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V Silayo

EFFECT OF SUN-DRYING ON SOME QUALITY CHARACTERISTICS OF SWEET POTATO CHIPS

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ABSTRACT

In the Lake regions of Tanzania sun drying of sweet potatoes is normally done on thatched roofs after peeling and slicing the sweet potato tubers into chips. Future use of alternative drying surfaces including corrugated iron roofs may be practised as thatched roof houses are being slowly replaced with corrugated iron roof houses. This paper investigated the use of three different drying surfaces for various thickness levels of sweet potato chips. The surfaces employed included raised coffee wire (perforated surface), ground floor and corrugated iron sheet and the chip thickness levels were 4, 8, 12 and 16 mm. Drying was done continuously for a period of about 56 hours including day and night. The parameters investigated were weight loss during drying and moisture content derived from the weight loss values. Moisture content measured drying performance of the different treatments. Microbial count and sensory evaluation of the dry samples was investigated. Final moisture content on the different drying surfaces were as follows: 21.94%and 43.13%on the perforated surface, 23.71%and 44.50%on the ground surface and 24.5%and 39.82% on the corrugated iron sheet for 4 and 16 mm slices, respectively. The mean log counts of mould on the perforated surface and the corrugated iron sheet ranged between 8.2 and 8.4 compared with 9.09 on the ground floor. Similarly, bacterial mean log counts on the perforated surface and the corrugated iron sheet ranged between 6.43 and 6.52 compared with 7.04 on the ground floor. Perforated surface and the corrugated iron sheet gave sensory quality attributes ranging between 3.36 and 3.92 compared with 2.95 and 3.04 for the ground floor on a 5-point hedonic test. However, the perforated surface gave overall significantly higher (P<0.05) quality attributes than the corrugated iron sheet and the ground floor. Generally, the perforated surface and the corrugated iron sheet were superior to the ground floor in terms of drying performance, quality of the dry product and sensory evaluation. Also, high drying performance, high quality of dry product and high scores in sensory evaluation were shown on the small size thickness (4-8 mm). Due to seemingly high price of corrugated iron sheets and the higher drying performance and quality attributes obtained on the perforated surface, drying on raised perforated surfaces is recommended unless a corrugated iron roof house exists. Slicing of sweet potato into thin slices (4-8 mm) before drying is highly recommended.

Keywords: sweet potatoes, drying, thatched roof, corrugated iron sheet, ground

floor

French

EFFET DU SECHAGE AU SOLEIL SUR CERTAINES CARACTERISTIQUES DE LA QUALITE DES PATATES DUCES FRITES

RESUME

Dans les régions des lacs de la Tanzanie, le séchage des patates douces au soleil se fait normalement sur des toits de chaume après avoir épluché et coupé en tranches les tubercules de patates douces pour en faire des frites. L'utilisation future des surfaces alternatives de séchage telles que les toits à tôle ondulée peut être pratiquée étant donné que les maisons couvertes de chaume sont remplacées petit à petit par des maisons avec toits en tôle ondulée. Le présent exposé fait état des recherches menées sur l'utilisation de trois surfaces différentes de séchage pour différents niveaux d'épaisseur des patates douces frites. Les surfaces employées comprenaient une surface perforée, une surface de plancher et une tôle ondulée, et les niveaux d'épaisseur des frites étaient de 4, 8, 12 et 16 mm. Le séchage était fait continuellement pendant une période d'environ 56 heures, y compris le jour et la nuit. Les paramètres qui ont fait l'objet de la recherche étaient la perte de poids pendant le séchage et le degré d'humidité dérivé des valeurs de la perte de poids. Le degré d'humidité a mesuré la performance du séchage des différents traitements. Le calcul microbien et l'évaluation sensorielle des échantillons secs ont fait l'objet de la recherche. Les degrés d'humidité finals sur les différentes surfaces de séchage étaient comme suit: 21,94% et 43,13% sur la surface perforée; 23,71% et 44,50% sur la surface de plancher et 24,5% et 39,82% sur la tôle ondulée pour des tranches de 4 et 16 mm, respectivement. Les chiffres moyens des moules sur la surface perforée et sur la tôle ondulée s'étendaient entre 8,2 et 8,4 par rapport à 9,09 sur la surface de plancher. D'une manière semblable, les comptages moyens des bactéries sur la surface perforée et sur la tôle ondulée s'étendaient entre 6,43 et 6,52 par rapport à 7,04 sur la surface de plancher. La surface perforée et la tôle ondulée ont donné des attributs d'une qualité sensorielle s'étendant entre 3,36 et 3,92 par rapport à 2,95 et 3,04 pour la surface de plancher sur un test hédonique de 5 points. Toutefois, la surface perforée a donné des attributs d'une qualité globale beaucoup plus élevée ($P<0,05$) que la tôle ondulée et la surface de plancher. En général, la surface perforée et la tôle ondulée étaient supérieures à la surface de plancher en ce qui concerne la performance de séchage, la qualité du produit sec et l'évaluation sensorielle. De même, la performance de séchage élevée, la qualité importante du produit sec et les chiffres élevés de l'évaluation sensorielle ont été montrés sur l'épaisseur de petite échelle (4-8 mm). Suite au prix apparemment élevé des tôles ondulées, à la performance de séchage plus élevée, et aux attributs de la qualité obtenue sur la surface perforée, le séchage sur des surfaces perforées élevées est recommandé s'il n'existe pas de maison à tôle ondulée. Il est particulièrement recommandé de couper les patates douces en tranches fines (4-8 mm) avant le séchage.

Mots-clés: patates douces, séchage, toit de chaume, tôles ondulées, surface de plancher.

INTRODUCTION

Sun-drying of biological food commodities involves simultaneous heat and mass transfers, where heat propagates within the product and water migrates from the interior of a product onto the surface from where it evaporates [1-4]. The process leads to preservation and addition of value to the commodity. Drying can also be a preparatory stage to secondary processing as in the case of sweet potato flour [5].

During sun-drying, the drying rate is primarily influenced by solar radiation intensity as a source of heat and other climatic factors including wind speed, relative humidity, and ambient temperature [4]. The drying rate also depends on product thermo-physical properties, product bed voidage, surface where the product is spread for drying, and product initial moisture content. Whereas most of the sun-drying rate determining factors cannot be controlled, drying surface can be chosen depending on availability and suitability. Use of elevated perforated surface on grains and sweet potato chips has been demonstrated to yield higher drying rates than ground floor due to increased buoyancy in the drying bed [4-7]. This introduces partial hot air drying for which the primary drying rate-determining factor is temperature [8]. When drying is applied to high moisture product, the removal of moisture is initially very fast but later on slows down as product moisture reduction continues [1,3,8-11]. High initial drying rate in high moisture products is useful as the surface develops open texture responsible for rapid diffusion of moisture from the interior. This phenomenon may apply to products such as sweet potatoes, cassava, peppers, tomatoes and the like. With low initial drying, case hardening may develop, thus lowering the drying rate even further, with a consequent spoilage by environmental agents [9]. Therefore, sun-drying of high moisture product should be started when there is enough sunshine, in addition to use of suitable drying surface.

The use of a particular drying surface depends on socio-economic status of the family involved or the area. In the lake regions of Tanzania, sun-drying of sweet potato tubers is traditionally done on thatched roofs into a product locally known as *michembe,* after slicing of the tubers into chips of about 7 mm [12]. *Michembe* is a traditional food product that serves as a famine relief food during the dry season in these areas, with a high possibility of adapting the technology to other sweet potato growing areas of Tanzania. In China, sweet potatoes are also processed in a similar way in preparation of animal feed mixes [13]. With the possibility of thatched roof houses being slowly replaced with houses with corrugated iron roofs as the socio-economic status improves in the rural areas, there is a need for researching the use of corrugated iron sheets for sun-drying of sweet potatoes. This ought to be compared with suitable alternative sun-drying surfaces. The objective of this study was to investigate the effect of sun-drying on the moisture content, microbial load and sensory characteristics of sweet potato chips.

MATERIALS AND METHODS

Materials

Fresh sweet potato tubers were purchased from the market for this study. They were of the Morogoro variety brought to Morogoro municipal market from Gairo division where the crop is abundantly grown.

Methods

Slicing and drying

Sweet potato tubers were peeled manually and then sliced into different sizes of chips, using a fabricated chipper [12], at knife settings of 4, 8, 12, and 16 mm. The different sizes of chips were sun dried for three consecutive days on galvanized corrugated iron sheet (30G) at roof level, concrete floor, and raised perforated surface (coffee wire) with aperture area of about 25 mm^2, and replicated three times. Thatched roof was not used in this investigation to avoid contamination of *michembe* due to inferior quality of thatching materials used in the locality. Weather data during sun-drying for the three replications were solar radiation of 22-25 MJm^{-2}, ambient temperature of 26-28^{0}C, mean relative humidity of 67-70%, and wind speed of 95-260 km/h. After drying, a portion of the chips was cooked for about 30 minutes for acceptance testing.

Weight of each drying sample was recorded at the beginning and at the termination of each drying trial. The difference in weight was used to calculate moisture content at the end of drying by using the equation of Silayo [4]. Initial moisture content was determined on a 5 g sample in a ventilated oven at 105 ^{o}C for 24 hours [14]. Weighing took place after every two hours until the weight remained constant. On the dried chips, microbial counts were done using potato dextrose agar (PDA) for molds and plate count agar (PCA) for bacteria, using 1 g samples [15]. The number of colony forming units was counted and multiplied by the dilution factor to give the microbial population as number of colony forming units (cfu/g).

Sensory evaluation

Sensory evaluation employing a 5-point hedonic scale was done involving 19 trained panellists in the laboratory on the raw dry chips and cooked dry chips. Color, smell, appearance, taste and general acceptability of the samples were assessed in this analysis, whereby a score of 5 was referred to as excellent and 1 the worst, on the respective indices.

Statistical analysis

The data obtained were analysed using procedure for General Linear Model (GLM) [16] for the percentage moisture content. Microbial count were analysed using Statigraphs Plus and sensory evaluation using ANOVA, both followed by the Duncan's Multiple Range Test (p=0.05).

RESULTS

The effect of thickness of chips and drying surface is demonstrated in the final average moisture content given in Table 1 and drying characteristics (Figures 1-4). The effect of sun-drying on different surfaces on the extent of microbial growth on *michembe* and sensory attributes and general acceptability of *michembe* are given in Tables 2 and 3, respectively. Sensory evaluation and general acceptability of uncooked and cooked *michembe* are as shown in Tables 4 and 5, respectively. Table 6 summarizes the effect of various sizes of *michembe* on sensory evaluation and general acceptability.

Figure 1

Percentage moisture content of *michembe* dried using different drying surfaces at 4mm thickness

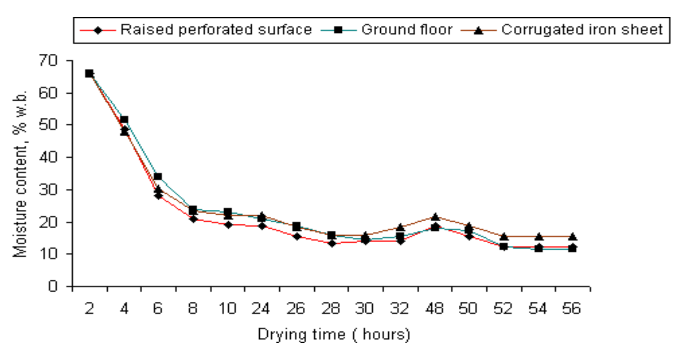


Figure 2

Percentage moisture content of *michembe* dried using different drying surfaces at 8mm thickness

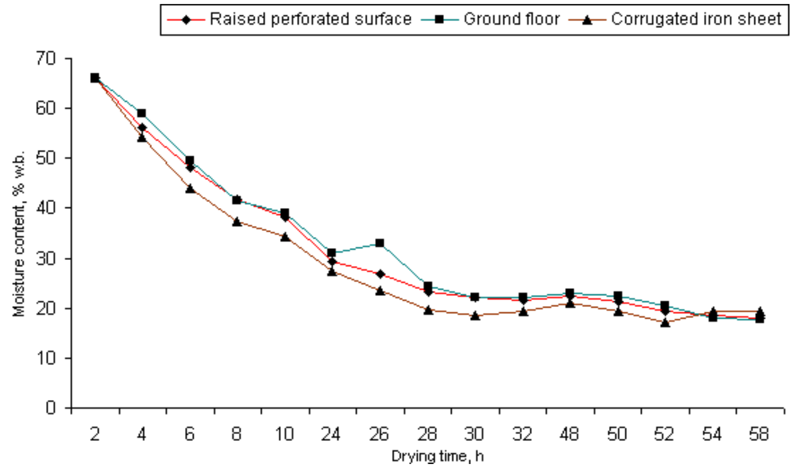


Figure 3
Percentage moisture content of *michembe* dried using different drying surfaces at 12mm thickness

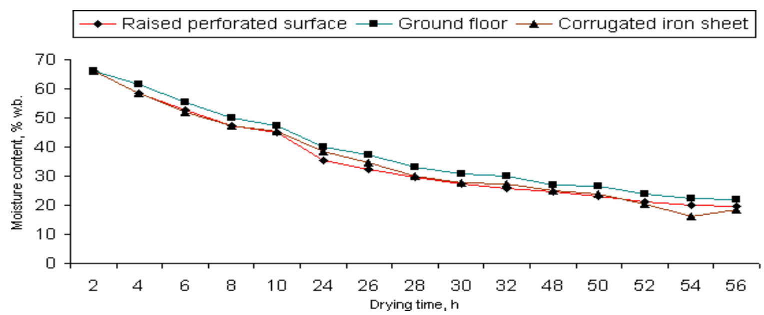
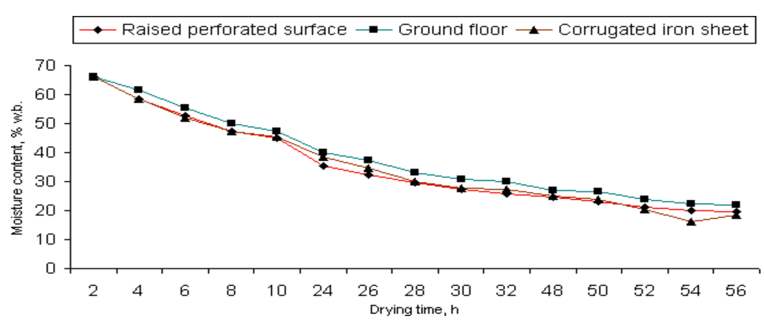


Figure 4
Percentage moisture content of *michembe* dried using different drying surfaces at 16mm thickness



DISCUSSION

Effect of Chips Thickness and Drying Surface on Sun-drying Performance

On the 4 mm slice thickness (Fig. 1), the perforated surface was the most effective drying surface and the corrugated iron sheet the most ineffective although the difference between the three surfaces was not significant ($P > 0.05$). Ineffectiveness in drying increased significantly ($P<0.05$) with chips thickness (Figs. 1-4), with the ground floor being the most ineffective of all the surfaces used. These observations were in agreement with earlier findings [4,6,7] that the perforated drying surface was better than the ground floor. However, the drying performance on the corrugated iron sheet did not differ significantly ($P > 0.05$) from the raised perforated surface except at 16 mm, where moisture content (Table 1) on the corrugated iron sheet was lowest. This was probably because the flow of air through the perforated bed that is said to improve drying [4] resulted in cooling of the thicker bed (16 mm), thus lowering the rate of drying. Also, better drying results of the 16-mm *michembe* on the corrugated iron sheet could be explained by relatively higher heat absorption by the metal surface compared with the rest of the surfaces that consequently accelerated the drying. Therefore, choosing between corrugated iron sheet and raised perforated surface should be based more on cost rather than performance.

Time to approach moisture equilibrium was short at 4 mm and increased with increasing thickness of slices (Figs. 1-4). This implies delayed drying for chips with large thickness, which may result in mold deterioration.

Effect of Drying Surface on Microbial Count

The highest mold and bacterial loads were observed on the chips dried on the ground floor as earlier observed [7], followed by the raised perforated surface. Corrugated iron sheet had the least load (Table 2). The difference between the raised perforated surface and corrugated iron sheet was not significant ($P > 0.05$). Although sun dried products are likely to be contaminated by air-borne microbes, the inferiority of the ground floor could be due to soil-borne microbes. This concurs with the findings of Kwaitia [17] that drying on ground floors is responsible for high levels of product contamination. Superiority of the corrugated iron sheet was probably attributed to possible high heating power originating from its high absorptivity and high thermal conductivity, hence destroying a substantial amount of the microbes compared with the other surfaces. However, contamination might also have come from the reported pre-drying processing activities [18,19].

Sensory Evaluation

Mean scores of appearance, color, and general acceptability of raw *michembe* dried on raised perforated surface were significantly ($P < 0.05$) higher than on the rest of the surfaces (Table 3), except on smell where the raised perforated surface did not differ significantly ($P > 0.05$) from corrugated iron sheet. For all the parameters, the ground floor resulted in the least scores, probably due to microbial contamination from the ground and tainting of the surface. The mean scores of appearance, smell, color, and general acceptability of raw *michembe* decreased significantly ($P<0.05$) as the thickness of chips increased (Table 4). The variation between the adjacent sizes was significantly ($P<0.05$) different in all parameters except smell, where variation between 4 and 8 mm chips thickness was not significant ($P>0.05$). This was because as the thickness of chips increased drying became poorer, thus encouraging microbial growth build up and enzymatic browning reactions.

On cooked *michembe* (Table 5), the organoleptic attributes were not so variable except that perforated surface gave *michembe* that were statistically ($P<0.05$) better than those dried on corrugated iron sheet. These were in terms of appearance, taste, smell and general acceptability. The only exception was on color, where the raised perforated surface did not differ significantly (P>0.05) from the corrugated iron sheet. The least scores were on the ground floor that however, did not differ significantly (P>0.05) from the corrugated iron sheet except on color. The mean scores of parameters decreased as the chips thickness increased (Table 6). Those at 4 mm were significantly (P<0.05) higher than the ones at 8 mm in terms of appearance, taste and color. Regarding smell and general acceptability, the change in quality was significant (P<0.05) for the 16-mm thick *michembe*. However, the 16-mm thick *michembe* showed significantly (P<0.05) lower mean scores than the remaining sizes in all the parameters except for the appearance.

CONCLUSIONS

Sun-drying of sweet potato chips on the ground floor resulted in inferior product. Since drying on either perforated surface or the corrugated iron sheet gave almost same results, choice of either of the surfaces should be based on cost. Poor performance of the ground floor is in compliance with high microbial load and inferior taste of the product. Whereas the ground floor gave the worst product, the perforated surface gave a better product in terms of appearance, color and general acceptability. Also, *michembe* of large size thickness were generally more inferior to the thin ones. Therefore, in making *michembe*, slicing of the tubers into thin chips with subsequent drying on either perforated raised surface or corrugated iron sheet is scientifically acceptable.

RECOMMENDATIONS

From economic point of view use of corrugated iron sheet may be more expensive than most of the suitable perforated surfaces, hence use of the latter is recommended unless a corrugated iron roof house exists. However, for health reasons such roofs should not be rusty or painted with lead-based colors. Such hazards prompt preference of raised perforated surface for sun-drying of sweet potato chips.

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Table 1
Final average moisture content of sweet potato chips (*michembe*) on the different drying surfaces for the entire drying period

Drying surface	Thickness (mm)			
	4	8	12	16
Perorated surface (raised)	21.94^{ah}	31.54^{cd}	35.19^{dj}	43.13^{fk}
Ground floor	23.71^{al}	32.65^{bm}	38.23^{en}	44.50^{fo}
Corrugated iron sheet	24.50^{ap}	28.96^{cq}	35.58^{dl}	39.82^{gm}

Means in the same column with the same letter are not significantly different at 5% level using Duncan's Multiple Range Test

Table 2
Effect of drying surfaces on mold count and bacteria contamination on *michembe*

Drying surface	Mean count[1] (log [cfu/f])	
	Mold log	Bacteria log

Corrugated iron sheet	8.20^{a}	6.43^{c}
Perforated surface (raised)	8.40^{a}	6.52^{c}
Ground floor	9.09^{b}	7.04^{d}

[1]Means in the same column with the same letter are not significantly different at 5% level using Duncan's Multiple Range Test

Table 3
Effect of drying surface on appearance, smell, color, and general acceptability of *michembe*

Drying surface	Appearance	Smell	Color	General acceptability
Perforated surface (raised)	3.93^{a}	3.62^{a}	3.88^{a}	3.92^{a}
Corrugated iron sheet	3.39^{b}	3.49^{a}	3.36^{b}	3.50^{b}
Ground floor	3.03^{c}	2.92^{b}	2.95^{c}	3.04^{c}

Means in the same column with the same superscripts are not significantly (P>0.05) different using Duncan's Multiple Range Test

Table 4
Effect of slice thickness on appearance, color, smell and general acceptability of uncooked *michembe*

Slice thickness (mm)	Appearance	Smell	Color	General acceptability
4	4.37^{a}	3.79^{a}	4.25^{a}	4.25^{a}
8	3.74^{b}	3.61^{a}	3.50^{b}	3.77^{b}
12	3.09^{c}	3.19^{b}	3.05^{c}	3.16^{c}
16	2.61^{d}	2.77^{c}	2.71^{d}	2.77^{d}

Mean in the same column with the same superscripts are not significantly (P>0.05) different suing Duncan's Multiple Range Test

Table 5
Effect of drying surface on appearance, smell, color, taste and general acceptability of cooked *michembe*

Drying surface	Appearance	Taste	Color	Smell	General acceptability
Perforated surface (raised)	3.53^{a}	3.66^{a}	3.46^{a}	3.62^{a}	3.64^{a}
Corrugated iron sheet	2.91^{b}	3.17^{b}	3.21^{a}	3.21^{b}	3.22^{b}
Ground color	2.79^{b}	3.14^{b}	2.82^{b}	3.18^{b}	3.01^{b}

Means in the same column with the same superscripts are not significantly (P>0.05) different using Duncan's Multiple Range Test

Table 6
Effect of chips thickness on color, smell, appearance, taste and general acceptability of cooked *michembe*

Chips thickness (mm)	Appearance	Taste	Color	Smell	General acceptability
4	3.67^{a}	3.56^{a}	3.61^{a}	3.49^{a}	3.65^{a}
8	3.33^{b}	3.35^{b}	3.30^{b}	3.44^{a}	3.53^{a}
12	3.05^{c}	3.26^{b}	3.23^{b}	3.42^{a}	3.51^{a}

16	3.25^b	3.09^c	2.51^c	3.00^b	2.49^b

Means in the same column with the same superscript are not significantly (P>0.05) different using Duncan's Multiple Range Test

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