EFFECTS OF ALOE VERA GEL PRE-TREATMENT AND DRYING METHODS ON SOME QUALITY PARAMETERS OF SLICED OKRA

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ABSTRACT

Okra (Abelmoschus esculentus L.) is a tropical and sub-tropical vegetable crop, usually desired both during its peak season in its fresh form and during the off-peak season in its dried form. Discoloration during thermal drying of okra often results in its reduced acceptability in dried form. This study investigated some quality parameters of differently dried okra slices. The okra slices were subjected to freeze-drying at -420 ºC, sun drying at 41 ºC and cabinet drying at 60 ºC, while slices pretreated with aloe vera gel were also subjected to sun drying and cabinet drying at 60 ºC. Fresh and dried samples were analyzed for moisture content, reconstitution index and colour retention. Results of the analysis was subjected to statistical analysis using Analysis of Variance (ANOVA). Results showed that the freeze-dried samples had the lowest moisture content (6.33) while the aloe vera treated samples generally had significantly higher moisture content among all the dried samples. The result further showed that the reconstitution index of the samples ranged from 0.72 for cabinet dried aloe vera treated samples to 0.63 for untreated sundried samples but was not significantly different from each other. The greenness of the fresh okra pods ranged from -12.70 to -13.76 while -4.62, -6.58, -8.51, -5.70 and -8.20 were reported for freeze-dried, untreated sundried, untreated cabinet dried, aloe vera treated sundried and aloe vera treated cabinet dried samples respectively. The untreated cabinet dried samples had the highest lightness (a) value (-8.51) among all the dried samples but was significantly indifferent ($p \leq 0.05$) from cabinet dried aloe vera treated samples which had a value of -8.20. Results further showed that all the dried samples except the sundried aloe vera treated samples scored above average in terms of colour retention. It was concluded that for the food industry, sundried and cabinet dried untreated okra slices as well as cabinet dried aloe vera treated okra slices may be equally acceptable in terms of colour. It is recommended that steam blanching as a pretreatment to cabinet and sun drying should be studied.*

KEYWORDS: Okra, Aloe vera, Drying, Colour

1. INTRODUCTION

Consumers around the world demand for food of high-quality and extended shelf life with its desirable inherent qualities such as colour, flavour, aroma and reconstitution stability. This has led to many processing techniques which have been developed to extend the shelf life of unstable foods while retaining its desirable inherent qualities. Chlorophyll containing vegetables are one of such shelf-unstable food materials, capable of losing its chlorophyll during thermal drying. Chlorophylls are highly susceptible to degradation during processing resulting in colour shift of chlorophylls from brilliant green to olive brown compounds such as pheophytin and pheophorbide in senescent tissues (Koca *et al*. 2006). Chlorophyll degradation is significantly mediated by factors such as enzyme chlorophyllase, heat, light, oxygen, chemicals and acids (Gunawan and Barringer, 2000; Koca *et al*., 2006).

Okra is a vegetable crop belonging to the genus *Abelmoschus*, family *Malvaceae* and has two main species: *Abelmoschus esculentus (L.) Moench* and *Abelmoschus caillei (A. Chev.) Stevels.* It is an important vegetable crop native to tropical and sub-tropical regions of the world, especially

Africa. It is a popular non-seasonal crop (although its peak period is usually in the raining season) usually enjoyed for its tender, delicious and slurry pod with brilliant green colour. Okra is usually desired, both during its peak season in its fresh form and off-peak season in its dry form. Thermally dried okra however absorbs a measure of ethylene, thus losing its attractive colour resulting in loss of preference, acceptability, and pleasantness. Discolouration during thermal drying of okra is mainly related to the replacement of magnesium ion in the porphyrin ring by hydrogen ions and subsequent formation of pheophytin and pheophorbide that result in a change in colour from bright green to dull olive green (Heaton and Marangoni, 1996; Toivonen and Brummell, 2008).

To stabilize and retain chlorophyll in stored green vegetables such as okra, various processing treatments have been applied. Olivas and Barbosa-Canovas (2005) studied the retention of chlorophyll in green apples using edible waxes, Gorny *et al*. (2002) studied the quality changes in fresh-cut pears slices by controlled atmospheres packaging, Aguayo *et al*. (2006) studied the atmospheric modification on quality changes in fresh –cut strawberries while Nwosu *et al.* (2016) studied the storage stability of cucumber using aloe vera gel. Globally, freeze drying of food materials is accepted as the best and most effective way of preserving foods of unstable colour and properties, however, freeze drying technology is sophisticated, expensive for the poor rurals and cannot be domesticated in areas with unstable power supply such as Nigeria.

Aloe vera, a tropical and subtropical plant is well-known for its numerous medicinal properties. Its gel, alternative to synthetic preservatives such as sulfur dioxide, is colourless, odourless (Jawadul *et al.,* 2014) and nutritionally safe to consume. Aloe vera gel-based edible coatings have been shown to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in fruits such as table grapes, sweet cherries and nectarines (Castillo *et al*., 2010;Ahmed *et al*., 2009; Martinez-Romero *et al*., 2006). This gel operates through a combination of mechanics, forming a protective layer against the oxygen and moisture of the air and inhibiting the action of micro-organisms that cause food borne illnesses through its various antibacterial and antifungal compounds (Serrano *et al*., 2006).

Several investigations have been reported on the optimum drying parameters, pre-treatments and the drying kinetics of okra (Pendre *et al.,* 2012; Shivhare *et al*., 2000; Ouedraogo *et al.,* 2017; Doymaz, 2005; Olaniyan and Omoleyomi, 2013; Shivhare *et al*., 2000); But, little can be found in literature on the quality retention in terms of colour of dried okra. This study investigated the effects of aloe vera gel pre-treatment and drying methods on some quality parameters of sliced okra with a view of retaining its chlorophyll.

2. MATERIALS AND METHODS

2.1 Materials

Freshly harvested and uninjured dwarf variety of okra (*Abelmoschus esculentus (L.) Moench)* was obtained from a rural farm, while fresh and healthy Aloe vera leaves were obtained from a horticultural garden, all in Ilorin, Kwara state, Nigeria. A hue and chroma colour analyser (Model number: CRL/FD/21/004) was used to analyse the colour of the okra samples. An electrically powered dryer designed and available at the Engineering and Scientific Services (ESS) Department of the National Centre for Agricultural Mechanization (NCAM) was used for the drying. The dryer which consists of a heat source, an air blower, the drying chamber and a

chimney was instrumented with a temperature controller/ monitor, an airflow controller/ monitor and a thermocouple. The moisture content of fresh and dried samples were determined using a digital moisture analyser (Ohaus, Model number: MB90. Serial number: B707695969). A laboratory manifold freeze dryer (Labconco freeZone 1 litre capacity), model number: 700201000 available at the Central Research Laboratory of the University of Ilorin, Ilorin was used in this study.

2.2 Sample Preparation

The freshly harvested okra was washed to remove and spread on a screen to drain water. The tails and butts of the cleaned okra pods were removed by a stainless-steel knife while the slicing was done with the aid of NCAM developed okra slicer. The thickness of the sliced okra was measured to be an average of 1 cm. Aloe gel which lies underneath the green outer leaf rind of the plant was obtained by separating the outer cortex of leaves from the gel. The gel was blended with an electric blender for 3 mins at low speed to homogenize, and the resulting gel poured into a plastic bowl for use. Samples treated with Aloe vera and sundried were labelled as $\mathbf{A_{11}}$ while samples treated with Aloe vera and dried using a cabinet dryer were labelled as $\mathbf{A_{12}}$. Untreated samples dried using a dryer were labelled UT_2 while untreated sundried samples were labelled as UT_1. Freeze dried samples were labelled as FD_0.

2.3 Method

Three replicates of 2 kg each of A_{11} and A_{12} were immersed in the homogenised aloe vera gell for 7 mins. The choice of the immersion time was based on the preliminary investigation carried out on habanero pepper which showed that 7 mins was appropriate for immersion in aloe vera gel. The treated and the untreated samples was then dried using the various drying techniques. The cabinet drying of okra was carried out at 60ºC. The choice of 60ºC was based on preliminary investigation. The okra samples were pre-freezed in a laboratory blast freezer at a eutectic temperature of -49ºC for 28 hours. The pre-frozen slices were then quickly attached to the manifold flask for drying, while the collector temperature was set to -70ºC and the vacuum pump was at 0.0025mbar. The okra samples were allowed to dry for 17 hours.

The fresh and dried samples were analysed for colour using methods described by the hue and chroma colour analyser manufacturer manual. The colour analysis was determined using the CIE L * a * b * parameters. According to the CIE colour space, L * parameter represents brightness and changes between 0 (black) to 100 (white); the a * parameter gives the green (-a *) or the red (+ a *), while the b * parameter gives the yellow (+ b *) or blue (-b *) (Mc Guire, 1992; Manolopoulou and Varzakas, 2016). The colour analysis were performed before and after drying.

The samples were further analysed for moisture content using methods described by the moisture analyser manufacturers manual at a temperature of 105ºC for 30 mins using a 2g sliced sample. Reconstitution index of the dried samples were determined as a ratio of rehydration ratio to dehydration ratio as described by Kumar *et al*. (1991) and used by Shivhare *et al*. (2000). All analysis were carried out in triplicates.

All results obtained in this study were subjected to Analysis of Variance (ANOVA) statistics. A Statistical Package for Social Sciences (SPSS) software version 22, created by IBM group was used for this purpose.

3. RESULTS AND DISCUSSION

The result of the moisture content is presented in Table 1. From the Table, moisture content ranged from 84.77 % in the control sample to 6.33% in the freeze dried samples. The dried samples also showed significant differences in moisture content, indicating the different level of dryness of the sample. Among the samples, the aloe vera treated samples showed the highest moisture level of 9.41% and 9.99% for cabinet dried and sundried samples, respectively. This significantly high moisture level in the aloe vera treated samples indicates a possible lower drying rate compared with other samples at the same drying conditions. It appeared that the aloe vera gel may have filled up respiratory pores in the okra pod and provided a protective film on the surface layer of the pods which slowed down the rate of heat diffusion within the slices and trapped moisture between the outer green layer of the slices and the protective film provided by the gel. This may have lowered the drying rate and resulted to significant higher moisture content of the sample within the same drying time. This agrees with the findings of Nwosu *et al.* (2016), who reported a protective film created by aloe vera gel during shelf storage of cucumber. According to the authors, the protective film reduced respiration and moisture loss in fresh cucumber samples during shelf storage. Doymaz (2005) reported a higher final moisture content (15% wb) of okra (*Hibiscus esculentus L.*) variety dried at 60ºC. Table 1 further showed that the moisture content of cabinet dried aloe vera samples were not significantly different from the untreated sundried samples at $p \leq 0.05$, it however showed significant difference from its cabinet dried counterpart. This higher moisture content of aloe vera treated samples suggests a lesser shelf life under ambient conditions.

The result of the reconstitution index of the dried samples is presented in Table 1. The Table showed that the reconstitution index of the samples ranged from 0.72 for cabinet dried aloe vera treated samples to 0.63 for untreated sundried samples. All the samples showed a reconstitution index greater than 0.5. This implies that the ability to reconstitute when utilized in food systems is higher than average.

Table 1. Moisture content and reconstitution index of control and differently dried okra

Sample	**Moisture content**	**Reconstitution Index**
Control	84.77 ± 0.2^{a}	-
FD_0	6.33 ± 0.57^{e}	0.66 ± 0.29^{a}
UT_1	9.07 ± 0.80^{cd}	0.63 ± 0.01^{a}
UT_2	8.42 ± 0.58^{d}	0.64 ± 0.01^{a}
A_{11}	9.99 ± 0.08^{b}	0.71 ± 0.01^{a}
A_{12}	9.41 ± 0.28^{bc}	0.72 ± 0.01^{a}

Values are mean of three replicates ± SD. Valueswith different superscript along the column are significantly different ($p \leq 0.05$).

FD_0 - Freeze dried samples; UT_1 - Untreated sundried samples; UT_2 - Untreated samples dried using cabinet dryer; A_{11} - Samples treated with Aloe vera and sundried; A_{12} - Samples treated with Aloe vera and dried using a cabinet dryer

The results further showed no significant difference from each other at $p \leq 0.05$. It appears that the protective film created by the gel in the aloe vera treated samples did not reabsorb much moisture to trigger a significant difference ($p \leq 0.05$) during its reconstitution. Shivhare *et al*. (2000) reported similar values of 0.72 and 0.80 for water blanched and NaCl blanched okra (*Abelmoschus esculenrus*) variety respectively at a drying temperature of 55ºC.

The result of the colour analysis is presented in Table 2. The greenness of the fresh pods ranged from -12.70 to -13.76 while that of the dried samples ranged from -4.62 for freeze dried samples to -8.51 for untreated cabinet dried samples. The low a* value of the freeze-dried samples may have resulted from freezer-burn experienced by the samples at the eutectic temperature of -49ºC before sublimation could occur. Additionally, it is possible that at such low temperature, the magnesium (Mg) ion at the centre of the chlorophyll porphyrin ring degraded, leading to the collapse of the chlorophyll structure and formation of pheophytin; this may have aided in the pronounced brown colour of the freeze-dried samples. This implies for the food industry, that freeze drying of okra pods could lead to an unacceptable sensory colour. The untreated cabinet dried samples showed a significantly higher green colour (-8.51) at $p \leq 0.05$ than other samples under study. This may have resulted from the steady rate of heat diffusion under hot air drying as opposed to the possible sudden temperature and air velocity changes during sun drying. During cabinet drying of the untreated samples, the steady rate of heat diffusion and moisture diffusion may have increased the drying rate as reported by Doymaz (2005), giving little time for the collapse of chlorophyll and resulting in the brilliant green colour of the dried samples. During sun drying however, sun intensity and air velocity fluctuates per time, leading to differentials in the rate of heat and moisture diffusion. This is an indication that drying rate may be an important factor in the colour of dried okra slices as reported by Shivhare *et al*. (2000).

Table 2. Result of colour Analysis of the differently dried samples

	Before Drying			After Drying		
Sample	L*	a*	b*	L*	a*	b*
FD_0	47.02 ± 2.63^{a}	-12.80 ± 0.93^{ab}	28.58 ± 2.59^{a}	46.64 ± 2.18^{a}	-4.62 ± 1.33^{a}	14.38 ± 0.22^{a}
UT_1	44.40 ± 1.15^{b}	-12.70 ± 0.49^{a}	15.09 ± 0.71^{c}	35.56 ± 4.97^{c}	-6.58 ± 0.54^{b}	15.38 ± 2.43^{a}
UT_2	45.94 ± 0.60^{ab}	-13.21 ± 0.43^{ab}	29.49 ± 0.29^{a}	40.64 ± 0.08^{bc}	-8.51 ± 0.07^{c}	14.42 ± 1.24^{a}
A_{11}	46.42 ± 0.08^{ab}	-13.76 ± 0.03^{b}	19.04 ± 0.11^{b}	43.71 ± 2.11^{b}	-5.70 ± 0.10^{ab}	16.92 ± 3.33^{a}
A_{12}	41.18 ± 0.08^{c}	-13.18 ± 0.11^{ab}	17.64 ± 0.05^{b}	40.18 ± 2.89^{bc}	-8.20 ± 1.32^{c}	15.49 ± 0.81^{a}

Values are mean of three replicates ± SD. Values with different superscript along the column are significantly different ($p \leq 0.05$). L* = brightness, -a* = green, b* = yellow. FD_0 - Freeze dried samples; UT_1 - Untreated sundried samples; UT_2 - Untreated samples dried using cabinet dryer; A_{11} - Samples treated with Aloe vera and sundried; A_{12} - Samples treated with Aloe vera and dried using a cabinet dryer

Table 2 further showed that the sundried aloe vera samples which had a value of -5.70 showed no significant difference ($p \leq 0.05$) from the untreated sundried samples. It however appeared that the protective film created by the aloe vera gel, which also filled the respiratory pores of the okra pods, may have trapped enough moisture with adequate activation energy at the surface layer of the pods (with low air flow velocity), long enough to collapse some of the magnesium (Mg) ions at the centre of the chlorophyll structures. These collapsed Mg ions may have been replaced by hydrogen ions from the chlorophyll matrix, leading to the formation of pheophorbide with a characteristic dull olive-green colour as described by Heaton and Marangoni (1996), Toivonen and Brummell (2008). It is also possible that with the retention of moisture at the surface layer of

the pods during sun drying of the aloe vera treated samples, adequate water activity (A_w) developed over time and catalysed slight enzymatic degradation at the soft surface tissues of the okra slices that promoted the dull olive-green colour of the dried samples. The cabinet dried aloe vera treated samples had a significantly higher value (-8.20) of a* than its sundried counterpart but showed no significant difference with the cabinet untreated samples which had a value of -8.51. This significantly higher value of a* than its sundried counterpart suggests that the air velocity was sufficient to break through the protective film created by the aloe vera gel and drive most of the diffused moisture away from the surface. This may also have helped in slowing down enzymatic action within the sample and promoted the diffused green colour of the dried sample.

Comparing the colour of the samples before and after drying, the freeze-dried samples differed the highest in terms of greenness, followed by sundried aloe vera treated samples which performed below average in terms of greenness. Other dried samples under study however performed above average. This implies for the food industry, that sundried and cabinet dried untreated okra slices as well as cabinet dried aloe vera treated okra slices may be equally acceptable in terms of colour.

4. CONCLUSION

Some quality parameters of differently dried okra have been revealed in this study. The study showed that there was no significant difference in the reconstitution index of both freeze-dried, aloe vera treated and untreated hot air-dried samples. The study further revealed that aloe vera treated samples had the highest moisture content among the dried samples irrespective of the drying method. The study also showed that the freeze-dried samples had the poorest colour in terms of greenness, followed by sundried aloe vera treated samples. Cabinetdrying had no significant colour difference in terms of greenness while all the dried samples except the sundried aloe vera treated samples scored above average in terms of colour retention. It therefore implies for the food industry, that sundried and cabinet dried untreated okra slices as well as cabinet dried aloe vera treated okra slices may be equally acceptable in terms of colour.

It is recommended that steam blanching as a pretreatment to cabinet and sun drying should be studied.

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