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A SURVEY OF FUNGI ASSOCIATED WITH MARKETED FRUITS OF SOME TOMATO CULTIVARS IN CENTRAL AND NORTHERN SENATORIAL DISTRICTS OF PLATEAU STATE, NIGERIA: NUTRITIONAL IMPLICATION OF CONSUMPTION OF "BARGEH" TOMATO

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ABSTRACT

The fruit quality and nutritional value of tomato are affected by pre- and post-harvest factors. Fungi are pathogens that cause economic losses of fruits. This study was aimed to survey the fungi associated with tomato fruits and to determine the nutritional status and implication of consuming "Bargeh" fruits in Central and Northern Senatorial Districts of Plateau State. Cultivars Tangeno/Rukuba, Syria, UTC 4, UTC 16, UTC 17, UTC 18, Derika/Danzaria were sampled from six markets, namely: Mangu, Pankshin, Barkin Ladi, Bukuru, Gyel and Farin Gada. The standard methods of isolating surface and tissue microorganism from fruits were used. Proximate analysis was carried out using the method of Association of Official Analytical Chemists. Results showed that *Saccharomyces*, *Penicillium*, *Aspergillus* and *Mucor* species were the fungal pathogens associated with tomato fruits in the districts surveyed. Proximate analysis showed that Derika/Danzaria had appreciable protein and ash contents in both the fresh and 'Bargeh' fruits. UTC 17 and Syria had a significantly ($p<0.05$) higher calcium in the 'Bargeh' fruits. The consumption of 'Bargeh' fruits of the three cultivars present no health hazard as other nutrients like crude fiber are provided by other cultivars.

Key Words: Tomato; cultivars; fruits; 'Bargeh'; fungi, proximate

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INTRODUCTION

Tomato *(Solanum lycopersicum* L.*)* is native to South America but was introduced into West Africa by Portuguese traders and freed slaves from the West Indies (Tindall, 1993; Nonneoke, 1989). Tomato production is estimated at an average of 410,033 tons per annum (Osemwegie *et al.,* 2010; Factfish website, 2018). Samuel *et al*. (2011) reported a global production of about 89.8 million metric tons with Nigeria as the second largest producer in Africa after Egypt and 13th in the world. The major producing areas in Nigeria lie between latitudes 7.5 °N and 13 °N, and within a temperature range of 25ºC – 34 °C (Villareal, 1980; Samuel *et al.,* 2011).These areas include Bauchi, Benue, Borno, Kaduna, Kano, Plateau and Sokoto States in the north. Tomato is among the most valuable crops grown by small-scale farmers (FAOSTAT, 2018).

The production of the crop is constrained by a myriad of biotic and abiotic factors. Biotic constraints such as arthropod pests, fungal, bacterial and viral diseases are among the most important drawbacks (Willis *et al*., 2018; Barasa *et al*., 2019). Lack of improved cultivars, storage method and knowledge of the pathogens associated with the fruits as well as the perishable nature of the fruits, pests and diseases are the other constraints (Suzuki *et al*., 2014; Blake, 2020). Tomato fruits have a short shelf-life, ripen within 5-7 days at 20-25^{0}C, become overripe and get spoilt within 15 days after harvest (Samuel *et al*, 2011; Barasa *et al*., 2019).

Tomato is rich in vitamins, minerals and lycopene (Enrique and Eduardo, 2006; John *et al.,* 2010*).* The crop is a source of antioxidants (Osemwegie *et al.,* 2010) that help to reduce the risk of prostate and breast cancer (Giovannucci, 1999; Pirie, 2020). The quality and nutritional value of freshly produced tomato fruits are affected by pre- and post-harvest factors such as improper handling, fungal and bacterial pathogens, storage or transportation (Kader, 1986; Barasa *et al*., 2019). Post-harvest tomato losses during storage and transportation

from farms to the markets are estimated to be as high as 20% in Nigeria (Olayemi *et al.*, 2010). Adeoye *et al.* (2009) reported that mechanical damage to tomato ranks highest in post-harvest losses followed by pathological damage while physiological damage ranks the least.

Fungi are the most important and prevalent pathogens, infecting a wide range of fruits and causing destructive and economic losses of the fruits during storage, transportation and marketing (Moss, 2002; Ndakidemi *et al.*, 2016; Mustapha *et al*., 2017). In view of the perishable nature of tomato fruits during the post-harvest storage, this study was aimed at investigating the fungi associated with fruits of eight tomato cultivars in Central and Northern Senatorial Districts of Plateau State and to determine the nutrient composition of "Bargeh" fruits and the health implication of their consumption.

MATERIALS AND METHODS

Collection of samples.

Samples of fresh and partially rotten fruits of tomato (referred to as "Bargeh") were collected from markets located in Mangu, Barkin Ladi, Pankshin, Jos South and Jos North Local Government Areas of Plateau State. The cultivars collected were Tangeno/Rukuba, Syria, UTC 4, UTC 16, UTC 17, UTC 18 and Derika/ Danzaria,

Isolation of microorganisms from the fruits

The technique of Mehrotra and Rangaswami (2006) for isolation of surface and tissue microorganisms from tomato fruits was adopted; this was carried out in the Diagnostic Laboratory of the National Veterinary Research Institute, Vom, Plateau, State, Nigeria.

Isolation of surface fungi

Tomato fruits of each cultivar were washed with ordinary water and then surface-sterilised with sterile water. The fruits were further washed in 2% (wt/vv) sodium hypochlorite for about 2 minutes. Each fruit was then washed with 10 ml sterile water. One (1) ml of the supernatant was transferred to McCartney bottle containing 9 ml of sterile water and shaken vigorously for some minutes to form a mixture or aliquot. About 1 ml aliquot was serially diluted to $10^{-2,}$ 10^{-3}, 10^{-4}, $10^{-5}$and 10^{-6}. About 0.5 ml of the 10^{-4}, 10^{-5} and 10^{-6} dilutions was plated onto prepared Potato Dextrose Agar (PDA) in Petri dish and 1 ml of chloramphenicol (antibiotic) was added to the PDA Petri dishes to prevent contamination by bacteria. The dishes were prepared in triplicates. The plates were incubated at 27ºC and observed daily for five days. After incubation, plates showing 10 -30 colonies were selected and used for further isolation and identification of the fungi. The fungal isolates were sub-cultured three times to obtain pure cultures of each isolate. The identities of the isolates were certified using cultural morphology, colony growth form and colour. The isolates were also compared with confirmed representatives of the species (Burnett and Hunter, 1998).

Isolation of the fungi form "Bargeh" fruit tissue

The partially rotten tomato fruits ("Bargeh") were soaked in 90% (vol/vol) ethanol for two minutes and thereafter washed four times with sterile distilled water. The fruits were then disinfected in 2% (wt/vol.) sodium hypochlorite (Sigma Aldrishchanire or Jik) for two minutes to remove any facultative pathogens. Thereafter, the fruits were washed four times in sterile water. Excess water was removed by blotting with sterile filter paper under aseptic conditions. The fruits were cut transversely with a sterile scalpel; pieces of the "Bargeh" fruit tissue were cut along with portions of the healthy tissue. This method of cutting the fruit pieces was used because the tissues between the rotten and healthy portions are believed to contain the primary pathogens while the rotten portion has secondary pathogens (facultative pathogens). The cut pieces were picked with a pair of sterile forceps and transferred onto prepared sterile Potato Dextrose Agar (PDA) plates at pH 6.0 in triplicates.

Similarly, pieces of healthy tissues were cut and plated on PDA plates to serve as the control. The triplicate plates were incubated at 27ºC±2 and observed daily for possible fungal growth. The procedure for sub-culturing, identification and comparing with confirmed species as in the surface-isolation above was adopted.

Proximate Analysis of the fresh and 'Bargeh' fruits

The proximate analysis of the freshly harvested fruits and the "Bargeh" fruits of each tomato cultivar was carried out using the method of AOAC (2000) in the Department of Biochemistry, National Veterinary Research Institute, Vom, Plateau State, Nigeria. The data collected were subjected to analysis of variance (ANOVA) test using the SPSS version 2.1. The means were separated using the Duncan's new Multiple-Range Test.

RESULTS

Results of the fungi associated with the tomato cultivars (Table 1) revealed that *Saccharomyces* spp was the most common fungus and likely pathogen associated with the rotting of cultivars Derika/Danzaria, UTC16, UTC17 and Rukuba/Tangeno which were surveyed in the study areas. *Aspergillus* spp were isolated from all but cultivar Rukuba/Tangeno.

Table one also shows that *Penicillium* spp was the common fungus associated with cultivars Derika/Danzaria, UTC4, UTC16, UTC17, UTC18, Syria and Tangeno/Rukuba. *Aspergillus niger* was observed to be associated with Derika/Danzaria, UTC17, UTC18 and Syria. *Penicillium nalgiovense* was isolated from Derika/Danzaria, UTC 4, UTC17, UTC18 and Tangeno/Rukuba. Morphological and cultural characteristics of the fungal isolates (Table 2) were used in the characterisation of *Aspergillus, Penicillium* and *Sacharomyces.* The study showed that *Penicillium* spp were associated with all the cultivars surveyed. *Aspergillus* and *Saccharomyces* species were isolated from all the tomato cultivars sampled.

Table 1. Fungal Isolates of tomato cultivars

Cultivar	Tomato Status	Fungi isolated
Derika (Danzaria)	"Bargeh"	*Aspergillus niger, Saccharomyces* spp (*Y*east)
Derika (Danzaria)	Fresh	*Penicillium nalgiovense*
UTC 4	"Bargeh"	*Penicillium nalgiovense*
UTC 4	Fresh	*Penicillium nalgiovense*
UTC 16	"Bargeh"	*Penicillium italicum, accharomyces* spp (yeast)
UTC 16	Fresh	*Penicillium italicum, Saccharomyces* spp
UTC 17	"Bargeh"	*Penicillium nalgiovense, Saccharomyces* spp
UTC 17	Fresh	*Aspergillus niger, Mucor plumbeus,*
UTC 18	"Bargeh"	*Aspergillus niger, Mucor plumbeus,*
UTC 18	Fresh	*Penicillium nalgiovense Aspergillus niger*
Syria	"Bargeh"	*Penicillium italicum,*
Syria	Fresh	*Penicillium italicum*
Tangeno/Rukuba	"Bargeh"	*Penicillium nagiovense, Saccharomyces* spp
Tangeno/Rukuba	Fresh	*Penicillium nagiovense, Saccharomyces* spp

Table 2 Morphological and cultural characteristics of fungal isolates

Fungal Isolate	Morphological and cultural characteristics
Aspergillus niger	Greenish, filamentous with profuse proliferation of black velvety spores; Septate hyphae, branched condiophore with secondary branches. The condiophore is enlarged at the tip forming roundish vesicle-like chains
Mucor sp**.**	Grows quickly and cover agar surface with white fluff that later turns grey, reverse side is white. Hyphae non-septate, sporangiophores are long, often branched and bear terminal spores-filled sporangia
Penicillium sp.	The colonies of *Penicillium* sp. grow rapidly and are flat, filamentous and velvety, woolly or cottony in texture. Chains of single-celled conidia (ameroconidia) are produced in basipetal succession from a specialised conidiogenous cell called a phialide
Sacharomyces sp	Colonies of *Saccharomyces* sp. grow rapidly. They are flat, smooth, moist glistening or dull, and cream to tannish cream in colour. Multilateral budding is typical. Pseudohyphae, if present, are rudimentary. Hyphae are absent.

Table 3 shows that crude protein was highest in the 'Bargeh' type of cultivar Danzaria (3.24 %) and lowest in the 'Bargeh' type of cultivar Syria (1.34 %). The crude protein values of the fresh fruits of cultivars UTC 17(1.75 %), UTC 18(1.84 %) and Syria (1.81 %) were statistically similar at 5 % level of probability. Crude protein varied from 0.75 % in the 'Bargeh' fruits of cultivar Syria to 1.80 % in the fresh fruits of cultivar Danzaria and the difference ($p<0.05$) was significant (Table 3). Crude fat was highest in the fresh fruits of cultivar UTC 4(0.31 %) and lowest in the 'Bargeh' fruits of cultivar Syria (Table 3) but the differences ($p>0.05$) were not significant (Table 3). Ash content was highest in the 'Bargeh' fruits of cultivar Danzaria (0.05 %) and lowest in the 'Bargeh' fruits of cultivar UTC 18. The ash contents in the fresh fruits of cultivars UTC 17(0.40 %), Syria (0.04 %), UTC 4(0.40 %) and the 'Bargeh' fruits of cultivar Syria (0.37 %) were statistically similar at $p=0.05$ (Table 3). Similarly, the ash content did not differ significantly in the fresh fruits of cultivar Danzaria (0.25 %), 'Bargeh' fruit of cultivar UTC 18 (0.28 %) and the fresh fruits of cultivar UTC 18(0.30 %).

Table 3 shows the calcium and phosphorus contents of fresh and 'Bargeh' fruits of the cultivars surveyed. Calcium content was highest in the fresh and 'Bargeh' fruits of cultivar Syria (0.33 %) and lowest in the 'Bargeh' fruits of cultivar UTC 4. Calcium content did not differ significantly in the 'Bargeh' fruits of cultivar UTC 17, fresh fruit of cultivar UTC 18 and the fresh fruits of UTC 4, with calcium content values of 0.18, 0.20 and 0.20 %, respectively. The phosphorus contents in the fresh (0.04 %) and 'Bargeh' (0.03 %) fruits of cultivar UTC 17, fresh (0.03 %) and 'Bargeh' (0.04 %) fruits of cultivar UTC 18 as well as fresh (0.04 %) and 'Bargeh' (0.04 %)fruits of cultivar Syria were similar. Similarly, the phosphorus content in the fresh and 'Bargeh' fruits of cultivars Danzaria and UTC 4 were statistically similar with a value of 0.01 % each.

Table 3. Proximate composition of fresh and 'Bargeh' fruits of tomato

Cultivar	Moisture	Crude protein	Crude fibre	Crude fat	Ash	NFE	Calcium	Phosphorus
UTC 17 (Fresh)	74.18^{c}	1.75^{de}	0.96^{de}	0.30^{a}	0.40^{c}	2.41^{c}	0.10^{e}	0.04^{a}
UTC17 ('Bargeh')	96.45^{a}	1.64^{ef}	1.30^{b}	0.13^{a}	0.33^{d}	0.15^{f}	0.18^{b}	0.03^{a}
UTC 18(Fresh)c	94.24^{b}	1.84^{cd}	0.87 ^{de}	0.16^{a}	0.30^{de}	2.59^{b}	0.20^{b}	0.03^{a}
UTC18('Bargeh')	95. 32^{a}	1.52^{g}	1.10^{c}	0.08^{a}	0.28^{e}	1.70^{d}	0.13^{de}	0.04^{a}
Syria (Fresh)	93.76^{b}	1.81^{cde}	0.70^{fg}	0.12^{a}	0.40^{c}	3.21^{b}	0.33^{a}	0.04^{a}
Syria ('Bargeh')	95.66^{a}	1.34^{h}	0.75^{f}	0.03^{a}	0.37^{c}	1.85^{d}	0.33^{a}	0.04^{a}
Danzaria(fresh)	94.57^{ab}	2.28^{b}	1.80^{a}	0.25^{a}	0.25^{e}	0.85^{e}	0.15^{c}	0.01^{b}
Danzaria('Bargeh')	94.35^{b}	3.24^{a}	0.80^{ef}	0.19^{a}	0.50^{a}	0.77^{e}	0.15^{c}	0.01^{b}
UTC 4(fresh)	93.93^{b}	1.93^{c}	1.00^{cd}	0.31^{a}	0.40^{c}	3.98^{a}	0.20^{b}	0.01^{b}
UTC 4('Bargeh')	93.44^{b}	1.53^{fg}	0.40^{g}	0.20^{a}	0.45^{b}	2.43^{c}	0.10^{e}	0.01^{b}
SE $\pm$	2.07	0.17	0.12	0.29	0.03	0.37	0.03	0.01

Means followed by the same letter(s) do not differ significantly at 5% level of probability (Duncan's new Multiple -Range Test (DMRT)

DISCUSSION

Fungi are common pre- and post-harvest pathogens of most food crops especially fruits and vegetables. The fungal pathogens (*Saccharomyces, Penicillium, Mucor* and *Aspergillus* species) isolated in this study were similar to those reported by Mustapha and Yahaya (2006) and Ebele (2011), who noted that *Aspergillus niger, Fusarium oxysporium, Penicillium expansum* and *Rhizopus stolonifer* were common post-harvest pathogens of fruits and vegetables. *Penicillium* and *Aspergillus* as well as *Alternaria, Fusarium, Geotrichum, Phytophthora* and *Botrytis* species are among the fungal pathogens of fruits and vegetables reported by Mohammed *et al.* (2013). Mohammed *et al.* (2013) reported that *Fusarium expansum, Penicillium notatum, Phytophthora infestans* secreted macerating enzymes which softened and caused decay of fruits in the field and in storage. Emadeldin *et al*. (2012) and Garuba *et al*. (2018) reported that the activities of fungi caused differences in proteins due to the activities of the cell wall enzymes such as alpha-galactosidase, beta-galactosidase, beta-manosidase and beta-glucosidase and that they are responsible for the rottening and softening of the fruits.

The moisture content of the fresh fruits of the tomato cultivars which ranged from 74.18% to 94.24% was within the standard average of 87.1% (ISO Standard, 1987). This is in agreement with earlier findings by Idah *et al*. (2010), Agbemafle *et al.* (2015) and Garuba *et al*. (2018), who reported that the moisture content of most vegetables ranged from 84-90%. The metabolism of the "Bargeh" fruits is responsible for the increase in the moisture content of the fruits.

The decrease in crude protein in the 'Bargeh' fruits as observed in this study is in line with Jwakdak and Akueshi (2014a) who reported decrease in protein content of some sweet potato cultivars under storage. Idah *et al*. (2010) reported the protein content of fresh tomato to be 0.05%, which decreased to 0.01% after two weeks of storage. Crude fibre content in the "Bargeh'' fruits was generally higher than that of the fresh fruits. The increase in crude fibre in this study is contrary to Johanson (1988) who reported decrease in the fiber content due to rot. Jwakdak and Akueshi (2014a) also reported decrease in some proximate composition of sweet potato cultivars under storage. Fibre has been reported to serve as roughage which prevents colon cancer in man (Lawal and Asala, 2008).

The decreace in crude fat and ash in all but cultivars UTC 4 and Derika/Danzaria is in line with Jwakdak and Akueshi (2012) who reported decrease in fat, ash and nitrogen free extract (NFE) in sweet potato after a period of storage. Idah *et al*. (2010) reported decrease in lipid content of tomato with increasing time of storage. Idah *et al*. (2010) observed that ash content of tomato drastically decreased from 1.49% to 0.46% after 14 days of storage and that NFE of fresh tomato decreased from 23.49% to 21.68% after seven days of storage. Garuba *et al. (*2018) reported that the method of storage and variety influenced the proximate composition of tomato.

The results of calcium and phosphorus contents in this study were in line with the findings of Jwakdak and Akueshi (2012), Garuba *et al.* (2018) and Barasa *et al.* (2019) who reported differences in calcium and phosphorus contents depending on the genotype.

CONCLUSION

Results of this study showed that *Saccharomyces, Penicillium and Aspergillus* species were associated with fresh and bargeh fruits of tomato. *Penicillum* spp were isolated from all the tomato cultivars in this study. The cultivar Derika/Danzaria had the highest contents of protein, ash, calcium and phosphorus in both fresh and "Bargeh" fruits. The cultivars UTC 17 and Syria had high calcium content in the "Bargeh" fruits.

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