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Original article

Effect of Blanching and Sun-Drying on the Nutritional and Microbiological Qualities of Vegetables in Ilorin Metropolis, Nigeria

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Abstract

Vegetable has been identified as a potential tool to curb the menace of malnutrition; however, leafy vegetables are highly perishable. This study evaluated the nutritional and microbiological qualities of vegetables before and after blanching and solar-drying. The vegetables were evaluated for proximate and microbiological analysis using streak and pour plate methods. Four bacteria and seven fungi were isolated and characterized, their percentages of occurrence show; *Pseudomonas putida* (25%), *Bacillus cereus* (12.5%), *Staphylococcus aureus* (37.5%), *Aeromonas hydrophila* 25%. Also, *Aspergillus niger* 25%, *Aspergillus flavus* 12.5%, *Rhizopus stolonifer* (16.66%), *Mucor micheli* (8.34%), *Candida albicans* (8.34%), *Alternaria alternate* (16.66%) and *Rhizopus oligoporus* (12.5%). Nutritional compositions were determined. These results showed evidence of contaminations by potential pathogens during production and a slate change in nutritional content of the preserved vegetables. It is now important to pay attention on microbial qualities of leafy vegetables to safeguard the health of the consumers and forestall the possible risk of vegetable borne diseases.

Keywords: Malnutrition, blanching, solar-drying, proximate and microbiological analysis.

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INTRODUCTION

Over the years, vegetables had played the twin roles of food and medicine for man and other animals across the globe. This fact had made vegetable very essential on the list of human diet [1]. It is widely accepted that vegetables are important components of a healthy diet, and their consumption could help prevent a wide range of diseases. Green vegetables are important sources of nutrients to the public where they contribute immensely to potassium, dietary fiber, folate, protein, mineral, vitamin A and vitamin C which are usually in short supply in rural communities across Nigeria, more so other African countries [2]. High consumption of vegetable has been associated with lower risk of cardiovascular disease in humans; while low vegetable intake has been estimated to cause about 31% of ischemic heart disease and 11% of stroke worldwide [3].

According to World Health Organization, low vegetable intake and low consumption of complex carbohydrates and dietary fiber are estimated to cause approximately 2.7 million deaths per year [4]. Edible vegetables are grown worldwide. In Nigeria, *Celosia argentea* (plumed cockscomb or silver cock's comb), *Telfairia ocidentalis* (fluted pumpkin) and *Amaranthus hybridus* (African spinach) are among the most cherished edible herbaceous plants [5], they are surplus during the raining season and are used to prepare soup for nutritional purpose and sometimes used inform of blood tunic by Nigerian locals for medicinal function [6].

Despite these nutritional and medicinal importance of the vegetables to man, they tend to deteriorate in quality due to physiological activities like loss of moisture within short time [7,8]. Since they are known to contain high moisture content, it is difficult to keep them for days after been harvested [9].Microbial contamination and spoilage may occur after a while, thus changing its structure, texture and appearance, resulting to wastage [10]. Spoilage can either be complete, following the development of pathogenic organisms like *Bacillus cereus; clostridium perfringens; Escherichia coli* etc., or partially, when a significant decrease of nutritional value and/or development of toxic byproducts occur after harvest [11]. The study aimed to assess the effect of blanching and sun-drying on the nutritional and microbiological qualities of vegetables in Ilorin metropolis.

MATERIALS AND METHODS

Sample collection

Three (3) types of full green vegetable samples were purchased from Ipata Market at different selling points. The samples were wrapped in sterile polythene bags; these were taken to the Plant Biology Laboratory (Unilorin) for identification as in (Fig. 1, 2 and 3) below.

Fig. 1. *Celosia argentea* (Silver cock's comb)

Fig. 2. *Telfairia ocidentalis* (Fluted pumpkin)

Fig. 3. *Amaranthus hybridus* (African spinach)

Blanching of the samples

The full green vegetable samples collected were blanched before drying, where several centimeters of water were poured into a large cooking pot with close-fitting lid, the water in the pot was heated to boiling, a rack was placed in the pot to hold the layer of the vegetables, this was covered to let the vegetables steam for a period of time, the samples from the layer were wilted and felt soft and heated through till when it blanched properly (12).

Sun-drying of the samples

After successful blanching, the vegetable samples were spread on towel-lined trays to remove excess moisture, a sanitary condition where sun light can reach the solution was used, this was then monitored for a week, after which the vegetables dried until shriveled and leathery for longer storage, this was then cooled for 30 minutes, from which the vegetables were removed from drying trays and later stored in an airtight container in a cool and dry place (12).

Proximate Composition of the Samples

Proximate analysis of the samples was conducted on both fresh and preserved vegetables as described by [17, 18, 19, 20]. The parameters tested are:

Determination of moisture content

The crucibles were used and aseptically weighted five grams (5g) each of the vegetable sample. 'Gallenkamp' oven was used and heated the crucibles and the samples at one hundred degree Celsius until constant weights are obtained. The dishes and their contents were cooled in desiccators containing fused calcium chloride as drying agents and then weighed. The loss in weight was thus expressed in percentage as the vegetables' moisture content [17].

Determination of crude Protein

Two grams (2g.) of the each vegetable sample was aseptically weighed into a 300mL standard Kjeldahl digestion flask containing 8 mL of sodium sulphate catalyst. Some anti-bumping chips and 30mL of concentrated sulphuric acid were added, and 20mL of concentrated sulphuric acid was added at 200˚C for 45minutes; it was allowed to cool to room temperature (26±2 ^{O}C). The content was

transferred into Kjeldahl distillation apparatus and 10mL of distilled water with 15mL of 45%, Sodium hydroxide were added until the volume in the recording flask reaches 20mL thus, produced an ammonium borate complex; which was diluted to fifty millilitres and titrated with two per cent hydrochloric acid solution to a pink end point. The crude protein content was determined by multiplying the percentage nitrogen content by the conversion factor of five decimal three recommended for vegetable analysis [18].

Determination of crude Lipid / Fat Content

Five hours at fifty degrees Celsius petroleum extract in Soxhlet apparatus was mixed with two grams (2g) of the powdered samples. The % crude fat content = {(E – F) / G} x 100 where; F = weight of empty conical flask (g), E = weight of flask + content after evaporation (g) and G = weight of sample extract (g) [17, 20].

Determination of fibre Content

Two grams (2g) of each sample was distributed into conical flasks, 1.5% sulfuric acid solution followed, and heated for thirty minutes. Vacuum filter was used for its filtration; the filtrate was collected and washed with distilled water using a pH paper to ensure that no trace of acid is detected. The extracts are transferred into new set of conical flasks as one decimal twenty five Sodium hydroxide is added and heated for thirty minutes. The filtrate was continuously collected and washed until no trace of base is detected using pH papers. The samples were then transferred into crucibles which were thereafter dried in an oven at one hundred and five degrees Celsius for twenty-four hours. After drying the crucibles were placed in a muffle furnace at four hundred degrees Celsius for six hours, the weight of each crucible was then taken. The ash was weighed and recorded [18, 20].

Determination of ash content

The samples were ignited to dull red in muffled furnace at five hundred and fifty degrees Celsius until greyish white ash are obtained. The crucible and their contents were cooled in desiccators and once the room temperature reaches, the ash content was determined and recorded [17, 18].

Determination of carbohydrate content

The values obtained for crude protein, fat, total ash and fibre were added and subtracted with one hundred grams to have the carbohydrate content of the vegetables [19, 20].

Determination of mineral content

Two (2) grams of each of the processed samples was weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550˚C in a muffle furnace. The resultant ash was dissolved in 5.0 ml of HNO_3 / HCl / H_2O (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 ml of de-ionized water was added and heated until a colorless

solution was obtained. The solution was transferred into a 100mL volumetric flask by filtration through Whatman filter paper and the volume was made to the mark with de-ionized water. A 10cm long cell was used and concentration of each element in the sample was calculated on percentage of dry matter (i.e. mg/100 g sample). Phosphorus content of the digest was determined using colorimetric method [20].

MICROBIOLOGICAL ANALYSES

Enumeration of Microorganisms

The method described by [16] was employed, after serial dilution to obtain 10^{-2} diluents, an aliquot (1ml) each of the stock (10^{-1} and $10^{-2)}$ was inoculated in triplicates on Nutrient Agar and Potato Dextrose Agar by pour plate techniques. Streptomycin antibiotic was incorporated into PDA medium to inhibit bacterial growth. The plates were incubated for at 37±2 ^{O}C for 24 hours for bacteria while PDA plates were incubated at room temperature (28±2^{o}C) for 72 hours. After incubation, distinct colonies were counted.

Sub culture

After enumeration, distinct colonies were sub-cultured onto nutrient agar slant in McCartney bottle and incubated at 37±2^{o}C for 24 hours to obtain pure culture of the isolates, after incubation the pure cultures were aseptically stored in the refrigerator at 4^{o}C as stock culture as described by [21].

Characterization and identification of bacterial Isolates

The bacterial isolates were characterized based on their colonial and cellular characterization as described by [10]. All the isolates were further identified using conventional biochemical methods as described by [10].

Characterization and identification of fungal Isolates

The fungal isolates were characterized by colonial morphology and microscopic observation of both reproductive and vegetative structures as described by [22, 23].

Statistical Analysis

The data obtained were subjected to SPSS version 20.0 software, using analysis of Variance (ANOVA), the data were analyzed to compare the mean differences between the three leafy vegetable samples.

RESULTS AND DISCUSSIONS

Proximate analysis of the vegetable samples

The proximate composition of fresh and treated vegetables revealed that, moisture content (10.42^{b}±0.30 - 80.37^{a}±0.29%), protein (3.40^{a}±0.05 - 15.74^{b}±0.31%), Crude fiber (3.20^{a}±0.15 -

12.06^{b}±0.04%), Total fat (1.13^{a}±0.18 – 4.28^{b}±0.02%), Total ash (4.77^{a}±0.30 – 11.40^{b}±0.22%), Total carbohydrate (4.49^{a}±0.05 - 57.24^{b}±0.10%), pH (4.62^{b}±0.01 – 5.80^{a}±0.29%) and Vitamin C (28.56^{a}±0.05- 73.12^{b}±0.18%) for the studied vegetables. The nutrient compositions of the three fresh vegetables show significant increase after treatment. *Telfairia occidentalis* had the highest vitamin C (73.12^{b}±0.18%) followed by *Amaranthus hybridus* (36.42^{b}±0.23%) and *Celosia argentea* had vitamin C content of (34.42^{b}±0.18%). The vitamin C content between *Telfairia occidentalis* and the other two vegetables were significantly different at (P> 0.05) and the *Telfairia occidentalis* has higher nutritional values than the other two except in terms of carbohydrate which was lower than others.

The three vegetables meet the Recommended Dietary Allowance (RDA) for vitamin C (75 mg/day) for an average adult [31]. The treatments show significant effects in nutritional composition of these vegetables. A similar study was reported by Njoroge *et al.*, [32] who worked on the effects of blanching time/temperature combination coupled with solar-drying on the nutritional and microbial quality of indigenous leafy vegetables in Kenya. The protein content in fresh and treated vegetables were found to be highest in *Telfairia occidentalis* (15.74^{b}±0.31%), *Celosia argentea* (12.16^{b}±0.36%) and *Amaranthus hybridus* (10.42^{b}±0.12%), this results oppose the works of [16, 34]. There was a drastic gain in protein content after blanching and solar-drying of the vegetable samples. The large amount of protein in these vegetables cannot be explained as the values were actually higher than the ones reported by [35], and most other published works.

An average adult weighing 64 kg requires 51.2 g/kg/day which may not be obtained from the fresh vegetables. Relatively, more benefit could be achieved by practicing blanching and solar-drying in order to have better protein retention after treatment. In addition, the amounts protein obtained after the preservation can play a significant role in providing cheap and affordable protein for rural communities [32, 33, 36]. The crude fibre content in the studied vegetables showed slight variation. The difference in crude fiber contents may be due to soil fertility and age of leaves at the time of harvest; this was noted [34]. However, the crude fiber content for the fresh and treated vegetables was lower than the FAO/WHO RDA for an average adult (38 g/day) [37].

The Results of the mineral content of fresh vegetables were demonstrated and revealed that, Potassium (98.59^{a}±0.76 - 161.70^{c}±0.92mg/100g), Calcium (51.47^{a}±0.61 - 72.51^{b}±0.29mg/100g), Magnesium (198.70^{b}±4.9 - 221.10^{c}±9.24mg/100g), Sodium (18.62^{a}±0.27 – 51.29^{b}±0.8mg/100g), Phosphorus (25.72^{a}±0.28 – 31.01^{c}±0.50mg/100g) and Iron (24.10^{b}±0.23 – 28.84^{a}±0.19mg/100g) for the studied vegetables. *Telfairia occidentalis* had the highest mineral content followed by *Amaranthus hybridus* and *Celosia argentea* except for Magnesium *Amaranthus hybridus* had the highest (221.10^{c}±9.24) and *Telfairia occidentalis* with the lowest (198.70^{b}±4.9) values: this shows that vegetables are rich source of minerals [19].

Table 1. Proximate analysis of sample A (*Celosia argentea*)

S/No	Parameters	Fresh A	Solar Drying	3min. Blanching + Solar	5min. Blanching + Solar	10min. Blanching + Solar
1	Moisture	$80.37^{a}\pm0.29$	$11.02^{b}\pm0.08$	$11.52^{b}\pm0.23$	$11.61^{b}\pm0.30$	$10.60^{b}\pm0.14$
2	Protein	$4.20^{a}\pm0.41$	$12.16^{b}\pm0.36$	$11.99^{b}\pm0.12$	$11.81^{b}\pm0.21$	$11.08^{b}\pm0.05$
3	Crude Fiber	$3.52^{a}\pm0.18$	$10.34^{b}\pm0.11$	$10.56^{b}\pm0.09$	$9.68^{b}\pm0.10$	$10.00^{b}\pm0.15$
4	Total Fat	$1.65^{a}\pm0.11$	$1.79^{b}\pm0.08$	$1.75^{b}\pm0.12$	$1.71^{b}\pm0.23$	$1.69^{a}\pm0.25$
5	Total Ash	$4.77^{a}\pm0.30$	$11.06^{b}\pm0.14$	$11.34^{b}\pm0.22$	$11.29^{b}\pm0.08$	$11.28^{b}\pm0.12$
6	CHO	$4.49^{a}\pm0.05$	$53.01^{b}\pm0.40$	$52.84^{b}\pm0.10$	$53.90^{b}\pm0.05$	$55.35^{c}\pm0.15$
7	pH	$5.50^{a}\pm0.11$	$4.94^{b}\pm0.23$	$4.83^{b}\pm0.18$	$4.80^{b}\pm0.00$	$4.91^{b}\pm0.14$
8	Vitamin C	$28.76^{a}\pm0.41$	$34.42^{b}\pm0.18$	$32.91^{b}\pm0.12$	$29.00^{a}\pm0.03$	$28.56^{a}\pm0.05$

Keys: CHO represents Carbohydrate, Fresh A represent *Celosia argentea*. Mean values on the same row followed by different letters are significantly different at P<0.05, otherwise they are the same.

Table 2. Proximate analysis of sample B (*Telfairia ocidentalis*)

S/No	Parameters	Fresh B	Solar Drying	3min. Blanching + Solar	5min. Blanching + Solar	10min. Blanching + Solar
1	Moisture	$71.70^{a}\pm0.23$	$10.66^{b}\pm0.02$	$10.62^{b}\pm0.12$	$10.60^{b}\pm0.20$	$10.60^{b}\pm0.23$
2	Protein	$3.97^{a}\pm0.28$	$15.40^{b}\pm0.06$	$15.74^{b}\pm0.31$	$15.11^{b}\pm0.04$	$15.01^{b}\pm0.11$
3	Crude Fiber	$7.10^{a}\pm0.12$	$12.06^{b}\pm0.04$	$11.08^{b}\pm0.05$	$11.08^{b}\pm0.04$	$11.03^{b}\pm0.22$
4	Total Fat	$1.13^{a}\pm0.18$	$4.28^{b}\pm0.01$	$4.28^{b}\pm0.02$	$4.27^{b}\pm0.02$	$4.26^{b}\pm0.02$
5	Total Ash	$5.23^{a}\pm0.23$	$10.30^{b}\pm0.18$	$10.32^{b}\pm0.12$	$10.31^{b}\pm0.06$	$10.28^{b}\pm0.12$
6	CHO	$10.90^{a}\pm0.07$	$47.95^{b}\pm0.15$	$48.24^{b}\pm0.09$	$48.57^{b}\pm0.14$	$48.77^{b}\pm0.10$
7	pH	$5.80^{a}\pm0.29$	$4.62^{b}\pm0.01$	$4.74^{b}\pm0.02$	$4.82^{b}\pm0.00$	$4.88^{b}\pm0.02$
8	Vitamin C	$68.72^{a}\pm0.12$	$73.12^{b}\pm0.18$	$71.02^{c}\pm0.09$	$69.98^{a}\pm0.07$	$68.57^{a}\pm0.14$

Keys: CHO represents Carbohydrate, fresh B represent *Telfairia ocidentalis*. Mean values on the same row followed by different letters are significantly different at P<0.05, otherwise they are the same.

Table 3. Proximate analysis of sample C (*Amaranthus hybridus*)

S/No	Parameters	Fresh C	Solar Drying	3min. Blanching + Solar	5min. Blanching + Solar	10min. Blanching + Solar
1	Moisture	$81.07^{a}\pm0.51$	$10.42^{b}\pm0.30$	$10.62^{b}\pm0.18$	$10.60^{b}\pm0.09$	$10.60^{b}\pm0.23$
2	Protein	$3.40^{a}\pm0.05$	$10.24^{b}\pm0.16$	$10.42^{b}\pm0.12$	$10.41^{b}\pm0.23$	$10.08^{b}\pm0.07$
3	Crude Fiber	$3.20^{a}\pm0.15$	$9.07^{b}\pm0.09$	$9.10^{b}\pm0.11$	$9.08^{b}\pm0.00$	$9.00^{b}\pm0.17$
4	Total Fat	$1.60^{a}\pm0.21$	$1.69^{a}\pm0.12$	$1.68^{a}\pm0.00$	$1.70^{a}\pm0.23$	$1.69^{a}\pm0.05$
5	Total Ash	$4.87^{a}\pm0.18$	$11.36^{b}\pm0.24$	$11.40^{b}\pm0.22$	$11.39^{b}\pm0.20$	$11.39^{b}\pm0.12$
6	CHO	$5.57^{a}\pm0.20$	$57.22^{b}\pm0.32$	$56.78^{b}\pm0.10$	$56.87^{b}\pm0.25$	$57.24^{b}\pm0.10$
7	pH	$5.60^{a}\pm0.11$	$4.91^{a}\pm0.15$	$4.82^{a}\pm0.05$	$4.80^{a}\pm0.13$	$4.91^{a}\pm0.15$
8	Vitamin C	$28.76^{a}\pm0.41$	$36.42^{b}\pm0.23$	$33.82^{c}\pm0.12$	$29.66^{a}\pm0.31$	$28.76^{a}\pm0.09$

Keys: CHO represents Carbohydrate, fresh C represent *Amaranthus hybridus*. Mean values on the same row followed by different letters are significantly different at P<0.05, otherwise they are the same.

Table 4. Mineral composition (mg/100g) of the three fresh vegetable samples

S/No	Parameters	Sample A	Sample B	Sample C
1	Potassium	98.59^{a}±0.76	102.40^{b}±0.51	161.70^{c}±0.92
2	Calcium	51.47^{a}±0.61	72.51^{b}±0.29	56.01^{c}±0.25
3	Magnesium	207.28^{a}±5.43	198.70^{b}±4.9	221.10^{c}±9.24
4	Sodium	19.36^{a}±0.40	51.29^{b}±0.83	18.62^{a}±0.27
5	Phosphorus	25.72^{a}±0.28	28.16^{b}±0.28	31.01^{c}±0.50
6	Iron	28.12^{a}±0.15	24.10^{b}±0.23	28.84^{a}±0.19

Keys: A represent *Celosia argentea*, B represent *Telfairia ocidentalis* and C represent *Amaranthus hybridus*. Mean values on the same row followed by different letters are significantly different at P<0.05, otherwise they are the same.

Microbiological analysis of the vegetable samples

The range of the mean values for the bacterial count of the three fresh vegetable samples show that: *Celosia argentea,* $2.0^{b} \times 10^{5}$ - $9.3^{d} \times 10^{2}$ cfu/g; *Telfairia ocidentalis,* $1.3^{e} \times 10^{4}$ - $4.7^{c} \times 10^{2}$ cfu/g and *Amaranthus hybridus,* $1.7^{c} \times 10^{4}$ - $6.1e \times 10^{2}$ cfu/g; this indicates the highest count ($9.3^{d} \times 10^{2}$) count in sample, with lowest count of $1.3^{e} \times 10^{4}$ in sample B. The values were significantly different at P<0.05. While the range for fungi count shows that: *Celosia argentea,* $0.8^{d} \times 10^{2} – 3.2^{c} \times 10^{3}$ cfu/g; *Telfairia ocidentalis,* $0.4^{d} \times 10^{2} – 9.0^{c} \times 10^{2}$cfu/g and *Amaranthus hybridus,* $1.1^{e} \times 10^{2}$ - $3.3^{c} \times 10^{3}$cfu/g; this indicates the highest ($9.0^{c} \times 10^{2}$) count in sample B, with lowest ($0.8^{d} \times 10^{2}$) count in sample A. The mean values for the fungal counts were significantly different at P<0.05. The highest count was observed by samples preserved by only solar-drying, there was slight decrease in microbial population on the samples that were blanched before solar-drying. The results show that, the blanched solar-dried treatment has effect on the microbial quality of vegetables [38]. However, this opposes the work of [32], who reported higher microbial counts on indigenous leafy vegetables found in Kenya.

According to WHO (2004) regulations governing microbiological standards for foodstuffs and related matters stated that "in the food industry, a product shall be deemed to be contaminated, impure, decayed or harmful or injurious to human health if any of such products contain more than 10^{6}cfu per gram for total viable count, 10^{4}cfu per gram of yeasts and molds and 10^{3}cfu per gram of coliforms.

Table 5. Bacterial counts ($\times 10^{3}$) of the three blanched and solar-dried vegetable samples

Vegetables	Fresh	Solar drying	3min. blanching + Solar drying	5min. blanching + Solar drying	10min. blanching + Solar drying
Celosia argentea	$2.8^{a} \times 10^{3}$	$2.0^{b} \times 10^{5}$	$3.2^{c} \times 10^{3}$	$9.3^{d} \times 10^{2}$	$5.1^{e} \times 10^{2}$
Telfairia ocidentalis	$1.19^{f} \times 10^{3}$	$1.3^{e} \times 10^{4}$	$2.5^{a} \times 10^{3}$	$4.7^{c} \times 10^{2}$	$3.4^{d} \times 10^{2}$
Amaranthus hybridus	$4.5^{b} \times 10^{3}$	$1.7^{c} \times 10^{4}$	$2.3^{d} \times 10^{3}$	$6.1^{e} \times 10^{2}$	$5.3^{a} \times 10^{2}$

Mean values on the same row and column followed by different letters are significantly different at P<0.05, otherwise they are the same.

Table 6. Fungal counts ($\times 10^3$) of the three blanched and solar-dried vegetable samples

Vegetables	Fresh	Solar drying	3min. blanching + Solar drying	5min. blanching + Solar drying	10min. blanching + Solar drying
Celosia argentea	$1.4^{a} \times 10^2$	$2.2^{b} \times 10^3$	$3.2^{c} \times 10^3$	$1.3^{a} \times 10^2$	$0.8^{d} \times 10^2$
Telfairia ocidentalis	$1.1^{b} \times 10^2$	$9.0^{c} \times 10^2$	$2.0^{a} \times 10^2$	$0.4^{d} \times 10^2$	$1.0^{b} \times 10^2$
Amaranthus hybridus	$1.5^{a} \times 10^2$	$1.9^{d} \times 10^3$	$3.3^{c} \times 10^3$	$1.1^{e} \times 10^2$	$1.4^{a} \times 10^2$

Mean values on the same row and column followed by different letters are significantly different at $P<0.05$, otherwise they are the same.

The four bacteria isolated were characterized to be Pseudomonas putida, Staphylococcus aureus, Bacillus cereus and Aeromonas hydrophila, while the seven fungi were characterized to be Aspergillus niger, Aspergillus flavus, Alternaria alternate, Rhizopus stolonifer, Rhizopus oligosporus, Mucor micheli and Candida albicans. Similar organisms were also isolated [22]; these microorganisms are common spoilage organisms of vegetables. Some of these microorganisms are normal flora of vegetables [24]. Many microorganisms that have been isolated from the vegetables must have found their ways through different means ranging from soil contact, exposure to air flora, use of organic manure and so on [25].

The enumerative analysis of microbial isolates revealed that, some isolates have being implicated with different human diseases. Pseudomonas putida is reported as a saprotrophic soil borne bacteria; this bacterium is called a multi-plasmid hydrocarbon-degrading Pseudomonas. It has being exploited for bioremediation, bio-control of damping diseases caused by Pythium and Fusarium fungi species. It has being used in organic synthesis [26]. The presence of Bacillus cereus, Staphylococcus aureus and Candida albican are of public health issues, because they have been implicated in many human diseases like Candidiasis, folliculitis (pimples) and furuncles etc. The presence of these organisms in the vegetables could be from poor handling, processing and preparation [27].

Aeromonas hydrophilia is of safety concern as its pathogenicity in humans has long been recognized, by causing gastroenteritis. It is also majorly considered as a pathogen of fish and amphibians [28]. The presence of these species is a good trace of the agro-conditions under which the vegetables have been grown and an indication that they could pose a health risk if consumed without proper processing [29].The fungus Aspergillus flavus had been linked to a number of human and animal infections. It presence is of significance to this study. It's known to produce mycotoxins which are associated with cancer diseases and it is regard as RG-2 organism in respect to human and animal pathogenicity. Aspergillus niger, one of the most common species of the aspergillomas is the most frequently encountered agent of otomycosis was dominant on the studied vegetables. Alternaria alternata is soil borne plant parasites and is recognized as a causative agent of mycotic keratitis; it is also placed as RG-1 organisms [30].

Rhizopus stolonifer pathogenicity is highly questionable but implicated in human infection; this fungus along with Rhizopus oligosporus has been reported severally as a microflora of fruits and vegetables. The Mucor species have are considered economically importance. Only few of them that are thermo-tolerant have been linked with a number of rare human infections. The identified Mucor Micheli has no link to human pathogenicity [30].

The frequency of bacterial occurrence in the sampled vegetables shows that; Pseudomonas putida (25%), Bacillus cereus (12.5%), Staphylococcus aureus (37.5%) and Aeromonas hydrophila (25%) (Figure 1). Also, the frequency of fungi occurrence in the sampled vegetables shows that; Aspergillus niger (25%), Asperllus flavus (12.5%), Rhizopus stolonifer (16.66%), Mucor micheli (8.34%), Candida albicans (8.34%), Alternaria alternate (16.66%) and Rhizopus oligoporus (12.5%) (Figure 2). Factors which could be responsible can include; poor handling, drying vegetables on exposed surfaces and packing them in containers not adequately cleaned [21].The presence of these pathogens is worrisome, however, the results further showed that microbial load was not high to harm the body and that the vegetables could be preserved over a considerable period of time [31].

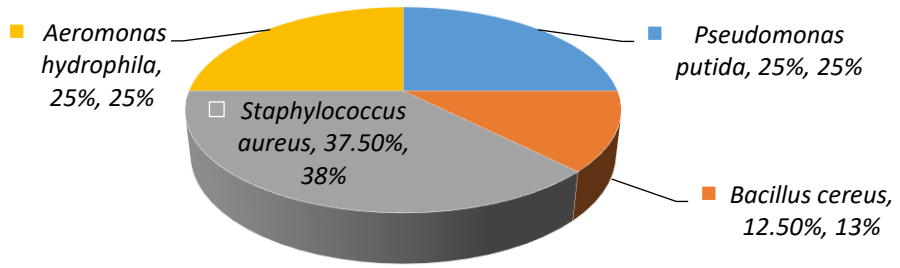

Figure 1. Percentage occurrence of bacterial isolates in fresh and treated vegetable samples

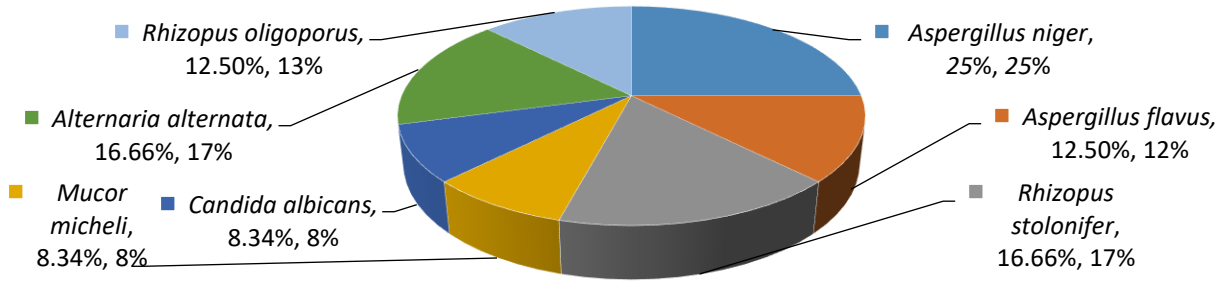

Figure 2. Percentage occurrence of Fungal isolates in fresh and treated vegetables samples

CONCLUSION

Blanching in combination with solar-drying could help to prolong the shelf life of *Amaranthus hybridus, Celosia argenta* and *Telfairia occidentalis* as well as enhance their nutritive properties. It is good to note that, solar-drying especially after blanching at 80^{o}C/10 minutes is an effective dehydration method that retains a good proportion of vitamins and minerals. In addition to the microbial load which will be lowered, this technology is relatively cheap and easy to practice by rural people.

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Competing Interests

No competing interests exist.

REFERENCES

1. Ogbe, A.O., and Affiku, J.P. Proximate Study, Mineral and Anti-nutrient Composition of *Moringa Oleifera* Leaves Harvested from Lafia, Nigeria Potential Benefit in Poultry Nutrition and Health. *Journal of Microbiology, Biotechnology and Food Sciences.* Vol 1 pp 296 – 308, 2011.
2. Brett, A., Cox, DR.S. Simmons, R. and Anstee, G. (1996). Producing Solar-Dried Fruits and Vegetables for Micro and Small-Scales Rural Enterprise Development: Handbook 3: Practical Aspect of Processing. Chatham, UK: Natural Resources Institute.
3. Sagar, V. R., and Suresh, K. P. Recent advances in drying and dehydration of fruits and vegetables. *Journal of Food Science and Technology*. Vol 47: 15-26, 2010.
4. Dias, J. S. "World Importance, Marketing and Trading of Vegetables," *Acta Horticulturae*, 921: 153-169, 2011.
5. Herrera, E., Jimenez, R., Aruoma, O. I., Hercberg, S., Sanchez-Garcia, I. and Fraga, C. "Aspects of Antioxidant Foods and Supplements in Health and Disease," *Nutrition Reviews,* 67 (1): S140-S144, 2009.
6. Awogbemi, O., and Ogunleye, I. O. Effects of drying on the qualities of some selected Vegetables. *International Journal of Engineering and Technology* Vol.1 (5), 2009
7. Okonya, J., and Maass, B. L. Can traditional leafy vegetable reduce protein and micronutrient malnutrition? A look at the nutrition quality of Cowpea leaves for two landraces grown in Uganda. Seminar paper from Tropentag 2010, Zurich, Germany "World food system – A contribution from Europe", 2010.
8. Lennox, J., and Nkra, B. O. Microbiological and Proximate Analysis of Fluted Pumpkin (Telfairia Occidentalis) Leaves and Seeds. *International Journal of Sciences:* Vol., 5(10), 2016.
9. Ndukwu, M. C. Development of clay evaporative cooler for fruits and vegetables preservation. *CIGR Journal,* 13 (1):1-8, 2011.
10. Montville, T. K., and Matthews, K. R. Food Microbiology: an Introduction ASM.Pp.362-ISBN 978-5558., 1-396-3, 2008.

11. Shittu, T. A., and Ogunmoyela, O. A. Water blanching treatment and nutrient retention in some Nigerian green leafy vegetables. Proceedings: 25th Annual Conference of the Nigerian Institute of Food Science and Technology, Lagos, 64-65, 2001.

12. Amaike, S. I., and Keller, N. P. *Aspergillus flavus*. *Annual Review of Phytopathology* .49:107-233, 2011.

13. Oluwatobi, S. O. The effect of processing techniques on the microbiological and nutritional qualities of the leafy vegetables *Vigna unguiculata* and *Moringa oleifera* grown in South Africa. Master's thesis Submitted in the University of South Africa, 2015.

14. FAO. Food wastage footprint: Impacts on natural resources. The World at Six Billion. A report from the United Nations regarding population dynamics in the future. Available at http://www.huwu.org/esa/population/publications/sixbillion/s 2013.

15. Food and Agricultural Organization. Global food losses and waste: Extent, causes and prevention. Study conducted for the International congress (FAO) Rome, 2011.

16. Kael, E. Design and testing of an evaporative cooling system using an ultrasonic humidifier. Department of Bioresource Engineering, Room MS1-027, Macdonald- Stewart Building, 21111 Lakeshore Road Ste. Anne De Bellevue, Quebec H9X 3V9. 2008: 1- 45, 2008.

17. Abalaka, M. E., Daniyan, S. Y., Oyeleke, S. B., and Adeyemo, S. O. The Antibacterial Evaluation of *Moringa Oleifera* Leaf Extracts on Selected Bacterial Pathogens. *Journal of Microbiology Research.* Vol 2 pp 1 – 4, 2012.

18. Association of Official Analytical Chemists (AOAC). *Official Methods of Analysis*. Washington D. C., Pp. 45-56, 2005.

19. Buck, A., Uba, A., and Oyeyi, T. I. Antimicrobial profile of Moringa oleifera extracts against some foodborne microorganisms. *Bayero Journal of Pure and Applied Sciences* 3:43-48, 2010.

20. Shahidi, F., Chavan, U. D., Bal, A. K. and Mckenzie, D. B. Chemical Composition of Beach Pea (*Lathyrus Maritimus* L.) Plant parts. *Food Chem.*, 64: 39-44, 1999.

21. Nahapetian, A. and Bassir, A. Changes in concentration and interrelationships of phytate, P, Mg, Cu, Zn in wheat during maturation. *J. Agric. Food Chem.*, 32: 1179-1182, 1975.

22. Kudjawu, B. D., Sakyi, D. E., Amoa-Awua, W. K. The micro-biota of dried traditional vegetables produced in the Sudan Savannah and Guinea Savannah agro-ecological zones of Ghana. Inter. *Food Research Journal*. 18:101-108, 2011.

23. Joshi, P. A., and Sonali, P. P. Microbiological Analysis of Fresh Vegetables and Fruits and Effect of Antimicrobial agent on Microbial Load. Department of Microbiology, Birla College of Art, Science and Commerce, Kalyan, India, 2010.

24. Bamigboye, O. O. Screening of Some Fungi Associated with Maize Cob Degradation for Cellulase Activity. *Greener Journal of Biological Science*; Vol. 3 (6), pp. 208-212, 2013.

25. Ofor, M. O., Okorie, V. C., Ibeawuchi, I. I., Ihejirika, G. O., Obilo, O. P., Dialoke, S. A. Microbial Contaminants in Fresh Tomato Wash Water and Food Safety Considerations in South-Eastern Nigeria. *Life Sci. Journ.*1:80-82, 2009.

26. Pelczar, M. J., Chan, E. C. S. and Krieg, N. R. Microbiology. 5th edition. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.

27. *Marqués, Silvia, Ramos and Juan, L. "Transcriptional control of the Pseudomonas putida TOL plasmid catabolic pathways". Molecular Microbiology.* ***9*** *(5): 923–9, 1993.*

28. Ezeronye, O. U., and Ubalua, A. O. Studies in the effect of abattoir and industrial effluents on the heavy metals and microbial quality of Aba River in Nigeria. *African Journal Biotechnology*. 3:266-272, 2005.

29. James, M. J. Modern Food Microbiology. Sixth Edition. Aspen food science text series. ISBN 0-8342-1671-X: QR115.J3, 2000.

30. Sapers, G. M., Gorny, J. R. and Yousef, A. E. Microbiology of Fruits and Vegetables. *Textbook.* CRC Press 2006; Taylor & Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton. ISBN 0-8493-2261-8, 2006.

31. Ellis, D., Davis, S., Alexiou, H., Handke, R. and Bartley, R. Descriptions of Medical Fungi. 2nd Edition. Nexus Print Solutions, South Australia 2032. ISBN 978095985 1267, 2007.

32. FAO/WHO. United Nations Food and Agriculture Organization/World Health Organization: Fruit and Vegetables for Health. *Report of a Joint FAO/WHO Workshop*, 1-3 September Kobe, Japan, 2004.

33. Njoroge, W. E., Matofari, J. W., Mulwa, R. M. S., and Joseph O. Anyango, O. J. Effects of blanching time/temperature combination coupled with solar-drying on the nutritional and microbial quality of indigenous leafy vegetables in Kenya. *African Journal of Food Science and Technology*. Vol. 6(7) pp. 209-219, 2015.

34. Uusiku, N. P., Oelofse, A., Duodu, K. G., Bester, M. J., and Faber, M. Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. *J. Food Comp. Anal.* 23:499-509, 2010.

35. Falade K., and Kolawole, T. Effect of Irradiation dose on the Physical, Functional and pasting properties of Cowpea (Vigna Unguiculata (L) Walp) Cultivars. *Journal of Food Process Engineering.* Vol 36(2) pp 147-159, 2013.

36. Barth, M., Thomas, R. H., Zhuang, H. and Breidt, F. Microbiological spoilage of fruits and vegetables. *Food Microbiology and Food Safety Journal.* Vol. 13, 2009.

37. Kantor, L. S., Lipton, K, and Manchester, A. Estimating and addressing America's food losses. *Food Review*. Jan-Apr: 2–12, 2010.

38. Mensah, J. K., Okoli, R.I., Ohaju-obodo, J. O., and Eifediyi, K. Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology. Vol. 7:2304-2308, 2008.