Journal of Food Security, 2021, Vol. 9, No. 2, 76-84
Available online at http://pubs.sciepub.com/jfs/9/2/5
Published by Science and Education Publishing
DOI:10.12691/jfs-9-2-5

Study of Yeasts Characteristics Isolated from the Fermented Peelings of Yams: Research of New Sources of Fermentative Strains

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Received March 05, 2021; Revised April 11, 2021; Accepted April 21, 2021

Abstract Yeast strains were isolated in this study from the perspective of fermentation technology. For this study, fermented peelings of three varieties of yam namely <<Bètè-bètè>>, «Kponan» and «Krenglè» were analyzed. The charge of yeasts were 124000 UFC, 3200 CFU, and 118000 CFU respectively for the fermented peelings of the varieties <<Bètè bètè>>, <<Kponan>> and <<Krenglè>>. Five species were identified by VITEK® 2 Systems method. Indeed, strains of *Candida ciferrii*, *Candida famata*, *Candida lusitaniea*, *Cryptococcus laurentii* and *Trichosporon mucoides* were isolated and identified. However, the predominance species were *Candida ciferrii*, and *Candida famata*. The strains of all the yeasts species had positive assimilation for the majority of carbon and nitrogen compounds tested. These yeasts showed also activities mainly for leucine-arylamidase, beta-N-acetyl-glucosaminidase, gamma-glutamyl-transferase, PNP-N-acetyl-BD-galactosaminidase 1 and alpha-glucosidase. The characteristics of these yeasts show thus great perspective of fermentation technology. Our work is the first ever on yeast diversity from fermented peelings of yams.

Keywords: *yam, fermented peelings, yeasts, carbon and nitrogen compounds assimilation, enzymatic activity*

Cite This Article: Armand Gildas Elvis Yao N'DRI, and Irène Ahou KOUADIO, "Study of Yeasts Characteristics Isolated from the Fermented Peelings of Yams: Research of New Sources of Fermentative Strains." *Journal of Food Security*, vol. 9, no. 2 (2021): 76-84. doi: 10.12691/jfs-9-2-5.

1. Introduction

Yams (*Dioscorea spp.)* are produced mainly in West African countries including Côte d'Ivoire [1]. This country is the second largest producer of this commodity in the world after Nigeria [2]. In all the producers' countries, yams are the staple food of over 500 million people [3,4]. They play thus, an important role in the food security of the producer countries [5,6,7]. However, the consumption of yam leads to the increasing of the peelings of yams rejected in the dump. These peelings of yams rejected in the environment increase the household. As it is known, the decomposition of the household leads to biogas formation such as methanol which is harmful for the environment. Moreover, the peelings of yam stored as household waste represent a loss of 10 to 15% of the weight of fresh yam in culinary processes [8]. It is also noted that, the socio-economical activities, the demographic and urban development increase this household waste. In West African countries including Côte d'Ivoire, the only use of the peelings of yam is to feed the sheep [9]. However, a little part of these peelings of yam is used as feed mainly in rural zones. In urban zones, all the peelings of yam are rejected in dump without any prospect of valuation. It is thus interesting to find out solutions to valorize these peelings of yam and reduce the household waste which decomposition in dump leads to production of biogas such as methanol which creates a large pollution of the environment. Previous studies have shown that the peelings of yam contain in addition to macronutrients, a higher protein content (12.2%) compared to the peelings of other tubers. Indeed, [9] showed that the peelings of yam have an organic matter content (93.97% ± 0.25) statistically identical to those of cassava (94.67% ± 0.02) and higher than those of sweet potatoes (92.82% ± 0.14). These peelings of yam could thus be used for other purposes. Indeed, previous other studies have shown that peelings of yam could be used for citric acid production. These studies showed that the fermentation of the peelings of yam led to the production of citric acid (8.4g/Kg) higher than those obtained with peelings of plantain (4.7g/kg), peelings of potato (6.6 g/Kg) and cassava (8.2 g/Kg) [10]. Thus, fermentation offers possibilities for using these peelings of yam. Indeed, fermentation of the peelings of yam could lead to the development of microorganisms such us yeasts which could possess industrial interest. The characterization of these yeasts which could possess good technological properties could be new solutions of valorization of the peelings of yams.

Thus, this study was carried out in order to characterize yeasts isolated from the fermented peelings of three varieties of yam more consumed in Côte d'Ivoire in order to find out new microbial strains from the perspective of fermentation technology.

2. Material

2.1. Biological Material

The biological material was the peelings of yams. For this study, three varieties of yam more consumed in Côte d'Ivoire were used [11]. Two of these varieties namely «Kponan» and « Krenglè » belong to the species *Dioscorea cayenensis-rotundata* and the other one namely «Bètè-bètè» belongs to the species *Dioscorea alata* (Figure 1). For each variety of yam, three samples were taken and the peelings of these three samples were mixed to obtain a lot of peelings. Each lot of peelings was put in sterile stomacher bag which was then hermetically closed for natural fermentation during seven days.

2.2. Methods

2.2.1. Yeasts' Isolation

For yeasts' isolation, a quantity of 10 g of each sample of fermented peelings of yams of each variety was added separately to 90 mL sterile peptone water contained in sterile bottle and the whole was shaken. From the suspension obtained, a 0.1 mL aliquot was surface plated onto the medium (Sabouraud with 1% of Chloramphenicol) as quickly and carefully as possible. The medium inoculated was incubated at 30°C for 3 days after which the number of fungi were demined [12].

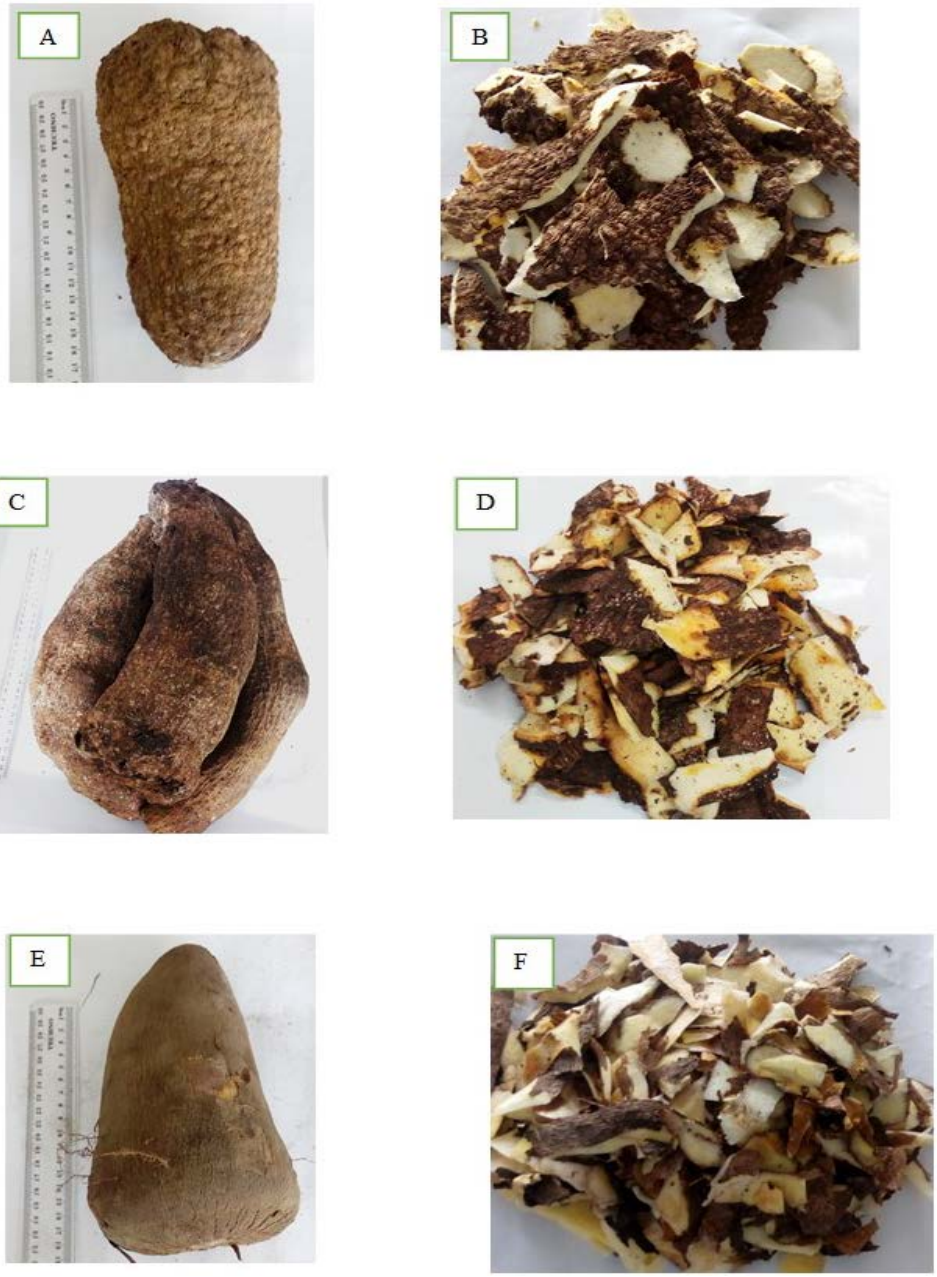

Figure 1. Tuber and peelings of the three varieties of yam: (A): Tuber of «Krèglè»; (B): Peelings of «Krèglè»; (C): Tuber of «Bètè-Bètè»; (D): Peelings of «Bètè-Bètè»; (E): Tuber of «Kponan»; (F): Peelings of «Bètè-Bètè»

2.2.2. Yeast Identification

The identification was carried out using the method of VITEK® 2 Systems. The microplate contains 46 biochemical tests determining the use of carbon sources, the use of nitrogen sources and enzymatic activity. The results were obtained in 18 hours. The carbon sources, the nitrogen sources and enzymes are in separate wells of microplate. The study was carried out by inoculating each colony of yeast firstly into liquid medium of Sabouraud with 1% Chloramphenicol and incubated at 30°C for 24 hours. After this incubation time, all the wells of the microplate were filled with 100 µL of the starved yeast cell suspension. The microplate inoculated by yeast suspension was incubation for 18 hours.

After this incubation time, the use of carbon sources, the use of nitrogen sources and enzymatic activity were noted by eye using the descriptors established by [13]. Then, the species were identified by using the card of VITEK® 2 Systems of biochemical characteristics of yeasts.

3. Results

3.1. Fungal Charge

The counting of yeasts colonies showed that the number of yeasts were 124000 UFC, 3200 CFU, and 118000 CFU respectively for the fermented peelings of the varieties <<Bètè bètè>>, <<Kponan>> and <<Krenglè>> (Figure 2). The analysis shows significant difference between the numbers of yeasts isolated from the fermented peelings of the three varieties of yam ($P<0.05$).

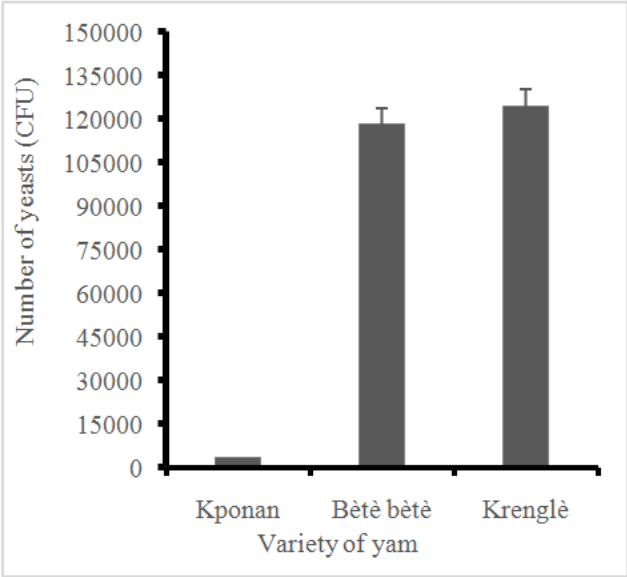

Figure 2. Charge of yeasts of the fermented peelings of the three varieties of yam

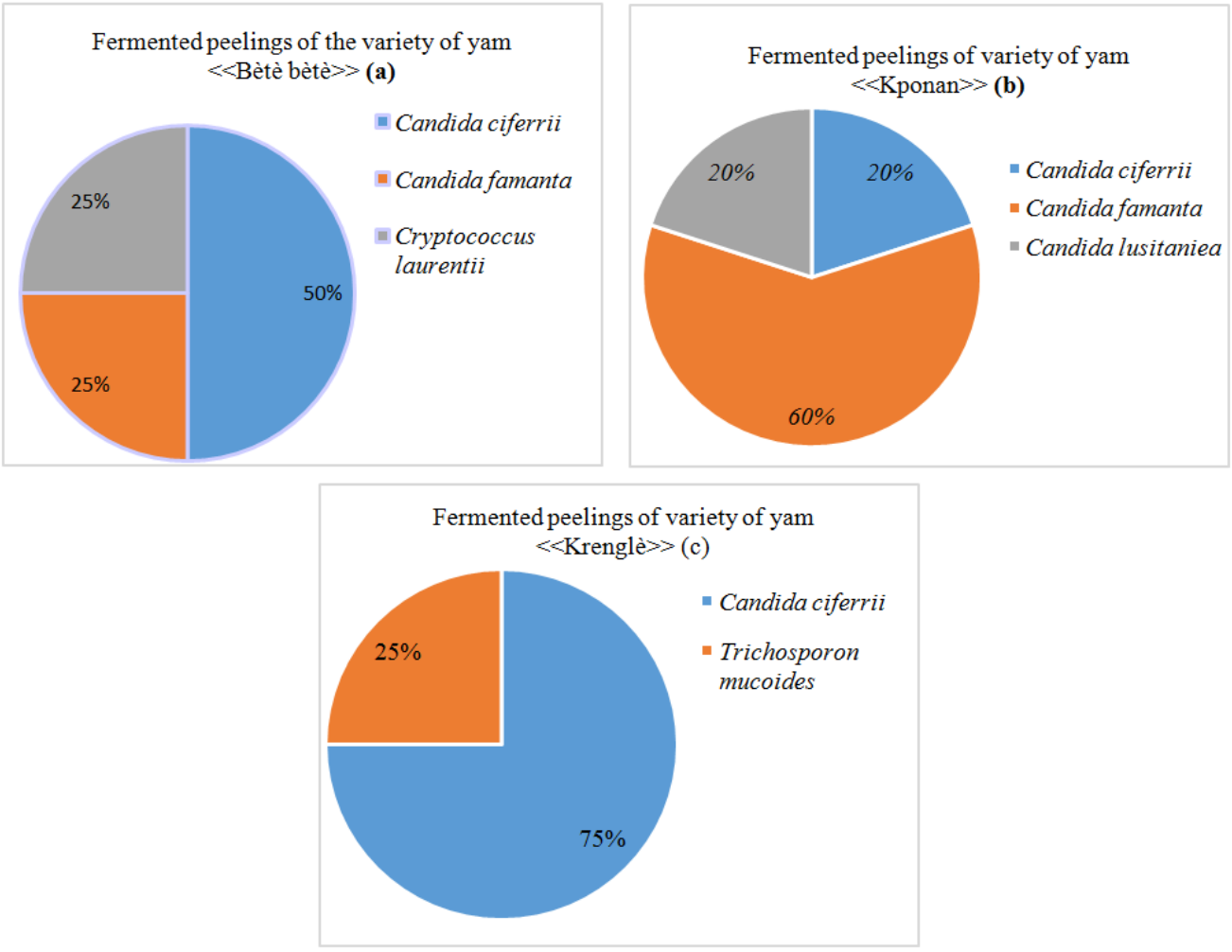

Figure 3. Frequency of yeasts species isolated and identified from the fermented peelings of three varieties of yam (Bètè bètè, Kponan and Krenglè)

3.2. Yeasts Identified

The identification tests showed a small variation of yeast species isolated from the fermented peelings of the three varieties of yam (Figure 3 a, b, c). Indeed, from the fermented peelings of the variety of yam <<Bètè bètè>>, the yeasts species identified were *Candida ciferrii* (50%), *Candida famanta* (25%) and *Cryptococcus laurentii* (25%). For the variety of yam <<Kponan>>, the species of yeasts identified from the fermented peelings were *Candida famata* (60%), *Candida ciferrii* (20%) and *Candida lusitaniea* (20%). For the variety of yam <<Krenglè>>, the species of yeasts identified from the fermented peelings were *Candida ciferrii* (75%) and *Trichosporon mucoides* (25%). Moreover, it is noted that, among the species isolated, *Candida ciferrii* was found in the fermented peelings of the three varieties of yam while *Candida famata* was isolated in the peelings of varieties <<Bêtê bêtê>> and <<Kponan>>. Moreover, the species of *Cryptococcus laurentii*, *Candida lusitaniea* and *Trichosporon mucoides* were isolated respectively only from the peelings of the varieties of yam <<Bêtê bêtê>>, <<Kponan>> and <<Krenglè>>.

3.3. Assimilation of Carbon and Nitrogen Compounds

The study of the assimilation of carbon and nitrogen compounds by yeasts isolated, showed a variability in the assimilation of these compounds within the stains of some species whatever the fermented peelings of the variety of yam. This suggest the existence of sub-groups of strains. Indeed, the strains of the species *Candida ciferrii* isolated and identified from the fermented peelings of the variety of yam <<Bètè bètè>> were divided into two sub-groups (sub-group A and sub-group B). However, the majority of compounds showed similar assimilation profiles for the two sub-groups of strains of *Candida ciferrii*. Indeed, the two sub-groups of strains had a positive assimilation for D-glucose, gentiobiose, D-maltose, D-galactose, D-trehalose, saccharose, D-teranose, D-mannose, D-maltose, D-mélibiose, L-glutamate, L-proline, L-malate, xylitol, 2-ceto-D-gluconate, arbutin, D-sorbitol, arginine, erythritol, glycerol, glucoronate, DL-lactate, N-acetyl-glucosamine, L-arabinose, acetate, D-galacturonate, citrate, L-sorbose and glucoronate (Table 1). For D-raffinose, L-rhamnose, lactose, D-xylose, nitrate, amygdaline, D-cellobiose, D-melezitose and L-sorbose, these two sub-groups of strains had negative assimilation. However, this similarity in assimilation was noted for the compounds above except for D-turanose, methyl-A-D-glucopyranoside and hydrolyze of esculin for which the sub-group A of strains had negative assimilated while the sub-group B had positive assimilation (Table 1).

For the second type of species (*Candida famata*) isolated from the fermented peelings of the variety of yam <<Bètè bètè>>, the strains had positive assimilation for D-glucose, D-turanose, L-glutamate, L-proline, L-malate, xylitol, D-trehalose, D-xylose, 2-ceto-D-gluconate, arbutin, methyl-A-D-glucopyranoside, D-mannose, D-sorbitol, N-acetyl-glucosamine, arginine, D-melibiose, saccharose; acetate, D-gluconate, D-galactose, D-melezitose, D-galacturonate, citrate of sodium, glycerol, gentiobiose, D-maltose, glucoronate and hydrolyze of esculin. However, these strains had negative assimilation for D-raffinose, L-rhamnose, lactose, nitrate, DL-lactate, amygdalin, D-cellobiose, erythritol, L-arabinose and L-sorbose (Table 1).

The third type of species isolated from the peelings of the variety of yam <<Bètè bètè>> was *Cryptococcus laurentii*. The biochemical tests showed that the strains of this species had positive assimilation for the majority of compounds tested (Table 1). Indeed, they had positive assimilation for L-malate, arginine, erythritol, glycerol, arbutin, D-galactose, gentiobiose, D-glucose, lactose, D-cellobiose, D-maltose, D-raffinose, D-mannose, D-melibiose, D-melezitose,, L-rhamnose, xylitol, D-sorbitol, saccharose, D-turanose, D-trehalose, L-arabinose, D-galacturonate, L-glutamate, DL-lactate, acetate, citrate (sodium), glucoronate, L-proline, 2-ceto-d-gluconate, n-acetyl-glucosamine, D-gluconate and hydrolyze of esculin.

However, these strains of *Cryptococcus laurentii* had negative assimilation for D-xylose, methyl-A-D-glucopyranoside, nitrate, amygdaline and urease (Table 1).

For the variety of yam <<Kponan>>, the yeasts isolated from the fermented peelings showed also a variability in the assimilation of carbon and nitrogen compounds within the stains of the species of yeasts identified. Indeed, two sub-groups of *Candida famata* were identified. These sub-groups had however a similar assimilation for the majority of compounds tested (Table 2). Indeed, the two sub-groups of strains of *Candida famata* had positive assimilation for D-glucose, D-turanose, L-glutamate, L-proline, L-malate, D-sorbitol, D-trehalose, 2-ceto-d-gluconate, arbutin, methyl-A-D-glucopyranoside, D-mannose, D-sorbitol, N-acetyl-glucosamine, arginine, D-melibiose, saccharose, acetate, D-gluconate, D-galactose, D-melezitose, D-galacturonate, citrate (sodium), gentiobiose, D-maltose and glucoronate. Besides these compounds mentioned above, the two sub-groups of strains of *Candida famata* had negative assimilation for erythritol, L-sorbose, L-arabinose, nitrate, DL-lactate and lactose (Table 2). However, the difference between the two sub-groups of strains of *Candida famata* was noted for the assimilation profiles of 5 compounds. Indeed, for D-raffinose and D-cellobiose, the sub-group A had positive assimilation while the sub-group B had negative assimilation. For D-xylose, glycerol and esculin, the sub-group A had negative assimilation while the sub-group B had positive assimilation (Table 2).

The second type of species identified from the fermented peelings of the variety of yam <<Pkonan>> was *Candida lusitaniae*. The strains of this species had positive assimilation for glucose, L-rhamnose, D-turanose, L-glutamate, L-proline, L-malate, xylitol, D-trehalose, D-xylose, 2-ceto-D-gluconate, arbutine, methyl-A-D-glucopyranoside, D-mannose, D-sorbitol, DL-lactate, N-acetyl-glucosamine, arginine, amygdaline, D-cellobiose, D-melibiose, saccharose, acetate, D-gluconate, erythritol, D-galactose, D-melezitose, D-galacturonate, citrate (sodium), gentiobiose, D-maltose, L-sorbose, esculine and glucoronate. However, for D-raffinose, lactose, nitrate, L-arabinose and glycerol, the strains of this species had negative assimilation (Table 2).

The strains of *candida ciferrii* were also isolated and identified from the fermented peelings of the variety of

yam <<Kponan>>. These strains of *candida ciferrii* had positive assimilation for the majority of the compounds tested (Table 2). Indeed, they had positive assimilation for L-malate, arginine, erythritol, glycerol, arbutine, D-galactose, gentiobiose, D-glucose, D-maltose, D-mannose, D-melibiose, xylitol, D-sorbitol, saccharose, L-arabinose, D-galacturonate, hydrolyze of esculine, L-glutamate, DL-lactate, acetate, citrate (sodium), glucoronate, L-proline, 2-ceto-D-gluconate, N-acetyl-glucosamine and D-gluconate.

However, they had negative assimilation for lactose, methyl-A-D-glucopyranoside, D-cellobiose, D-raffinose, D-melezitose, L-sorbose, L-rhamnose, D-turanose, D-tréhalose, nitrate and D-xylose (Table 2).

For the variety of yam <<Krenglè>>, the biochemical tests showed also a variability in the assimilation of carbon and nitrogen compounds within the stains of the species of yeasts isolated from the fermented peelings. Indeed, for the species *Candida ciferrii* isolated from these fermented peelings, three sub-groups of strains were identified. However, these three sub-groups of strains had similar assimilation for the majority of compounds tested (Table 3). Indeed, they had positive assimilation for L-malate, arginine, erythritol, arbutine, D-galactose, gentiobiose, D-glucose, D-maltose, D-mannose, D-Melibiose, xylitol, D-sorbitol, saccharose, D-trehalose, D-galacturonate, L-glutamate, DL-lactate, acetate, citrate (sodium), glucoronate, L-proline, 2-ceto-d-gluconate, N-acetyl-glucosamine and D-gluconate. For amygdaline, lactose, methyl-A-D-glucopyranoside, D-cellobiose, D-raffinose, D-melezitose, L-sorbose, L-rhamnose, nitrate and hydrolyze of esculine, the three sub-groups of strains had negative assimilation (Table 3). However, besides this similarity, differences were observed between the three sub-groups of strains of *candida ciferrii*. Indeed, for glycerol, the sub-groups A and C had negative assimilation, while the sub-group B and had positive assimilation. For D-turanose, the sub-group A had positive assimilation while the sub-groups B and C had negative assimilation. For L-arabinose, the sub-groups A and C had positive assimilation while the sub-group B had negative assimilation. For D-xylose, the sub-groups A and B had negative assimilation while the sub-group C had positive assimilation (Table 3).

Table 1. Carbon and nitrogen assimilation by strains of yeasts isolated from the fermented peelings of the variety of yam <<Bètè bètè>>

Yeasts strains / **Carbon and nitrogen compounds**	*Candida ciferrii* (Sub-group A)	*Candida ciferrii* (Sub-group B)	*Candida famata*	*Cryptococcus laurentii*
L−malate	+	+	+	+
Arginine	+	+	+	+
Erythritol	+	+	-	+
Glycerol	+	+	+	+
Arbutin	+	+	+	+
Amygdalin	-	-	-	-
D−Galactose	+	+	+	+
Gentiobiose	+	+	+	+
D−Glucose	+	+	+	+
Lactose	-	-	-	+
Methyl−A-D−Glucopyranoside	-	+	+	-
D−Cellobiose	-	-	-	+
D−Maltose	+	+	+	+
D−raffinose	-	-	-	+
D−Mannose	+	+	+	+
D−Melibiose	+	+	+	+
D−Melezitose	-	-	+	+
L−Sorbose	-	-	-	-
L−Rhamnose	-	-	-	+
Xylitol	+	+	+	+
D−Sorbitol	+	+	+	+
Saccharose	+	+	+	+
D−Turanose	-	+	+	+
D−Trehalose	+	+	+	+
Nitrate	-	-	-	-
L−Arabinose	+	+	-	+
D−Galacturonate	+	+	+	+
Esculine	-	+	+	+
L−Glutamate	+	+	+	+
D−Xylose	-	-	+	-
DL−Lactate	+	+	-	+
Acetate	+	+	+	+
Citrate (sodium)	+	+	+	+
Glucuronate	+	+	+	+
L−Proline	+	+	+	+
2-Ceto-D−Gluconate	+	+	+	+
N−Acetyl-Glucosamine	+	+	+	+
D−Gluconate	+	+	+	+

(-): Negative assimilation
(+): Positive assimilation

Table 2. Carbon and nitrogen assimilation by strains of yeasts isolated from the fermented peelings of the variety of yam <<Kponan>>

Yeasts strains / Carbon and nitrogen compounds	*Candida famata* (Sub-group A)	*Candida famata* (Sub-group B)	*Candida ciferrii*	*Candida lusitaniea*
L-malate	+	+	+	+
Arginine	+	+	+	+
Erythritol	-	-	+	+
Glycerol	-	+	+	-
Arbutin	+	+	+	+
Amygdalin	-	-	-	+
D-Galactose	+	+	+	+
Gentiobiose	+	+	+	+
D-Glucose	+	+	+	+
Lactose	-	-	-	-
Methyl-A-D-Glucopyranoside	+	+	-	+
D-Cellobiose	+	-	-	+
D-Maltose	+	+	+	+
D-raffinose	+	-	-	-
D-Mannose	+	+	+	+
D-Melibiose	+	+	+	+
D-Melezitose	+	+	-	+
L-Sorbose	-	-	-	+
L-Rhamnose	-	-	-	+
Xylitol	+	+	+	+
D-Sorbitol	+	+	+	+
Saccharose	+	+	+	+
D-Turanose	+	+	-	+
D-Trehalose	+	+	+	+
Nitrate	-	-	-	-
L-Arabinose	-	-	+	-
D-Galacturonate	+	+	+	+
Esculine	-	+	+	+
L-Glutamate	+	+	+	+
D-Xylose	-	+	-	+
DL-Lactate	-	-	+	+
Acetate	+	+	+	+
Citrate (sodium)	+	+	+	+
Glucuronate	+	+	+	+
L-Proline	+	+	+	+
2-Ceto-D-Gluconate	+	+	+	+
N-Acetyl-Glucosamine	+	+	+	+
D-Gluconate	+	+	+	+

(-): Negative assimilation
(+): Positive assimilation

Table 3. Carbon and nitrogen assimilation by strains of yeasts isolated from the fermented peelings of the variety of yam <<Krenglè>>

Yeasts strains / Carbon and nitrogen compounds	*Candida ciferrii* (Sub-group A)	*Candida ciferrii* (Sub-group B)	*Candida ciferrii* (Sub-group C)	*Trichosporon mucoides*
L−malate	+	+	+	+
Arginine	+	+	+	+
Erythritol	+	+	+	-
Glycerol	-	+	-	+
Arbutin	+	+	+	+
Amygdalin	-	-	-	-
D−Galactose	+	+	+	+
Gentiobiose	+	+	+	+
D−Glucose	+	+	+	+
Lactose	-	-	-	+
Methyl−A-D−Glucopyranoside	-	-	-	-
D−Cellobiose	-	-	-	+
D−Maltose	+	+	+	+

Yeasts strains / Carbon and nitrogen compounds	*Candida ciferrii* (Sub-group A)	*Candida ciferrii* (Sub-group B)	*Candida ciferrii* (Sub-group C)	*Trichosporon mucoides*
D−raffinose	-	-	-	+
D−Mannose	+	+	+	+
D−Melibiose	+	+	+	+
D−Melezitose	-	-	-	+
L−Sorbose	-	-	-	-
L−Rhamnose	-	-	-	+
Xylitol	+	+	+	+
D−Sorbitol	+	+	+	+
Saccharose	+	+	+	+
D−Turanose	+	-	-	+
D−Trehalose	+	+	+	+
Nitrate	-	-	-	-
L−Arabinose	+	-	+	+
D−Galacturonate	+	+	+	+
Esculine	-	-	-	+
L−Glutamate	+	+	+	+
D−Xylose	-	-	+	+
DL−Lactate	+	+	+	+
Acetate	+	+	+	+
Citrate (sodium)	+	+	+	+
Glucuronate	+	+	+	+
L−Proline	+	+	+	+
2-Ceto-D−Gluconate	+	+	+	+
N−Acetyl-Glucosamine	+	+	+	+
D−Gluconate	+	+	+	+

(-): Negative assimilation
(+): Positive assimilation.

The second type of species isolated from the fermented peelings of the variety of yam <<Krenglè>> was *Trichosporon mucoides*. The strains of this species had positive assimilation for glucose, maltose, saccharose, galactose, lactose, D-raffinose, inositol, cellobiose, D-trehalose, D-melezitose, D-xylose, L-arabinose, L-malate, arginine, glycerol, arbutine, gentiobiose, D-mannose, D-melibiose, L-rhamnose, D-sorbitol, D-turanose, D-galacturonate, hydrolyze esculine, L-glutamate, DL-lactate, acetate, citrate (sodium), glucoronate, L-proline, 2-ceto-D-gluconate and D-gluconate. These strains of *Trichosporon mucoides* had however negative assimilation for adonitol, erythritol, amygdaline, methyl-A-D-glucopyranoside, L-sorbose, urease, nitrate and N-acetyl-glucosamine (Table 3).

3.4. Enzymes Activity

The two sub-groups (Sub-groups A and B) of strains of *candida ciferrii* isolated from the fermented peelings of the variety of yam <<Bètè bètè>> showed activities for beta-N-acetyl-glucosaminidase, leucine-arylamidase and gamma-glutamyl-transferase. However, for PNP-N-acetyl-BD-galactosaminidase 1 and alpha-glucosidase, the sub-group B showed activities, while no activities were shown by the sub-group A (Table 4). Moreover, for urease, the strains of the sub-group A showed activity, while the strains of sub-group B didn't show any activity.

Table 4. Enzymatic activities of yeast strains isolated from the fermented peelings of the three varieties of yam

Yeasts / Enzymes		1	2	3	4	5	6	7	8
Variety of yam Bètè bètè	*Candida ciferrii* (Sub-group A)	-	+	-	+	+	-	+	-
	Candida ciferrii (Sub-group B)	-	+	-	+	+	+	-	+
	Candida famata	-	+	-	+	-	-	-	+
	Cryptococcus laurentii	-	+	-	+	+	-	-	+
Variety of yam Kponan	*Candida ciferrii*	-	+	-	+	+	-	+	-
	Candida famata (sub-group A)	-	+	-	+	-	-	-	+
	Candida famata (sub-group B)	-	+	-	+	-	-	-	+
	Candida lusitaniea	-	+	-	+	-	-	-	+
Variety of yam Krenglè	*Candida ciferrii* (sub-group A)	-	+	-	+	+	-	-	-
	Candida ciferrii (sub-group B)	-	+	-	+	+	-	+	-
	Candida ciferrii (sub-group C)	-	+	+	+	-	-	+	-
	Trichosporon mucoides	-	+	-	+	+	+	-	+

(+): Enzymatic activity
(-): No enzymatic activity
1)- L-lysine-arylamidase; **2)**-Leucine-arylamidase; **3)**-Tyrosine-Arylamidase; **4)**- Beta-N-Acetyl-Glucosaminidase; **5)**- Gamma-Glutamyl-Transferase; **6)**-PNP-N-acetyl-BD−galactosaminidase 1; **7)**- Alpha-glucosidase; **8)**- Urease

For the second type of species (*Candida famata*) isolated from the fermented peelings of the variety of yam <<Bètè bètè>>, the strains showed activities for beta-N-acetyl-glucosaminidase, leucine-arylamidase and alpha-glucosidase (Table 4). For the third type of species isolated from the peelings of the variety of yam <<Bètè bètè>> (*Cryptococcus laurentii*), the strains showed activities for leucine-arylamidase, beta-N-acetyl-glucosaminidase, gamma-glutamyl-transferase and alpha-glucosidase (Table 4).

For the variety of yam <<Kponan>>, the two sub-groups of strains of *Candida famata* isolated from the fermented peelings showed activities for beta-N-acetyl-glucosaminidase, leucine-arylamidase and alpha-glucosidase (Table 4). The second type of species identified from the fermented peelings of the variety of yam <<Pkonan>> was *Candida lusitaniae*. The strains of this species showed also activities for beta-N -acetyl-glucosaminidase, leucine-arylamidase and alpha-glucosidase (Table 4). The strains of *candida ciferrii* were also identified from the fermented peelings of the variety of yam <<Kponan>>. These strains of *candida ciferrii* showed activities for leucine-arylamidase, beta-N-acetyl-glucosaminidase, gamma-glutamyl-transferase and urease (Table 4).

For the variety of yam <<Krenglè>>, three sub-groups (Sub-groups A, B and C) of strains of *Candida ciferrii* were isolated from the fermented peelings. These three sub-groups of strains showed activities for leucine-arylamidase and beta-N-acetyl-glucosaminidase. However, for tyrosine-arylamidase, the sub-group C showed activity while the sub-groups A and B didn't show any activity. For gamma-glutamyl-transferase, the sub-groups A and B showed activity, while the sub-group C didn't show any activity (Table 4). For urease, the sub-groups B and C showed activity while the sub-group A didn't show any activity. The second type of species isolated from the fermented peelings of the variety of yam <<Krenglè>> was *Trichosporon mucoides*. The strains of this species showed activities for leucine-arylamidase, beta-N-acetyl-glucosaminidase, gamma-glutamyl-transferase, PNP-N-acetyl-BD-galactosaminidase 1 and alpha-glucosidase (Table 4).

4. Discussion

This study which is a contribution for the identification of new source of yeast strains for the perspective of fermentation technology was started by the evaluation of the charge of yeasts of the fermented peelings of yam of three varieties of yam (<<Bètè-bètè>>, <<Krenglè>> and <<Kponan>>) more consumed in Côte d'Ivoire. The charge of yeasts for the fermented peelings of the variety of yam <<Bètè-bètè>> was more important than that obtained with the fermented peelings of the variety of yam <<Krenglè>> which was followed by that obtained with the fermented peelings of the variety of yam <<Kponan>>. These varieties of yam are tubers rich in carbohydrates which are components important for the development of yeasts as it was shown in previous study [14]. Thus, this suggests that the peelings of the variety <<Bètè-bètè>> are richer in these carbohydrates than the amount of these compounds in the fermented peelings of the variety <<Krenglè>>. This amount is followed by that in the fermented peelings of the variety <<Kponan>>.

These three varieties of yam contained however, a small variation of yeast species dominated by two species namely *Candida ciferrii* and *Candida famata*. *Candida lusitaniea*, *Cryptococcus laurentii* and *Trichosporon mucoides* were also isolated and identified in this study. As it is noted, strains of the genus *Candida* were more abundant in the fermented peelings of the three varieties of yam analyzed. Yeasts which belong to the genus *Candida* were abundantly also isolated by [15] from the peelings of potatoes. Thus, starches seem to be great source of these yeasts. However, in our study, yeasts of the genus *Candida* identified were *Candida ciferrii*, *Candida famata* and *Candida lusitaniea*, while those of the genus *Candida* isolated from the peelings of potatoes by [15] were *Candida utilis*, *Candida guilliermondii*, *Candida lusitaniae* and *Candida famata*. These yeasts species isolated from the fermented peelings of the three varieties of yam had positive assimilation for the majority of carbon compounds tested. However although the yeasts of the genus *Candida* were predominant in the fermented peelings of the three varieties of yam analyzed, the strains of *Cryptococcus laurentii* had positive assimilation of for more carbon compounds tested than the other yeasts strains isolated. These carbon compounds are the most frequently used substrates by yeasts. It is thus interesting to note that the strains of yeasts isolated and mainly those of *Cryptococcus laurentii* had the ability to use a wide range of carbon compounds.

For enzymes activities, the strains of *Trichosporon mucoides* showed activities for more enzymes than the other species identified. The strains of this species were followed by those of the species *Cryptococcus laurentii*. Thus, it is noted that enzymes activities could be due to the source from which yeasts were isolated and also to the strains of yeasts species.

Moreover, all the yeasts identified are known to be amylases producers. Previous studies showed that several species of yeasts were amylases produced [15; 16; 17 and 18]. However, these yeasts are mainly those of the genus *Candida*. The production of amylases by these yeasts is due to the starch of the peelings of yam analyzed. Indeed, previous studies have shown that starch is the inducer of α-amylase activity [18].

This present work gives for the first time, information on yeast diversity from fermented peelings of yams.

5. Conclusion

This present study has shown that the fermented peelings of three varieties of yam namely <<Bètè-bètè>>, «Kponan», and «Krenglè» are sources of yeasts. These yeasts were strains of the species *Candida ciferrii*, *Candida famata*, *Candida lusitaniea*, *Cryptococcus laurentii* and *Trichosporon mucoides*. The strains of all these yeasts species had positive assimilation for the majority of carbon and nitrogen compounds tested. These yeasts showed also activities mainly for leucine-arylamidase, beta-N-acetyl-glucosaminidase, gamma-glutamyl-transferase, PNP-N-acetyl-BD-galactosaminidase 1 and alpha-glucosidase. The characteristics of these yeasts

show thus great perspective of fermentation technology. Our work is the first ever on yeast diversity from fermented peelings of yams.

Acknowledgements

The authors gratefully acknowledge the Pasteur Institute of Abidjan (Côte d'Ivoire) for the identification of yeasts during this study.

Competing Interests

Authors have declared that no competing interests exist.

References

[1] Ettien, J.B.D., Sorbo F. & Brahima K. Screening of new yam clones *(D. alata* and *D. rotundata*) in nematode prone ecology of *Guinea savanna* zone in West Africa. *Journal of Applied Biosciences*, 61, 4540-4550, 2013.

[2] Kouakou, A.M., Zohouri, G.P., Dibi K.E., N'zué, B. and Foua-Bi. Emergence d'une nouvelle variété d'igname de l'espèce *Dioscorea alata* L., la C18, en Côte d'Ivoire, *Journal of Applied sciences*, 57, 4151-4158, 2012.

[3] Onyeka, T., Petro, D., Ano, G., Etienne, S. and Rubens, S. Resistance in water yam (*Dioscorea alata*) cultivars in the French West Indies to anthracnose disease based on tissue culture-derived whole-plant assay. *Plant Pathology*, 55(5), 671-678, 2006.

[4] FAOSTAT. Available on http://www.fao.org/faostat/fr/#data. 2019.

[5] Adeniji, O., Adebayo, C. and Ajayi, O. Analysis of marketing margin of yam in selected rural areas of Niger State, Nigeria, *Basic Research Journal of Agricultural Science and Review*, 1(3), 58-62. 2012.

[6] Cornet, D. Influence des premiers stades de croissance sur la variabilité du rendement parcellaire de deux espèces d'igname (*Dioscorea* spp.) cultivées en Afrique de l'Ouest. Thèse de Doctorat unique des Sciences agronomiques et écologiques, Institut des Sciences et Industries du Vivant et de l'Environnement (*AgroParisTech*), 174 p, 2015.

[7] Sanginga, N. and Mbabu, A. Racines et tubercules (manioc, igname, pomme de terre et patate douce). Document de référence. *Banque africaine de développement*, 35 p, 2015..

[8] Faostat, 2003. Statistiques agricoles de la FAO, 2003. Available on http //www.fao.org.

[9] Montcho, M., Babatounde, S., Aboh, B.A., Bougouma, Y.V., Chrysostome C.A.A.M. and Mensah G.A. Utilisation des sous-produits agricoles et agro-industriels dans l'alimentation des ovins Djallonké au Bénin: perception des éleveurs, préférences et performances de croissance, *Afrique Science*, 13(5), 174-187, 2017.

[10] Kouadio, E., Kouassi A., Yaya Soro, Y., Vaca-Garcia, C. and Kouassi, B.Y. Valorisation des déchets d'agro-ressources par bio-production d'acide citrique. *Journal de la Société Ouest-Africaine de Chimie*, 044, 36-42, 2017.

[11] Nindjin, C. Konan, G., Agbo, N., Otokore, D., Bricas, N., Farah, Z. and Girardin, O. Les variétés d'igname (*Dioscorea* spp.) rencontrées sur les marches en Côte d'Ivoire et leur préférence culinaire. *Annales des Sciences Agronomiques*, 9(2), 2007.

[12] Kouadio, I.A., Koffi, L.B., Jean Gnopo Nemlin, J.G., Dosso M.B., Effect of Robusta (*Coffea canephora* P.) coffee cherries quantity put out for sun drying on contamination by fungi and Ochratoxin A (OTA) under tropical humid zone (Côte d'Ivoire), *Food and Chemical Toxicology*, 50, 1969-1979, 2012.

[13] Kurtzman C.P., Fell J.W., Boekhout, T., Robert, V. Methods for isolation, phenotypic characterization and maintenance of yeasts, p 87-110. In Boekhout CPKWF (ed), The Yeasts 5th ed. *Elsevier, London*. 2011.

[14] Guiraud, J. P. Microbiologie alimentaire. *Dunod, Paris*. 310-321, 1998.

[15] Ouédraogo N., Savadogo A., Zongo C., Somda K. M. A. and Traoré S. High performance amylolytic yeast strains isolation and identification for valorization of potatoes waste available in Burkina Faso. *International Food Research Journal*, 19(4), 1463-1469, 2012.

[16] Acourene, S. and Ammouche, A. Optimization of ethanol, citric acid and α-amylase production from date wastes by strains of *Saccharomyces cerevisiae*, *Aspergillus niger* and *Candida guilliermondii*. *Journal of Industrial Microbiology and Biotechnology*, 39, 759-766, 2012.

[17] Moubasher Hani, Salwa S. Wahsh and Nabil Abo El Kassem. Isolation of Aureobasidium pullulans and the effect of different conditions for pullulanase and pullulan production. *Microbiology*, 82 (2), 155-161. 2013.

[18] Dakhmouche-Djekrif, S. Production et caractérisation de l'amylopullulanase de la levure *Clavispora lusitaniae* ABS7 isolée de blé cultivé et stocké en zones arides. Thèse présentée en cotutelle pour l'obtention du grade de Docteur de l'Université de Technologie de Compiègne, 211 p, 2016.