., 2006).

Ice cream is a frozen dessert usually made from daily products, such as milk and cream and often combined with fruits or other ingredients (Wikipedia, 2014). Ice cream became popular throughout the world including Nigeria in the second half of the 20th century after refrigeration became common and cheap (Wikipedia, 2014). Technological innovations lead to the introduction of various food additives into ice cream, the notable one being the thickener and stabilizing agent (kendall, 2013). Most commercial ice creams contain soluble gums which are considered as hydrocolloids (Learning Food Resource, 2014), like guar gum, locust beam gum, carrageenan, xanthan gum, gelatin etc (Ice cream Greek,2014). Most of these hydrocolloids are edible gums in different forms (Mahfoudhi *et al*., 2012). These aimed at reducing iciness, extending shelf life, providing a smooth texture and slowing down the melting process of ice cream. Microbiological evaluation of hydrocolloids extracted from flesh and peel of cocoyam, sweet potato, trifoliate yam and aerial yam flour and sensory attributes of ice cream produced from it were studied in this work.

2 Materials and methods

2.1 Source of Materials/Sample Collection

White flesh sweet potato (*Ipomoea batatas*), cocoyam (Colocasia esculenta) were purchased from Ubani market Umuahia, trifoliate yam (*Dioscorea dumentorum*) was purchased from Orien-Ntigha in Isi-alaNgwa North of Abia State and aerial yam (*Dioscorea bulbifera*) from the Abakiliki main market in Ebonyi State. Ice cream ingredients were purchased from Ubani Market in Umuahia of Abia State.

2.2 Sample preparation/flour production

2.2.1 Sample preparation of the fresh tubers

Each of the tuber samples (Sweet potato, yams and cocoyam) were washed, peeled and chopped into smaller units of about 5-6 cm long (Ofori and Hahn, 1994). The peels and flesh were divided into three (3) portions each. Each of the three portions was dried to constant weight using sun, air and oven drying methods respectively.

- Sun drying: A portion of the various tuber samples (fresh and peels) were kept in the sun between 9 am to 4.30pm daily and were dried to constant weight for four (4) days.
- Air drying (Room temperature): A second portion of each flesh and peels samples were placed in spread platform in an airy room to shed the samples from sun rays. These were dried to constant weight for 8 days.
- Oven drying: A third portion of each flesh and peel tuber samples were placed in an electrothermal oven (model; DHG) and dried to constant weight at 60 degree celsus for 48 hours.

2.2.2 Flour production

The chips of fresh sweet potato, yams and cocoyam flesh and peel samples that were sun, air and oven dried to a constant weight respectively were milled into fine powder using Thomas Willey mill and Binatone blender model BLG-401. Each of the samples flour was obtained from the fine powder by sieving with 150 micrometer aperture sieve. They were placed in plastic bag and stored in air-tight plastic container.

2.2.3 Defatting of the flesh and peels flour (cold method)

The peels and flesh flour samples were defatted as described by Size-Tao and Sathe (2004). The flour samples were soaked with n-hexane in theratio of 1:10 (w/v) for 24 hours. It was then filtered using filter paper and the residue (defatted samples) obtained.

2.3 Extraction and purification of the defatted flour samples

The extraction and purification was done by the methods of Oladipo and Nwokocha (2011); Onwueluzo*et al*. (1993). A quantity of 120g of flesh and peels of the defatted samples were dispersed in 800 ml of distilled water in 1000 ml beaker and the supernatant was decanted. The content left in the beaker was passed through muslin cloth. Each of the residue was re-constituted with 500 ml distilled water and sieved again with muslin cloth. Excess cold 99.9% ethanol was added to the residue. The precipitate formed was collected as a residue when the content in the beaker was filtered using muslin cloth. The crude hydrocolloids were scooped into 500 ml beaker using table spoon. The crude extract was purified by dissolving in distilled water, homogenized and gradually precipitated with twenty (20) percent Ammonium sulphate and then washed with distilled water.

The residue after washing was placed in 500 ml beaker and precipitated with excess cold 99.9% ethanol. This procedure was done severally until the washing was negative to biuret test. The precipitate extracts were dewatered and was oven dried at 65 °C for 48 hours.

2.4 Determination of microbial load

Bacterial and fungal loads in the extracted purified food gums samples were determined using standard method described by AOAC (2006). MacConkey agar medium was used for bacteria and Sabouraud dextrose agar for moulds and yeast (Winn *et al*., 2006; Mitchell, 2010).

2.5 Recipe for home made vanilla ice cream with gelatin or hydrocolloids

This recipe was by Gupta (2014) with some modifications.

Ingredients

- 2 cups of milk (200 ml glass cup)
- 3 grams (gelatin or hydrocolloids)
- 1 tablespoon vanilla
- 360 grams of sugar
- 8 eggs (albumin only)

2.6 Method

The egg white was whisked with egg whisker until it became completely foamy. The sugar, milk, vanilla and either gelatin or the extracted hydrocolloids respectively were whisked to mix them together in another bowl. Gradually, the mixed mixtures were gently added to the whisked egg white that has formed foam. All the contents were thoroughly whisked and later scooped into a plastic bowl and immediately covered with air tight lid and stored in the freezer. A frozen ice cream was brought out of the freezer after 8 hours.

Figure 1 Experimental Ice cream samples for sensory evaluation

2.6.1 Sensory evaluation

The sensory evaluation of homemade vanilla ice cream was determined using a twenty members panelist consisting of staff and students of Michael Okpara University of Agriculture as well as staff of National Root Crops Research Institute, Umudike. Each ice cream in a coded plastic bowls with lids contained different extracted purified hydrocolloids, gelatin (control 1) and ice cream without hydrocolloids and gelatin (control II). The panelists were instructed to evaluate the coded ice cream samples for taste, mouthfeel, smoothness, flavor, appearance and general acceptability using a nine (9) point hedonic scale which ranged from 1(dislike extremely) to 9 (like extremely) (Iwe 2010). Sachet water was provided to rinse the mouth between evaluations.

2.5 Data analysis

Data obtained were subjected to Analysis of Variance (ANOVA) to determine the level of significance and the means separated by Duncan Multiple Range Test, Statistical Analysis System (SAS) software.

3 Results and discussion

Tables 1 and 2 showed the microbial result of extracted and purified hydrocolloids of flesh and peels samples. The result showed that the total bacterial plate count for sun dried and air dried samples were 3.12×10^3 CFU/g to 3.69×10^3 CFU/g, while fungi count showed 4.21×10^3 CFU/g to 4.68×10^3 CFU/g. These results indicate that the level of microorganisms in the samples were lower than the 10^4 permissible limits (ICMSF, 1996). Four species of bacteria (*Micrococcus*, *E. coli*, *Salmonella* and *Staphylococcus aureus*) were identified in the sun-dried and air-dried samples, while 2 species of fungi (yeast and mould) were also detected in the sun-dried and air-dried samples. The oven-dried sample had no microbial growth.

The low microbial load of sun-dried and air-dried samples could be attributed to the level of purification of the crude extracted hydrocolloids. Okoye *et al*. (2012) reported that purification of crude food gums reduced its microbial load, while the negative microbial growth in the oven-dried samples is attributed to the drying method in which the application of heat was more intensified than the others. This is in line with Ezeama (2007) who stipulated that, application of heat reduces the microbial population of food substances. The overall microbial evaluation result showed that the method of drying the experimental material before extraction affected the microbial load positively by decreasing the population. while purification reduces the microbial load of samples.

Table 1 Evaluation of microbial load of flesh samples

Sample names	**TPC (CFU/g)**	**Identified bacteria**				**YMC (CFU/g)**	**Identified fungi**	
		Micrococcus	***E. coli***	***Salmonella***	***Staph. aureus***		*Yeast*	*Mould*
Dumetorum(Trifoliate yam) flesh oven drying	-	-	-	-	-	-	-	-
Sun drying	3.33×10^3	+	+	+	+	4.33×10^3	+	+
Air drying	3.41×10^3	+	+	+	+	4.62×10^3	+	+
Colocasiaesculenta(Cocoyam) flesh oven drying	-	-	-	-	-	-	-	-
Sun drying	3.17×10^3	+	+	+	+	4.29×10^3	+	+
Air drying	3.22×10^3	+	+	+	+	4.21×10^3	+	+
Whiteflesh sweet potato flesh oven drying	-	-	-	-	-	-	-	-
Sun drying	3.68×10^3	+	+	+	+	4.68×10^3	+	+
Air drying	3.69×10^3	+	+	+	+	4.59×10^3	+	+

TPC = Total plate count; CFU = Colony forming unit; YMC = Yeast mould count; + = Moderate growth; - = No growth.

Table 2 Evaluation of microbial load of peel samples

Samples	TPC (CFU/g)	Identified bacteria				YMC (CFU/g)	Identified fungi	
		Micrococcus	*E. coli*	*Salmonella*	*Staph. aureus*		Yeast	Mould
dumetorum (Trifoliate yam) peel oven drying	-	-	-	-	-	-	-	-
Sun drying	3.25 x 10^3	+	+	+	+	4.29 x 10^3	+	+
Air drying	3.42 x 10^3	+	+	+	+	4.57 x 10^3	+	+
Colocasia esculenta (Cocoyam) peel oven drying	-	-	-	-	-	-	-	-
Sun drying	3.13 x 10^3	+	+	+	+	4.36 x 10^3	+	+
Air drying	3.44 x 10^3	+	+	+	+	4.60 x 10^3	+	+
White flesh sweet potato peel oven drying	-	-	-	-	-	-	-	-
Sun drying	3.12 x 10^3	+	+	+	+	4.31 x 10^3	+	+
Air drying	3.18 x 10^3	+	+	+	+	4.26 x 10^3	+	+

TPC = Total plate count; + = moderate growth; YMC = Yeast mould count; CFU = Colony forming unit; - =No growth

Sensory evaluation results of the ice cream produced using oven-dried flesh and peel samples of extracted and purified hydrocolloids of white flesh sweet potato (*Ipomoea batatas*), trifoliate yam (*Dioscora dumentorum*) and cocoyam (*Colocasia esculenta*) are shown in Table 3.

There were significant differences (P<0.05) in the taste, with oven-dried white flesh sweet potato peel ranking highest (Table 3) No significant difference was observed between oven dried trifoliate yam peel (8,65) and oven-dried white flesh sweet potato peel (8.70). The taste of all the samples were acceptable by the panelist, however the least accepted taste was in Gelatin control (6.9). Oven dried cocoyam peel was the highest (8.2) in mouthfeel while the least acceptable was Gelatin control (5.85) samples. However, there were no significant differences (P>0.05) in the mouthfeel of oven dried cocoyam peel (8.2) and oven dried white flesh sweet potato peel (8.0), also between oven dried white flesh sweet potato peel and oven dried cocoyam flesh (7.80). There were significant differences (P<0.05) in the smoothness of the samples. The smoothness of the samples was acceptable by the panelist except Gelatin control (4.9) that was disliked moderately. Flavour of oven dried white flesh sweet potato peel (8.10) was most acceptable although there were no significant differences (P>0.05) between the flavour of the samples (oven dried cocoyam flesh, oven dried cocoyam peel and oven dried white flesh sweet potato peel (7.9). The flavour of all the samples was acceptable except Gelatin control (6.25) that recorded the lowest value. Appearances of all the samples were acceptable. The most acceptable appearance was oven dried white flesh sweet potato flesh (8.20) while the least acceptable was oven dried trifoliate yam flesh (6.45) and Gelatin control (6.45).

There were significant differences (P<0.05) in the general acceptability with oven dried *Colocasia esculenta* flesh (7.95) ranking the highest. There were no significant differences (P>0.05) between general acceptability of oven dried *Colocasia esculenta* (7.95), oven dried white flesh sweet potato peel (7.9), oven dried white flesh sweet potato flesh (7.85) and oven dried *Colocasia esculenta* peel (7.85). Although, all the samples evaluated were generally accepted, the least was in Gelatin control (6.00) samples that recorded significant differences (P<0.05) with other samples. Among the parameters evaluated, sample with the highest value was the extracted and purified hydrocolloids when compared to the control I (Gelatin control) and control II (Without hydrocolloids and gelatin control)

The trends of the sensory evaluation results, along with the comments by the panelists indicate that hydrocolloids extracted from flour of flesh and peels of tuber crops cultivated locally in Nigeria can be used in controlling the organoleptic characteristics of ice cream. In addition, they can be used to substitute gelatin in ice cream making. Although, the appearance of oven dried trifoliate yam peel was not very acceptable by some panelists, the thickness was the highest as commented by the panelist. Hence, oven dried trifoliate yam could be used to improve the consistency of food during formulation.

Flavour of the ice cream samples treated with hydrocolloids was higher than the ones treated with gelatin. This is in agreement with some research studies that gelatin masked flavour of ice cream (Gum Technology,2009; Bahramparvar and Tehrani, 2011).These extracted and purified hydrocolloids irrespective of flesh or peels of the tuber crops will be a huge relief for those that are not comfortable in using xanthan gum (Weingerten, 2010). Furthermore, they can also be used as alternative food gums for Guar gum for those that are sensitive to soy (Livestong, 2014) and locust bean gums, in that using large amount of it can lead to flatulence and bloating (Kresser, 2014).

In addition, this study is in agreement with the reports of Golding and Matia-Merino (2014) and Russell (2009), they both reported that some of the functions of some food hydrocolloids (food gums) are to control ice crystal, release flavor, increase smoothness, improve mouthfeel etc in ice cream. The smoothness of gelatin that was disliked moderately (4.9) may be attributed to undissolved particles and formation of ice crystal commented by the panelists. According to Bahramparvar and Tehrani (2011), hydrocolloids (food gums) are used to improve consistency in ice cream, this is the reason why control 11(without hydrocolloids and gelatin control) was not consistent.

Table 3 Sensory evaluation results of the ice cream produced using the best oven dried flesh and peel samples of extracted and purified hydrocolloids**.**

Samples	**Taste**	**Mouth feel**	**Smoothness**	**Flavour**	**Appearance**	**General acceptability**
Oven dried trifoliate yam flesh	7.65[cd]	7.60[c]	7.10[e]	6.85[d]	6.45[f]	7.25[c]
Oven dried trifoliate yam peel	8.65[a]	7.40[dc]	7.45[d]	7.10[c]	7.04[e]	7.30[c]
Oven dried cocoyam yam flesh	7.90[cb]	7.80[b]	7.90[b]	7.75[b]	7.90[b]	7.95[a]
Oven dried cocoyam yam peel	8.00[b]	8.20[a]	8.05[a]	7.65[b]	7.05[e]	7.85[ba]
Oven dried white flesh potato flesh	7.60[d]	7.15[d]	7.75[cb]	7.65[b]	8.20[a]	7.85[ba]
Oven dried white flesh potato peel	8.70[a]	8.00[ba]	7.70[cb]	8.10[a]	7.65[d]	7.90[ba]
Gelatin control	6.9[e]	5.85[f]	4.90[f]	6.25[e]	6.35[g]	6.00[ed]
Without hydrocolloids and gelatin control	8.00[b]	6.60[e]	7.50[cd]	6.85[d]	7.70[c]	7.30[c]
LSD	0.2829	0.2829	0.2808	0.1193	0.0704	0.1082

Samples means with the same letter down the columns are not significantly different (P>0.05).

4 Conclusion

This study showed that microbial load of the hydrocolloids samples extracted from the selected tuber crops were below the permissible limits of 10^4 irrespective of the drying method of the selected tuber crops. Sensory evaluation results of the ice cream indicated the hydrocolloids could be incorporated into ice cream making to control its organoleptic characteristic. The results as outlined in this work suggest the usefulness of these purified extracted hydrocolloids in ice cream making. However, the hydrocolloids should be incorporated in other food formulation. These hydrocolloids that had health benefit could replace some existing one, thereby increasing local availability of hydrocolloids. In addition, aid in reduction of post-harvest losses or waste of these tuber crops.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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