

Elaboration of By-Products of Cará (*Dioscorea* spp.) From Agroecological Experience

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Received: January 8, 2020

Accepted: August 26, 2020

Online Published: September 15, 2020

doi:10.5539/jas.v12n10p205

URL: <https://doi.org/10.5539/jas.v12n10p205>

Abstract

Yam (*Dioscorea* spp.) is a tuberous plant of high energy and nutritional value, with great importance for the industry and as a food because of its composition. With the purpose of developing bakery products and determining its acceptability, cake, biscuit, pasta, pancake, bread, and pizza were prepared with 0 to 20% of starch in substitution for wheat flour. Yam starch was obtained when arriving at the industry in Caapiranga-AM, the flagship yam processing town in the region. Sensory evaluation was carried out by a target audience of 50 individuals, using a hedonic scale. For the statistical analysis, the Tukey's test was used, and it was found that in the overall analysis, the best treatments were the control (no yam starch) and the one with 5% of yam starch. The production of these byproducts is viable, adding value to yam and delivering a product with better quality to consumers.

Keywords: starch, acceptability, food security

1. Introduction

Amazonia houses the largest socio-biodiversity in the planet, representing the habitat of 200 ethnic groups with 170 different languages, as well as riverside dwellers, *quilombolas* (Note 1) and migrants (Goodland & Irwin, 1975). Its genetic stock is immeasurable in global scale and shelters a forest that stores more than one hundred billion tons of carbon, that is, an untouched sanctuary, as well as one of the greatest river basins in the world, which projects for the country a strategic potential in the near future, in addition to representing an asset of inestimable economic and social value (Benchimol, 2000).

In the Amazon region, yam is an excellent food crop which grows well under dryland agroecosystems conditions. Yam has been cultivated in the region of the lower Solimões River, where this crop is the main source of income and self-consumption. Cultivation of yam is an old activity, back to the first settlers who inherited it from indigenous cultures and is one of the elements present in the diet of riverside populations. Historically, yam is grown in small areas, using family labor, with production destined for family consumption and some surpluses sold to the main town halls of Amazonas municipalities. However, most species are still little studied, especially *D. trifida*, compared to other species of edible *Dioscorea* (Pedralli, 1998; Ramos-Escudero et al., 2010).

The possibility of cultivating yam for production of starch leads to researches not only on agronomic aspects but on technological and nutritional aspects as well, aiming at the commercial exploitation of this tuber. It allows the supply of local economy through the agricultural sector by planting yam for production of raw material and other products due to the excellent characteristics and technological properties of its nutritional components.

Manzano (2007) reports that yam (*Dioscorea* spp.) starch has desirable technological characteristics such as tolerance to high temperatures and low pH values, which varies according to the species, providing another potential starch product that could be used by the industry, but is still commercially unexplored. In the food industry, starch is used in the preparation of creams, pies, jellies, baking powder, and ice cream. In bakery, it could be used as a complement to the traditional wheat flour, even in breads, without influence on the final result. And either sweet starch or sour starch can be used in the production of breads, cakes, cookies, *sequilho* (Note 2),

etc. Yam starch can be used in recipes with no problems, since it does not have a typical flavor or smell, and so it does not interfere in the end product. In addition, it costs less than other kinds of starch.

This study was carried out within the scope of the *Projeto Centro de Agroecologia e Desenvolvimento Rural* [Project Center of Agroecology and Rural Development], an initiative for jobs and income generation and strengthening of family farming in rural Amazon communities, financed by national government agencies that foster the development of skills and knowledge on food security and techniques for production of tubers-derived byproducts. It is worth noting that one of the main gaps is the lack of yam byproducts and delicacies, and this work aims to present some alternative uses of this tuberous plant.

2. Material and Method

The material of this study was collected in Caapiranga, located at the left bank of the lower Solimões River, 147 km from the capital of the state. Analyses of proximate composition of raw and cooked yam were carried out, followed by the preparation of yam products.

The starch extraction process followed an adapted version of the method described by Cereda et al. (2003): the tubers were washed, peeled, and cut into small pieces, and then this material was crushed, followed by filtration through 100 and 200 mesh sizes. The filtered material was decanted for 48 hours, the supernatant was discarded, and the decanted material was dehydrated at 40 °C to obtain the starch.

Mixtures made up of wheat flour and 5, 10, 15 and 20% of yam starch were used to prepare cakes, biscuits, pasta, pancakes, bread and pizza. A basic formulation to be used as control was prepared without yam starch. These percentages were defined using as parameters studies conducted by Marques et al. (2005) and Freitas et al. (1997). Then, the formulations were standardized based on the traditional characteristics of byproducts such as color and appearance, and the order of addition of the ingredients and quantities were determined (Table 1).

Table 1. Formulation of bakery byproducts based on partial replacement of wheat flour by yam starch at 5, 10, 15 and 20%

Ingredients	Control	5%	10%	15%	20%
<i>Cake</i>					
Wheat flour (g)	360	342	324	306	288
Starch of Yam (g)	0	18	36	54	72
Sugar (g)	320	320	320	320	320
Margarine (g)	48	48	48	48	48
Eggs	3	3	3	3	3
Milk (mL)	360	360	360	360	360
Yeast (g)	20	20	20	20	20
<i>Cookie</i>					
Wheat flour (g)	330	313.5	297	280.5	264
Starch of Yam (g)	0	16.5	33	49.5	66
Butter (g)	220	220	220	220	220
Sugar (g)	120	120	120	120	120
<i>Spaghetti</i>					
Wheat flour (g)	400	380	360	340	320
Starch of Yam (g)	0	20	40	60	80
Eggs	4	4	4	4	4
Salt (g)	2.5	2.5	2.5	2.5	2.5
<i>Pancake</i>					
Wheat flour (g)	120	114	108	102	96
Starch of Yam (g)	0	6	12	18	24
Eggs	1	1	1	1	1
Milk (mL)	240	240	240	240	240
Oil (mL)	15	15	15	15	15
Salt (g)	2.5	2.5	2.5	2.5	2.5
<i>Bread</i>					
Wheat flour (g)	1000	950	900	850	800
Starch of Yam (g)	0	50	100	150	200
Water (mL)	800	800	800	800	800
Sugar (g)	10	10	10	10	10
Salt (g)	20	20	20	20	20
Oil (mL)	80	80	80	80	80
Egg	1	1	1	1	1
Biological yeast (g)	125	125	125	125	125
<i>Pizza</i>					
Wheat flour (g)	180	171	162	153	144
Starch of Yam (g)	0	9	18	27	36
Milk (mL)	240	240	240	240	240
Eggs	1	1	1	1	1
Salt (g)	5	5	5	5	5
Margarine (g)	15	15	15	15	15
Yeast (g)	10	10	10	10	10
Sugar (g)	3.5	3.5	3.5	3.5	3.5

The processed formulations were assessed sensorially, using the 9-score hybrid hedonic scale, where (1) corresponded to “disliked it very much” and (9) “liked it very much”. Fifteen untrained tasters performed a sensory evaluation to determine acceptance relating to appearance, texture, color, aroma, taste and overall impression. The tasters were instructed to wash the mouth with water during the conduction of the tests to avoid possible interference of residual taste. The samples were coded using one-digit numbers at random and served in plastic plates and cups. The tests were conducted at the Laboratory of Animal Products Technology, Faculty of Agricultural Sciences, Federal University of Amazonas.

The experiment adopted a completely randomized design with five treatments (0%, 5%, 10%, 15% and 20% of yam starch) and 50 replications. The data of the acceptance test were analyzed by the Sisvar software, version 4.6, and the results were assessed using the Tukey's test at 5% probability level.

3. Results and Discussion

The values found in the samples analyzed on a dry basis are described in Table 2.

Table 2. Physicochemical characteristics of sweet and sour yam starch

Parameters (%)	Sweet (%)	Sorrel (%)
Humidity	16.45	13.24
Ashes	0.27	0.14
Protein	2.45	2.05
Carbohydrate	79.87	82.22
Fiber content	0.45	0.30
pH	6.38	5.02

The results of the physicochemical analysis indicated some differences between the sweet and the sour starch, in which the pH parameter exhibited the highest acidity level in the sour starch, indicating a possible expansion property. The current legislation does not provide a classification for manioc sour starch, and for this reason the 1978 legislation was used for comparison. In literature, no references were found for the physicochemical characteristics of yam starch, and there is not even a specific legislation for it. For this reason, for comparison purposes, data on manioc starch were used. Data in literature indicates a low protein content for manioc starch, ranging from 0.38 to 0.90, while data for sweet and sour yam starch showed higher protein values, of 2.45 and 2.05, respectively. When comparing data on a dry basis with that in literature, the average ash content was the same as those contained in the references. Concerning the dry basis moisture content, the values obtained for sweet and sour starch were 16.45 and 13.24, respectively, which are high when compared with information found in literature, which indicates a moisture level of 11.71, which meets the legislation standard (Aplevicz, 2006; Brasil, 1978). Thus, for sweet and sour starch, the values exceeded the standard, which is 13.0%.

The proximate composition of foods per 100 g of edible portion is described in Table 3.

Table 3. Proximate composition of foods per 100 g of edible portion

Parameters	Cooked Yam	Yam <i>in nature</i>
Humidity (%)	78.8	73.7
Energy (Kcal)	78	96
Protein (g)	1.5	2.3
Lipids (g)	0.1	0.1
Carbohydrates (%)	18.9	23.0
Food Fiber (%)	2.6	7.3
Ashes (g)	0.6	0.9
Vitamin C (mg)	Tr	8.8

Note. Tr = trace.

Source: TACO, 2011.

Table 4 shows the mineral content of foods per 100 g of edible portion.

Table 4. Proximate composition of foods per 100 g of edible portion

Parameters	Cooked Yam	Yam <i>in nature</i>
Calcium (mg)	5	4
Magnesium (mg)	15	11
Manganese (mg)	0.02	0.01
Phosphorus (mg)	28	35
Iron (mg)	0.3	0.2
Sodium (mg)	1.0	Tr
Potassium (mg)	203	212

Note. Tr = trace.

Source: TACO, 2011.

We can see that yam is a source of carbohydrates and potassium. With regard to the products made from this raw material, we can cite ice cream, *vatapa* (Note 3), bread, pudding, cake, *brigadeiro* (Note 4), mousse, candies, pies made with fresh *pirarucu* (Note 5), *pé de moleque* (Note 6), and flours.

With respect to byproducts made from starch, it is worth noting that, in general, the byproducts had better acceptance of their conventional production and with 5% of starch. Probably, the low acceptance of the product was a consequence of the tendency that starch has to change the food appearance (own observation). For cake, treatment A (control) achieved better acceptance for all variables, followed by treatment B and C (5% and 10% of yam starch, respectively), considered good with regard to appearance and color (Table 5).

Table 5. Acceptance test based on sensory evaluation of cake samples

Variables	Treatments				
	A	B	C	D	E
Appearance	7.96 a	7.34 a	7.44 a	6.90 ab	5.74 b
Texture	7.96 a	7.48 ab	7.28 ab	6.98 ab	6.16 b
Color	7.84 a	7.54 a	7.54 a	6.78 ab	5.90 b
Aroma	7.94 a	7.24 ab	7.12 ab	7.30 ab	6.52 b
Flavor	7.96 a	7.54 ab	7.14 ab	7.76 ab	6.72 b
Global Analysis	7.82 a	7.64 a	7.34 ab	7.16 ab	6.18 b

Note. * Significant at 5% probability level by the F-test.

With respect to biscuit, for the variable taste, the best acceptance was for treatment A (control), but for the other characteristics, the best treatment was with 5% of starch. Considering that it achieved a preponderant acceptance compared with the other treatments, it could be used for partial replacement of wheat (Table 6).

Table 6. Acceptance test based on sensory evaluation of biscuit samples

Variables	Treatment				
	A	B	C	D	E
Appearance	7.14 ab	7.78 a	7.08 ab	6.48 bc	5.60 c
Texture	7.08 b	7.88 a	6.88 ab	6.90 ab	6.16 b
Color	7.36 ab	7.80 a	7.18 bc	6.64 c	5.82 d
Aroma	7.10 ab	7.72 a	7.18 ab	7.06 ab	6.62 b
Flavor	7.42 a	8.06 ab	7.12 bc	6.98 bc	6.60 c
Global Analysis	7.06 ab	7.68 a	6.84 b	6.50 bc	6.00 c

Note. * Significant at 5% probability level by the F-test.

In the production of pasta, the best treatments were A (control) and B (5% of starch), and treatment A had better acceptance for aroma when compared to B, and better taste compared with the control (Table 7).

Table 7. Acceptance test based on sensory evaluation of pasta samples

Variables	Treatment				
	A	B	C	D	E
Appearance	6.50 a	6.44 a	5.52 b	5.30 b	5.32 b
Texture	6.74 a	6.70 a	6.14 b	6.04 b	6.22 b
Color	6.78 a	6.48 a	5.74 b	5.60 b	5.56 b
Aroma	6.26 a	6.04 ab	6.00 ab	5.80 b	6.10 ab
Flavor	6.10 bc	6.56 a	5.56 d	5.76 cd	6.18 b
Global Analysis	6.28 ab	6.62 a	6.06 b	6.10 b	6.10 b

Note. * Significant at 5% probability level by the F-test.

The best treatment for pancake production was treatment A (control) for all variables, followed by treatment E (20% of starch) which had good acceptance with regard to the variables appearance, color, aroma and taste (Table 8).

Table 8. Acceptance test based on sensory evaluation of pancake samples

Variables	Treatments				
	A	B	C	D	E
Appearance	6.90 a	6.52 ab	6.24 ab	5.42 b	7.10 a
Texture	6.58 a	6.42 b	6.40 b	5.48 c	6.54 ab
Color	6.86 a	6.62 a	6.30 a	5.56 b	6.84 a
Aroma	6.76 a	6.56 ab	6.20 bc	5.90 c	6.86 a
Flavor	6.56 a	5.94 ab	5.54 b	5.28 b	6.54 a
Global Analysis	6.48 a	5.96 ab	5.64 bc	5.18 c	6.16 ab

Note. * Significant at 5% probability level by the F-test.

For bread, the best treatment was A (control) for the majority of the parameters, but for aroma, treatment E (20% of starch) achieved the best acceptance (Table 9).

Table 9. Acceptance test based on sensory evaluation of bread samples

Variables	Treatments				
	A	B	C	D	E
Appearance	6.98 a	6.18 b	6.06 b	5.82 b	5.88 b
Texture	6.78 a	6.18 b	5.86 bc	5.94 bc	5.60 c
Color	7.00 a	6.54 b	6.38 b	6.22 b	6.30 b
Aroma	6.10 c	6.24 c	6.72 ab	6.42 bc	6.86 a
Flavor	7.14 a	6.88 ab	6.62 b	6.78 ab	6.96 ab
Global Analysis	6.84 a	6.46 ab	6.66 b	6.18 b	6.60 ab

Note. * Significant at 5% probability level by the F-test.

For the production of pizza, the best treatment was A (control), which achieved good acceptance for the most of the variables, except for aroma, followed by treatment B (5% of starch), which had good acceptance with respect to color, aroma and overall impression (Table 10).

Table 10. Acceptance test based on the sensory evaluation of pizza samples

Variables	Treatments				
	A	B	C	D	E
Appearance	6,80 a	6,68 ab	6,64 ab	6,36 b	6,00 c
Texture	6,88 a	6,52 abc	6,76 ab	6,40 bc	6,30 c
Color	6,94 a	7,06 a	6,50 b	6,22 c	6,10 c
Aroma	6,84 ab	6,96 a	6,78 ab	6,48 b	6,88 ab
Flavor	7,27 a	7,00 ab	6,88 bc	6,68 c	6,76 bc
Global Analysis	6,98 a	7,02 a	6,70 ab	6,44 b	6,34 b

Note. * Significant at 5% probability level by the F-test.

Considering that in the overall evaluation (which comprises appearance, texture, color, aroma and taste), we can see that for pizza, bread and cake the best treatments were for 0 and 5% of yam starch. For the other byproducts, the best treatment was the control (Figure 1).

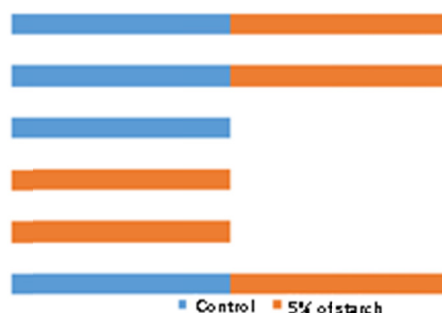


Figure 1. Acceptance test based on the overall evaluation of byproducts made with yam starch

5. Conclusion

The study allowed to conclude that partial replacement of wheat flour by yam starch to make biscuits, cake, pasta, pancake, bread and pizza is possible, and the quality of the product varies according to the percentage of starch used.

Of the diverse recipes tested, the best result was for 5% of yam starch in cake, biscuit, pasta and pizza. For pancake, the best treatment was for partial replacement with 20% of yam starch.

The other byproducts achieved better acceptance using the conventional ingredients. Probably, the low acceptance was due to the tendency that yam starch has to change the appearance, texture, color, aroma, and taste.

The production of yam starch as an alternative of income generation can result in more productivity, allowing, in addition to an increased offer of the product, knowledge of future generations on the importance of this culture, which is unquestionable. But it is still necessary more studies with other byproducts made with yam starch for a better knowledge on the use of this tuber.

Acknowledgements

This study was financed in party by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-Brazil (CAPES) and published with the financed support of the Programa de Apoio à Publicação de Artigos Científicos of the Fundação de Amparo à Pesquisa do Estado do Amazonas (PAPAC/FAPEAM).

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Notes

Note 1. Residents of *quilombo* settlements first established by fugitive slaves.

Note 2. Brazilian gluten-free cookies made with corn starch.

Note 3. *Vatapá* is a typical food of Bahia, made from bread, shrimp, coconut milk, and other ingredients, which are mashed into a creamy paste.

Note 4. *Brigadeiro* is a typical Brazilian sweet made from condensed milk and chocolate.

Note 5. *Pirarucu* is a large freshwater fish of Brazilian rivers.

Note 6. *Pé-de-moleque* is a traditional candy made of peanuts and sugar.

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