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Research Article

TECHNICAL SHEET OF PHYSICOCHEMICAL AND MYCOLOGICAL CHARACTERISTICS OF THE GROUNDNUT PASTE SOLD IN RETAIL MARKETS OF ABIDJAN TOWN (COTE D'IVOIRE)

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ABSTRACT

The aim of this work was to contribute to the food safety of Ivorian consumers by investigating the proximate composition and the toxic fungal contamination of the groundnut paste offered for retail sale on the different markets of Abidjan. Groundnut paste samples (225) were collected from the main markets of the 9 communes of Abidjan town and their physicochemical and mycological characteristics were determined. Statistical analyses were performed on the data obtained. Mean proximate composition was as follow: moisture (1.23 – 4.50 %), pH (6.26 – 6.72), titratable acidity (10.33 – 17.33 meq/100 g), ash (4.67 – 5.82 %), crude fibre (5 – 5.63 %), protein (23.33 – 28.58 %), lipids (42.58 – 49.32 %), carbohydrate (17.29 – 23.92 %) and energy (570.66 – 625.92 kcal/100 g). The total fungi isolated ranged from 2.7 x 10^5 to 1.2 x 10^6 CFU/g. Eight (8) genera of fungi were isolated: *Mucor*, *Alternaria*, *Helmintosporium*, *Geotrichum*, *Fusarium*, *Cladosporium*, oldbb*Penicillium* and *Aspergillus.* The predominant fungi belonged to *Aspergillus* genus (86.67 %) followed by *Penicillium* (70.37 %). The mycotoxigenic fungi were isolated with a frequency of 49.63; 41.48; 53.33; 74.82 and 48.19 % for *Aspergillus niger*, *Aspergillus versicolor*, *Aspergillus ochraceus*, *Aspergillus flavus* and *Aspergillus parasiticus*, respectively. Groundnut paste sold in retail markets in Abidjan town are nutritive and could meet the dietary needs of the population. However, the presence of mycotoxigenic fungi represents a public health problem.

Keywords: Groundnut paste, physicochemical characteristics and fungal contamination.

INTRODUCTION

Groundnut (*Arachis Hypogaea*) is an oleaginous plant belonging to the *Arachis* kind, of the family of Fabaceae which includes the majority of leguminous seeds and having a high importance economic and nutritive[1-2]. It is a tropical plant originating in South America which was introduced in Africa, Asia and Europe[3-4]. Groundnut is the fifth culture among the most significant oilseeds in the world[5], the second edible source of oil[6], the third significant source of plant proteins and the twelfth vegetable production in the world[7]. It is cultivated on 25,44 million hectares in the world for a production estimated at 45,22 million tons and an average productivity of 1,8 ton per hectare in 2013[8]. After Asia, first producing continent, with China and India respectively 13 and 9 million tons of production, the African continent occupies the second place with 10 million tons. The production of the Côte d'Ivoire records a constant progression of 81 thousand tons in 2008, with 93,5 thousand tons in 2012[9].

Groundnut constitutes a major annual oilseed crop and a good source of protein containing high lysine content which makes it a good complement for cereal[10]. The proximate biochemical composition of mature groundnut seeds is per 100 g edible portion: moisture (6.5 g), protein (25.8 g), lipids (49.2 g), carbohydrate (16.1 g), dietary fibre (8.5 g), calcium (92 mg), magnesium (168 mg), phosphorus (376 mg) and iron (4.6 mg)[11]. However, groundnut contains some anti-nutritional factors such as phytic acid, condensed tannins, trypsin and amylase inhibitor, that may limit their usage and

nutritional value[12]. Indeed, groundnuts are liable to fungal contamination during handling, storage and transportation, exposing them to the risk of contamination with aflatoxin[13-14]. Moreover, groundnuts can be contaminated with aflatoxin during pre- and post-harvest processing and the risk of contamination increases along the marketing chain due to poor handling practices[15-16]. The main aflatoxin producing fungi in groundnuts are *Aspergillus flavus*, *Aspergillus parasiticus* and *Aspergillus nomius* which mostly infect groundnuts as a complex[17-18]. According to[19], aflatoxin produced by *Aspergillus sp*., has immunosuppressive effects and epidemiological studies have shown a positive correlation between aflatoxin intake and the incidence of liver cancer.

Groundnut and its derivatives are often classified as street food which satisfies essential need of the urban population by being affordable and available[20]. Groundnuts seeds are eaten raw, boiled or roasted, made into butter or paste and are used for thickening soups[21]. Groundnut pastes is made by grinding dry roasted groundnuts into a paste[22]. Groundnuts are also used as major ingredients in the formulation of weaning food with other cereals such as sorghum, corn, and millets because of their high protein and omega 6 fatty acid contents[23]. In Côte d'Ivoire, the use of marketed groundnut paste in the confection of sauce is very popular among the urban population. Generally, groundnut paste is produced by traditional methods characterized by poor hygienic conditions. To our knowledge, there is no scientific data on physicochemical and microbiological quality of marketed groundnut paste. Therefore, the aim of this work is to assess the physicochemical properties and the level of toxic fungal contamination of groundnut paste sold in retail markets.

MATERIALS AND METHODS

Fig. 1: Site of taking away of the groundnut pastes

Sample collection

Groundnut pastes (**Figure 1**) were collected for 6 month (June to December 2012) in the main markets of the 9 communes of Abidjan (Côte d'Ivoire): Abobo, Adjamé, Attécoubé, Cocody, Koumassi, Marcory, Port-Bouet, Treichville, Yopougon identified as AB, AD, AT, C, K, M, P, T and Y. A total of 225 samples used for analysis were obtained as follow: groundnut pastes were randomly and aseptically collected from different sellers in each market and immediately transported in icebox (4°C) to the laboratory.

Physicochemical analysis

Proximate analysis was carried out using the[24] standard methods. The moisture content was determined by the difference of weight before and after drying the sample in an oven (MEMMERT, Germany) at 105°C until constant weight. Ash fraction was determined by the incineration of dried sample (5 g) in a muffle furnace (PYROLABO, France) at 550°C for 12 h. The percentage residue weight was expressed as ash content. pH and titratable acidity were determined as follow: 10 g of groundnut paste sample was homogenized with 100 mL of distilled water and then filtered. The pH value was recorded after the electrode of pH-meter (HANNA, Spain) was immersed into the filtered solution. The filtered solution was titrated to the end point with sodium hydroxide solution 0.1 N and phenolphthalein as indicator. Crude fibre was determined by the formula of[25]: 2 g of sample were weighed into separate 500 mL round bottom flasks and 100 mL of 0.25 M sulphuric acid solution was added. The mixture obtained was boiled under reflux for 30 min. Thereafter, 100 mL of 0.3 M sodium hydroxide solution was added and the mixture were boiled again under reflux for 30 min and filtered under suction. The insoluble residue was washed with hot water and dried to a constant weight in an oven (MEMMERT, Germany) at 100ºC for 2 h, cooled in desiccator and weighed. The weighed sample was then incinerated, and weighed for the determination of crude fibre content. Proteins were determined through the Kjeldhal method and the lipid content was determined by Soxhlet extraction using hexane as solvent. Total carbohydrate was determined by the formula of[26]: 100 – (% moisture + % protein + % fat + % ash). The calorific value (energy) was calculated as follow: (protein x 4) + (carbohydrate x 4) + (lipid x 9). The results of ash, fibre, protein, lipid and carbohydrate contents were expressed on dry weight basis.

Mycological analysis

The isolation of fungi was carried out according to the agar dilution method as described by[27]. Ten (10) gram from each groundnut paste sample, were homogenized with 90 mL of buffer peptone water (AES Laboratory, France) and serial decimal dilutions (10^{-1} to 10^{-4}) were performed. Fungal species were isolated on the semi selective Dichloran Rose Bengal Chloramphenicol (DRBC) agar (Biokar Diagnostics, France). The medium was poured into sterile Petri dish and 0.1 mL of each sample suspension was spread-plated onto the DRBC agar in triplicate. The plates were incubated for 5 to 7 days at 25°C. Fungal isolates were sub-cultured on Malt Extract and Czapek Yeast medium agars (Oxoid, UK) and incubated for 5 to 7 days at 25°C for purification. Fungi were identified by using taxonomic schemes based on microscopic observation and culture appearance including colonies colours, texture, reverse colour, hyphae arrangement, conidia shape and nature of spores[28-29]. For the differentiation between *Aspergillus parasiticus* and *Aspergillus flavus* colonies, AFPA agar (Oxoid, UK) supplemented with chloramphenicol, was used. The total fungal count for each plate was expressed as colony-forming units per gram of sample (CFU/g). Each genus or specie identified was then expressed as percentage (%) of the total isolated fungi.

Statistical analysis

All the analyses were performed in triplicate and the data were analyzed using EXCELL and STATISTICA 7.1 (StatSoft). Differences between means were evaluated by Duncan's test. A significance difference was established at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Physicochemical properties

The physicochemical composition of groundnut pastes samples tested is shown in **table 1**. All the parameters generally showed significant difference ($p < 0.05$) except for ash, fibre and protein content of groundnut pastes samples. The lowest value of moisture content was 1.23 ± 0.20 % for the commune C while the highest value was 4.30 ± 0.20 % for the commune AB. These values are lower than that (7.48 %) of raw groundnut seeds[30] and this fact could be explained by the decrease of moisture content during the roasting which is an important step of groundnut paste processing[21]. pH values of the marketed groundnut paste ranged from 6.26 to 6.72 and these values are comparable to those (6.3 - 6.5) reported by[31]. These values were also positively correlated with the titratable acidity

ranged from 10.33 to 17.33 meq/100 g. The mean value for ash (4.67 – 5.82 % %) found is this study was higher than that (3.4 %) of raw peanut seeds indicated by[1]. Indeed[30] stated that roasted groundnut, used for groundnut paste manufacturing, was more advantageous in mineral content than the raw ones. The average crude fibre content in this results (5 – 5.63 %), indicate an ability of groundnut paste to maintain a normal intestinal tract because diet low in crude fibre may cause constipation and colon diseases. In view to their protein content (23.33 – 28.58 %), the studied groundnut pastes could be considered as a valuable source of protein in improving the nutrition status of humans[32]. In addition, the lipid content of the marketed groundnut paste falls within the range (42.58 – 49.32 %) reported by[33] for groundnut paste prepared with two Nigerian cultivars of *Arachis hypogea*. This result suggested that groundnut it is an interesting oleaginous crop for which the implementation should result in the economic well-being of rural people. Lipids also play a nutritionally role in providing essential fatty acids for humans. The relatively highest values of energy (570.66 – 625.92 kcal/100 g) of groundnut pastes samples analyzed in this study may be attributed to the highest values of their protein and fat contents. Moreover, these energy levels could cover the recommended energy for an adult, which is estimated to 800 kcal per day[34].

Fungal contamination

The fungal count of groundnut pastes, collected from markets, is given in **table 2**. The mycoflora was mainly represented by eight genera: *Mucor*, *Alternaria*, *Helmintosporium*, *Geotrichum*, *Fusarium*, *Cladosporium*, *Penicillium* and *Aspergillus* **(Table 2)**. The predominant fungi belonged to *Aspergillus* genus (86.67 %) and *Penicillium* (70.37 %) **(Figure 2)**. In addition, *Aspergillus* strains were isolated from all the samples analyzed whatever the commune. The groundnut pastes samples collected from Port-Bouet were more contaminated with *Helmintosporium* (44.44 %) and *Geotrichum* (25.95 %) while those collected from Treichville were more contaminated with *Alternaria* (31.11 %) and *Fusarium* (26.66 %). The highest occurrence of *Mucor* (30.23 %) was noted for the samples collected from Cocody. The total fungi count enumerated ranged from 10^4 to 10^6 CFU/g with the highest value (1.2 x 10^6 CFU/g) for the samples collected from Attécoubé. Other studies made in Kenya, Benin and Mali, have also revealed the occurrence of *Aspergillus*, *Fusarium* and *Penicillium* in groundnut pastes and other groundnut products[35-36]. The presence of *Aspergillus* sp. implies a risk of mycotoxin production and represent a health risk for the consumers[37]. According to[38], the mycotoxins produced by *Aspergillus* sp. include aflatoxins and ochratoxin A (OTA). Among the mycotoxins, aflatoxins produced by *Aspergillus flavus, Aspergillus parasiticus* and *Aspergillus nomius* are natural carcinogenic compound causing mutation[39].

The contamination level of the toxigenic flavi fungi is depicted by the **figure 3**. The highest occurrence of these fungi were 49.63; 41.48; 53.33; 74.82 and 48.19 % for *A. niger, A. versicolor*, *A. ochraceus*, *A. flavus* and *A. parasiticus*, respectively. The observed fungi contamination of the studied groundnut pastes exposing the consumers to a potential risk of acquiring food borne disease. Indeed, food borne illnesses of microbial origin are a major international health problem associated to food safety in developing countries[40]. The high susceptibility of groundnut contamination is mainly due to their nutritional content, useful to numerous fungi. Contamination of street-vended food such as groundnut paste has been attributed to exposure to polluted environment, poor sanitation and poor hygienic practices by the vendors[41]. There have been several suggested interventions to improve the hygiene of street foods such as groundnut paste.

CONCLUSION

The studied groundnut pastes sold in retail markets of Abidjan town are nutritive and could meet the dietary needs of the population when consumed with other foods. Indeed, these groundnut pastes constitute a valuable sources of protein, fat, crude fibre and minerals. However, the presence of toxigenic fungi as *Aspergillus flavus*, *Aspergillus ochraceus* and *Aspergillus parasiticus* in these groundnut products highlight a potential public health problem concerning the consumption by the consumers.

Table 1: Proximate composition of groundnut paste samples sold in retail markets of Abidjan town

Parameters	Communes investigated								
	AB (n=5)	AD (n=5)	AT (n=5)	C (n=5)	K (n=5)	M (n=5)	P (n=5)	T (n=5)	Y (n=5)
Moisture (%)	4.17^{b}±0.20	3.20^{a}±0.20	4.30^{b}±0.20	1.23^{d}±0.20	2.37^{c}±0.30	2.87^{a}±0.06	2.43^{c}±0.11	1.53^{d}±0.11	4.17^{b}±0.25
pH	6.72^{g}±0.00	6.67^{a}±0.01	6.69^{f}±0.00	6.66^{a}±0.01	6.44^{d}±0.00	6.40^{c}±0.01	6.26^{b}±0.01	6.58^{e}±0.01	6.70^{f}±0.01
Acidity (meq/100g)	17.33^{a}±1.15	15.30^{ac}±1.15	16.67^{a}±1.15	15.33^{ac}±1.15	12.31^{b}±1.15	11.30^{b}±1.15	10.33^{b}±1.15	14.63^{bc}±1.15	17.30^{a}±1.15
Ash (%)	5.67^{a}±0.80	4.67^{a}±0.60	4.87^{a}±0.60	5.16^{a}±1.00	5.50^{a}±1.20	5.82^{a}±1.16	5.61^{a}±0.80	4.86^{a}±1.00	5.47^{a}±1.31
Fibre (%)	5.47^{a}±0.50	5.33^{a}±0.60	5.00^{a}±0.00	5.63^{a}±1.14	5.15^{a}±0.28	5.15^{a}±0.28	5.00^{a}±0.00	5.47^{a}±0.50	5.31^{a}±0.50
Fat (%)	49.32^{c}±0.34	47.37^{ab}±0.52	49.03^{bc}±0.49	46.12^{a}±0.43	47.12^{a}±0.78	47.28^{ab}±0.86	42.58^{d}±0.93	49.03^{bc}±0.87	47.39^{ab}±0.97
Protein (%)	26.54^{ab}±2.53	26.55^{ab}±1.34	24.79^{ab}±1.34	27.42^{ab}±0.51	25.67^{ab}±1.34	23.92^{a}±1.34	23.33^{a}±2.20	28.58^{b}±2.20	25.96^{ab}±2.20
Carbohydrate (%)	17.29^{c}±2.87	21.40^{a}±1.87	21.55^{a}±1.34	22.66^{b}±1.45	19.84^{e}±1.30	21.24^{a}±2.21	23.92^{a}±2.28	22.52^{b}±3.08	18.95^{d}±3.18
Energy (kcal/100g)	619.90^{h}±24.66	617.85^{g}±17.56	625.70^{a}±15.15	609.97^{c}±13.78	613.47^{e}±14.27	613.06^{d}±21.94	590.66^{b}±22.89	625.92^{a}±29.01	615.26^{f}±30.24

Data are represented as means ± SD (n=3). Mean with different letters in the same row are statistically different ($p < 0.05$) according to Duncan's test.
AB: Abobo, AD: Adjamé, AT: Attécoubé, C: Cocody, K: Koumassi, M: Marcory, P: Port-Bouet, T: Treichville, Y: Yopougon.

Table 2: Genera of fungi isolated from groundnut paste samples sold in retail markets of Abidjan town

Fungi isolates (%)	Communes investigated								
	AB (n=5)	AD (n=5)	AT (n=5)	C (n=5)	K (n=5)	M (n=5)	P (n=5)	T (n=5)	Y (n=5)
Mucor	6.00^{a}±1.00	5.80^{b}±0.80	7.70^{c}±0.80	30.23^{d}±2.50	0.00^{g}±0.00	10.80^{b}±0.80	7.41^{c}±0.80	13.34^{e}±0.80	9.10^{f}±0.80
Alternaria	17.00^{a}±1.00	21.32^{b}±1.00	11.11^{c}±0.80	0.00^{g}±0.00	18.29^{d}±1.00	0.00^{g}±0.00	0.00^{g}±0.00	31.11^{e}±2.50	20.45^{f}±1.00
Helmintosporium	6.00^{a}±0.00	0.00^{d}±0.00	13.67^{b}±1.00	6.98^{a}±1.00	0.00^{d}±0.00	0.00^{d}±0.00	44.44^{c}±3.00	0.00^{d}±0.00	7.95^{a}±1.00
Geotrichum	0.00^{g}±0.00	12.63^{a}±1.00	15.38^{b}±1.00	0.00^{g}±0.00	0.00^{g}±0.00	8.12^{c}±1.00	25.93^{d}±2.00	6.67^{e}±1.00	3.41^{f}±0.00
Fusarium	5.00^{a}±0.00	4.46^{d}±0.00	0.00^{d}±0.00	0.00^{d}±0.00	15.85^{b}±1.00	0.00^{d}±0.00	0.00^{d}±0.00	26.66^{c}±1.00	0.00^{d}±0.00
Cladosporium	3.00^{a}±0.00	0.00^{d}±0.00	6.84^{b}±1.00	0.00^{d}±0.00	7.32^{c}±1.00	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{d}±0.00
Penicillium	28.00^{a}±1.00	33.68^{b}±2.50	18.80^{c}±1.00	39.54^{d}±2.00	31.71^{b}±2.00	32.43^{b}±2.00	0.00^{f}±0.00	0.00^{f}±0.00	27.27^{e}±2.00
Aspergillus	35.00^{a}±2.50	22.11^{b}±1.00	26.50^{c}±1.00	23.25^{d}±1.00	26.83^{e}±1.00	48.65^{f}±3.00	22.22^{g}±2.00	22.22^{g}±2.00	31.82^{h}±2.00
Total (CFU/g X 10^{4})	100^{a}±5.00	95^{b}±5.00	120^{c}±5.00	43^{d}±3.00	82^{e}±3.00	37^{f}±3.00	27^{g}±2.00	45^{h}±3.00	88^{i}±3.00

Data are represented as means ± SD (n=3). Mean with different letters in the same row are statistically different ($p < 0.05$) according to Duncan's test.
AB: Abobo, AD: Adjamé, AT: Attécoubé, C: Cocody, K: Koumassi, M: Marcory, P: Port-Bouet, T: Treichville, Y: Yopougon.

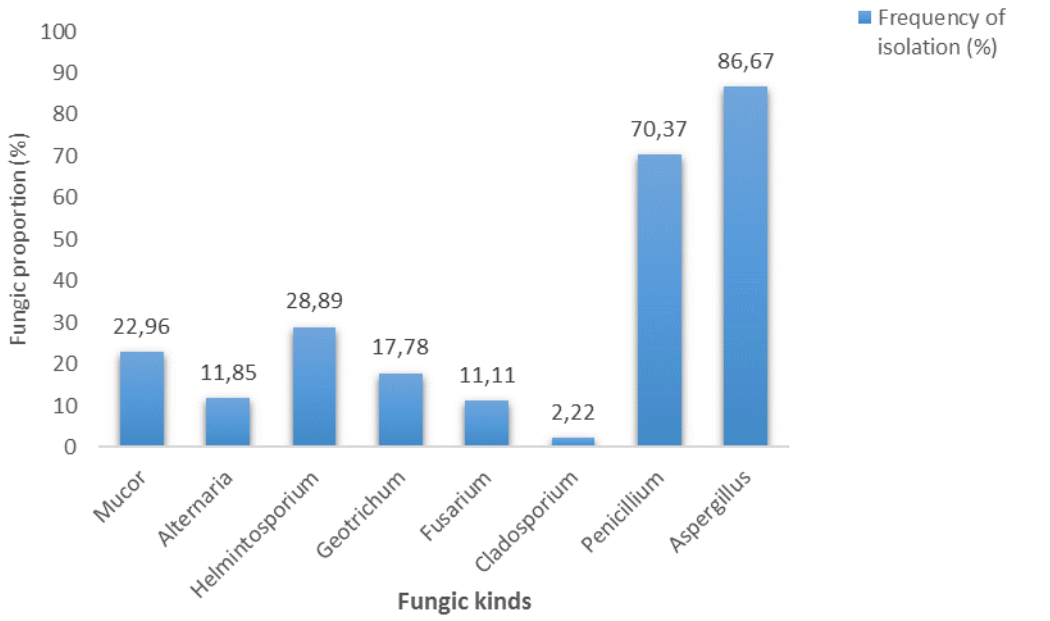

Fig. 2: Frequency of isolation fungal from groundnut pastes samples sold in retail markets of Abidjan town

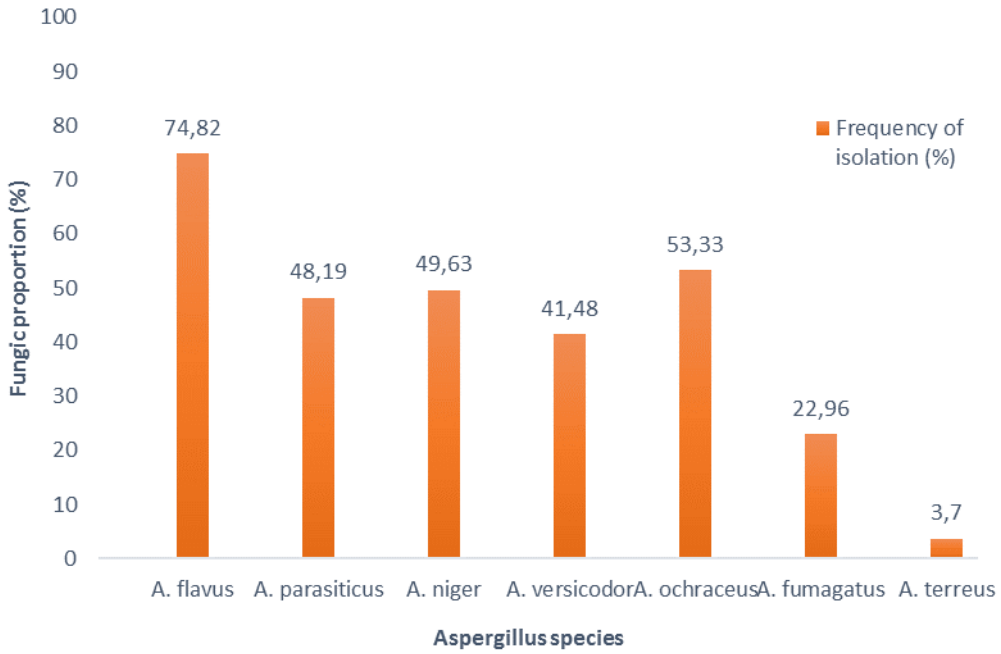

Fig. 3: Frequency of isolation of fungic species of *Aspergillus* from groundnut pastes samples sold in retail markets of Abidjan town

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