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Research Article

Fungal Species and Biochemical Composition of Four Varieties of Irish Potato (*Solanum tuberosum*) Cultivated in Jos, Plateau State, Nigeria

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Abstract

Researchers have studied the possible microbes that could be associated with potato tubers. Most researchers reported microbes associated with decayed potato in storage but limited information exist on fungal species associated with non-deteriorated potato and on biochemical composition of specific varieties of potato grown and consumed in Jos, Nigeria. This study seeks to enquire if same or more microbial communities already established in previous studies will be found on identified non-deteriorating potato varieties and their biochemical composition. Identified varieties of Marabel, Caruso, Diamant and Nicola potato were obtained from Root Crop Research Institute, Vom, Plateau State. Fungal species were isolated at 25°C, 37°C and 45°C on Czapek Dox and Potato Dextrose Agar using soil plate method. Biochemical composition was determined by standard protocol. The genera *Aspergillus, Mucor, Penicillium, Rhizopus* and *Fusarium* were dominant at 25°C and 37°C while *A. Fumigatus* grew at 45°C. Of all the fungal species, *Aspergillus flavus* was dominant while the least was *Fusarium oxysporum.* The biochemical composition showed that moisture ranged from 71.67 ± 0.15^{d} to 81.07 ± 0.11^{a}, Protein ranged from 2.65 ± 0.03^{b} to 4.13 ± 0.02^{a}, crude fiber ranged from 3.20 ± 0.10^{d} to 3.70 ± 0.20^{a}, lipid ranged from 0.13 ± 0.03^{a} to 0.33 ± 0.02^{a}, Ash ranged from of 0.77 ± 0.06^{b} to 1.16 ± 0.03^{a}, carbohydrate ranged from 10.48 ± 0.02^{d} to 19.64 ± 0.02^{a}, calcium ranged from 0.13 ± 0.01^{a} to 0.17 ± 0.01^{a}, phosphorus ranged from 0.03 ± 0.00^{b} to 0.28 ± 0.20^{a} and dry matter ranged from 18.67 ± 0.58^{d} to 28.30 ± 0.20^{a} across the varieties. Isolated fungi could be attributed to Poor handling of potato and storage conditions while the proximate composition may be based on result of varietal difference.

Keywords: Fungal Isolates; Biochemical Composition; Non-deteriorated Irish Potato Tubers

Introduction

Irish potato (*Solanum tuberosum* L.) is a tuber crop and for many years it has been a source of staple food to many people and ranks fourth after rice in global distribution [1,2]. Popular potato cultivars cultivated in Nigeria such as Nicola, Marabel and Caruso are also grown in different parts of the world including Egypt, Italy, Turkey, Germany, Pakistan, and China [3-9].

Tubers contain edible starch materials as such serve as sources of food to both humans and animals as well as a source of raw materials for the manufacture of starch, beverages, flours, fermented foods [10,11]. Being a potential industrial raw material especially in developing countries, such as Nigeria, microbial deterioration is aided due to its high moisture content, neutral pH and nutrient content.

Crop plants have an influence on microorganisms and may be responsible for changes in soil microbial population and diversity [12]. Potato roots excrete substances that directly influence the growth of rhizomicrobiome [13]. Since the storage organs have close proximity with the soil habitat especially in the farm, their surfaces harbor lots of fungal and bacterial species that may predispose tubers to disease which is a threat to their cultivation [14]. They penetrate the tubers as a result of wounds on the tubers [15]. *Fusarium* spp have been reported to affect potato in the field and after harvest [16-18]. *Fusarium* species were reported to cause deterioration in potato both in the field and in storage [19]. Many fungi form mycorrhizal association with plants roots at the top of the soil which is important for the production of spores [20]. Potato in storage can be associated with many fungal isolates such as *Fusarium* spp, *Alternaria* spp, *Phytophthora infestans*, *Helminthosporium solani*, *Rhizoctonia solani*, *Collectotrichum coccodes* [21] and many other genera of fungi as reported by [22]. [20] reported many fungal genera associated with potato.

Temperature plays an important role in influencing the growth of microorganisms. [23] isolated fungal species at 25°C using variety of media. Many researchers have also reported the growth of fungi within some temperature limits as reported by [24-26] and many others.

Potato tubers are a source of dietary energy and other nutrients though the addition of vegetables and whole grain to potato-based diet is an excellent source of nutrient. A weight of 150g size of potato provides nearly half an adult's daily requirements of vitamin C [27]. It contains both major and minor nutrients [28], among such are protein, fat, fiber, carbohydrate, minerals like phosphorus, calcium, folate among others. It also serves as a low-fat diet. It is a carbohydrate rich food made of about 70 to 80% carbohydrate [29], it's one of the sought-after staple foods globally. The nutrient composition of potato is greatly influenced by soil type, cultivar and climatic conditions [30,31]. [32] reported only the proximate composition of Kenyan potato. There is limited data on the microbiological quality of non-deteriorated potato tubers as well as the proximate composition of the varieties grown in Jos, Nigeria, therefore there is a need to investigate.

This objective of this study was the baseline for isolation and identification of fungal species associated with four different varieties of non-deteriorated potato which are potential industrial raw material and to determine their biochemical composition. The data from this study will give knowledge of the nutritional value of what they are consuming as well as the microorganisms associated with even fresh non-deteriorated tubers.

Materials and Methods

Isolation of fungal species from the four varieties of non-deteriorated potato tubers

One kilogram (1kg) of non-deteriorated healthy identified Irish potato tubers (IPT) were randomly picked from each basket containing the *Solanum tuberosum L.* (Irish potato) cultivars: Marabel, Caruso, Nicola and Diamante. The representative tubers from each lot of cultivars were washed with potable water and surface sterilized with 70% ethanol and each tuber was homogenized with the peel using high performance Kuchef blender (model 8236). About 0.03g was plated out on sterilized Czapek Dox Agar (Oxoid) and Potato Dextrose Agar (Oxoid) using soil plate method [33]. About 50mg of chloramphenicol and 5mg gentamycin were added in the culture media to suppress bacterial growth. The plates were incubated at 25°C, 37°C and 45°C. Fungi species were identified using cultural, morphological and standard taxonomic keys [34].

Biochemical composition of non-deteriorated potato tubers

The four [4] varieties of non-deteriorated potato tubers were subjected to proximate analysis, using the standard method of [35]. The proximate composition was done as described by [36]. The parameters analysed were moisture (vacuum oven method), protein (Kjeldah's method), crude fibre (gravimetric method), lipids (soxhlet method), ash (dry ashing method), and for carbohydrate the percentage was obtained by simple difference, Mineral content was determined using methods adopted by [37].

Results

Fungal species isolated from four non-deteriorated varieties of potato tubers

In this study ten [10] different fungal species were isolated from the four non-deteriorated potato varieties and the percentage frequency of occurrence is shown in figure 1. They are: *Aspergillus flavus, A. fumigatus, A. nidulans, A. niger, A. terreus, Mucorracemosus, Penicillium* sp, *Rhizopus stolonifer, Fusarium solani* and *F. oxysporon*.

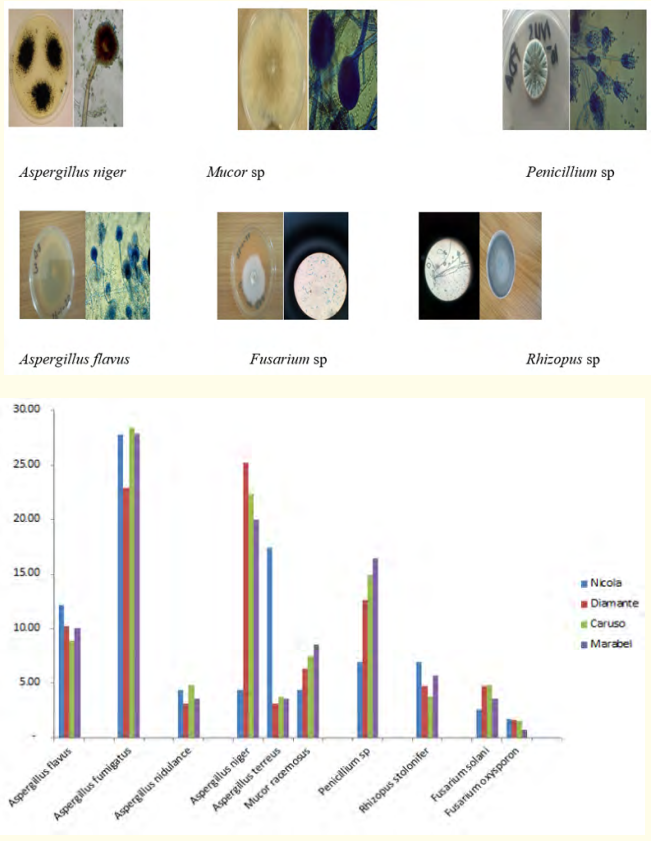

Figure 1: Percentage frequency of occurrence of fungi species associated with the four varieties of non-deteriorated tubers.

Fungi isolated at varying temperatures of 25, 37 and 450C of the four non-deteriorated potato tubers

Almost all the fungi species isolated did not grow at the temperature of 45°C as shown in table 1, only *A. fumigatus* grew at that temperature. There was fast fungal growth 25 and 37°C for all the other fungal species. The fungal species isolated at 25 and 37°C were *Aspergillus flavus, A. fumigatus, A. nidulans, A. niger, A. terreus, Mucor racemosus, Penicillium* sp, *Rhizopus stolonifer, Fusarium solani* and *F. oxysporum* but only *A. fumigatus* grew at 45°C.

Temperature of isolation	25°C	37°C	45°C	Total
Aspergillus flavus	+	+	-	2
A. fumigatus	+	+	+	3
A. nidulans	+	+	-	2
A. niger	+	+	-	2
A. terreus	+	+	-	2
M. racemosus	+	+	-	2
Penicillium sp	+	+	-	2
R. stolonifer	+	+	-	2
F. solani	+	+	-	2
F. oxysporon	+	+	-	2
Total	10	10	1	21

Table 1: Fungi species isolated from the four varieties of non-deteriorated potato tubers at varying temperatures of incubation.

+ = Present, - = Absent.

Biochemical composition of the four non-deteriorated potato tuber varieties

The result at $P \leq 0.05$ reveals significant difference in the biochemical composition of the four potato varieties, as presented in (Table 2). Caruso had the highest protein, fibre, calcium and dry matter values with the lowest moisture content, while marabel had the lowest carbohydrate and dry matter values, but the highest moisture content. Diamante is having the highest carbohydrate and lipid values with the lowest protein content and Nicola had the lowest fibre, lipid and phosphorus values.

Sample	Moisture	Crude protein	Crude fiber	Lipid	Ash	Carbohydrate	Calcium	Phosphorus	Dry matter
Caruso	71.67 ± 0.15^{d}	4.13 ± 0.02^{a}	3.70 ± 0.20^{a}	0.18 ± 0.02^{a}	1.14 ± 0.05^{a}	18.8 ± 0.03^{b}	0.33 ± 0.02^{a}	0.12 ± 0.01^{a}	28.30 ± 0.20^{a}
Diamante	73.55 ± 0.05^{c}	2.47 ± 0.03^{b}	3.43 ± 0.42^{c}	0.33 ± 0.02^{a}	0.77 ± 0.06^{b}	19.64 ± 0.02^{a}	0.13 ± 0.01^{a}	0.03 ± 0.00^{b}	26.52 ± 0.20^{b}
Nicola	79.73 ± 0.21^{b}	2.65 ± 0.03^{b}	3.20 ± 0.10^{d}	0.13 ± 0.03^{a}	1.16 ± 0.03^{a}	13.13 ± 0.02^{c}	0.17 ± 0.01^{a}	0.03 ± 0.00^{b}	20.10 ± 0.10^{c}
Marabel	81.07 ± 0.11^{a}	4.02 ± 0.02^{a}	3.47 ± 0.02^{b}	0.27 ± 0.02^{a}	0.87 ± 0.02^{b}	10.48 ± 0.02^{d}	0.15 ± 0.03^{a}	0.28 ± 0.20^{a}	18.67 ± 0.58^{d}

Table 2: Biochemical composition of the four varieties of non-deteriorated potato tubers.

At $p \leq 0.05$, results are represented as mean ± standard deviation. Different superscripts denote significant difference while same superscripts denote that there is no significant difference; comparison was done across the columns.

Discussion

Fungi isolated from the four non-deteriorated varieties of potato tubers

The presence of the genera *Fusarium*, *Aspergillus* and *Penicillium* species in the healthy potato tubers indicates poor handling of the tubers during harvest and bagging for storage. The aerial spores that must have settled on the potato would likely be another source of contamination of all the potato varieties. This agrees with the works of [38] who isolated *Fusarium oxysporon* and *Fusarium solani* from potatoes in Michigan. [39] isolated different species of *Fusarium solani* and *F. oxysporon* which are cosmopolitan fungi from mango (*Mangifera indica*) in Pakistan. The genus *Fusarium* are cosmopolitan in nature and can be isolated from different crops. Also, 40Trabelsi., *et al*. [25] isolated many genera of *Aspergillus* and *Penicillium* species used for the biocontrol of *Fusarium* rot in potato. *R. stolonifer* was also reported to be associated with postharvest loss of potato by [40,41]. The presence of these fungi could be as a result of applying animal waste on the farm land and also due to the abundance of the spores in the air. This agrees with findings of this present study.

Fungi isolated at varying temperatures of 25°C, 37°C and 45°C from four non-deteriorated varieties of potato tubers

The growth of *Aspergillus fumigatus* at a temperature of 45°**C** indicates its thermotolerant nature and its ability to grow at varied temperature. This is in agreement with the work of [24] who reported the growth of *Aspergillus* spp at temperatures between 25°C and 37°C which are also in consonance with the reports of [26] who reported that species of *Aspergillus* grew as a result of modeled temperature and relative humidity.

There was fast growth of *Fusarium* sp at a temperature of 25 and 37°C in this present study which agreed with the work of [25,42], that reported *Fusarium* sp to grow at varied temperatures but showed maximum growth at 25 and 37°C. They also reported that very high temperatures are lethal to them. *Penicillium* sp was isolated at 25 and 37°C which is in line with the report of [24], who isolated *Penicillium* sp and *Aspergillus* sp at different temperatures. This suggests that the fungi are mostly mesophilic.

In this present study *R. stolonifer* was also isolated at 25 and 37°C, which is in agreement with the studies of [43] who observed the survival of spores of *Rhizopus stolonifer*, *Aspergillus niger*, *Botrytis cinerea* and *Alternaria alternata* after exposure to ethanol solutions at various temperatures. The ability of all the fungi species isolated in this study to grow at varied temperature shows their ubiquitous nature and their capability of surviving at various environmental conditions. Some have been implicated as part of human pathogen aside their deteriorative activities in raw and processed foods.

Biochemical composition of non-deteriorated four varieties of potato tubers

The variation seen in all the parameters in the four varieties of the potato tubers is a reflection of the difference in their nutritional content, soil composition, agronomic and genetic factors. The maximum and minimum moisture, protein and fiber values were 71.67 to 81.07, 2.47 to 4.13, and 3.20 to 3.70 respectively as seen in (Table 2) agrees with the works of [44], who reported the moisture content of a freshly harvested potato in US to be 78.63%. [45] reported moisture within the range 68.74 to 81.44 for potato tuber. Their works are closely related to this study.

The ash, lipid and carbohydrate in this present study had values that ranged from 0.77± 0.06b to 1.16± 0.03a , 0.13±0.03a to 0.33±0.02a and 10.48±0.02d to 19.64±0.02a respectively as seen in Table 2 are not in agreement with the works of [46] who reported a higher crude fiber, ash content which ranged from 1.990 to 3.597 and 3.677 to 5.180 respectively as well as lipid with values ranging from 0.410 to 1.197 in their work on potato compared to the values in this present study, [47] also reported closely related values for moisture, lipid, ash and carbohydrate which ranged from 81.03 to 75.55, 0.08 to 0.07, 1.10 to 0.88 and 20.43 to 15.61 respectively but crude fiber and protein were lower with values that ranged from 1.11 to 0.77 and 1.76 to 1.63 respectively in their study compared to the values of this present study. The values of calcium and phosphorus recorded in this study ranged from 0.13 to 0.33 g/100g and 0.28 to 0.13 g/100g for calcium and phosphorus respectively which is lower than those reported by [50] whose values ranged from 37 to 80 mg/100g. The low mineral content may be as a result of poor uptake of mineral by the plant. The reason

for the low values may be as a result of phytic acid concentration according to [48]. The dry matter content in this study ranged from 18.67 to 28.30 which is closely related to studies of [32] who reported values that ranged from 19.50 to 24.13.

Conclusions

The fungal presence and diversity shows some level of contamination which may be attributed to the soil which is a reservoir of microorganisms or the indoor environment during storage. The fungal diversities were able to grow at varying temperatures of incubation. The biochemical (proximate composition) of the tubers is a source of knowledge for the first time of the nutritional composition of the selected non-deteriorated varieties of potato cultivated in Jos.

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Highlights

The fungal load and biochemical (proximate) composition associated with four varieties of potato tubers will foster good agricultural practices and ensure proper hygiene and decontamination of tubers intended for processing.

The biochemical (proximate) composition differed among the non-deteriorated potato varieties due to possibly varietal differences, climatic conditions, agricultural practices, nature of soil and genetic variation.

The presence of the fungal species isolated in this study reveal the possible poor handling of the tubers during harvest and poor handling during bagging, considering the abundance of fungal spores in the soil and the indoor environment.

The knowledge of the biochemical (proximate) composition of the different potato varieties for the first time in Jos makes it more acceptable by many consumers.

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