EFFECTS OF USING SUCROSE AND SODIUM CHLORIDE SOLUTIONS AS PRETREATMENTS ON DEHYDRATION OF BITTER LEAF (V*ernonia amygdalina*)

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Abstract
Leafy vegetables are highly perishable. Bitter leaf is a medicinal plant and nutritionally rich. Having bitter leaf in dry form will extend its shelf life, enhance easy packaging and transportation to many parts of the world. *This work studied dehydration and rehydration of bitter leaves using osmotic solutions. Bitter leaves were dehydrated using 30% sucrose, 40% sucrose, 30% sucrose + 10% NaCl, and 40% sucrose + 10% NaCl solutions for 1-4 h and finally dried in an oven at 40 °C. Dehydrated leaves were rehydrated for 30– 90 min. Mass transfer kinetics, rehydration and organoleptic qualities were evaluated. Results showed that pH of osmotic solution, weight loss and solid gain increased with an increase in osmotic treatment time. Increase in rehydration time led to an increase in dry matter loss and pH of rehydration solution. Untreated sample took longer time to dry. Moisture of dried products (7.98-8.60%), protein (41-47%), fat (11.49-11.23%), ash (11.15-12.33%), fibre (7.23-9.47%). Organoleptic scores showed that all parameters measured had scores above 5.90 out of 9 points. Results showed the feasibility of dehydrating bitter leaf using osmotic treatment without significant change in quality, which can increase* access to it. It may serve as an excellent raw material for the healthy food industry. The knowledge about moisture transfer kinetics, as well as rehydration is needed by the industry to manage and control efficiently drying process. Short dehydration time required by osmotically treated bitter leaf will reduce energy cost during dehydration as well as increase turn over.

Keyword: *Dehydration; rehydration; mass transfer kinetics; osmotic solutions; proximate analysis; organoleptic*

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1. INTRODUCTION

Leafy vegetables have been reported as potential sources of micronutrients. Many types of leafy vegetables are consumed in Africa (Tortoe, 2010). Epidemiological studies indicate that increased intake of vegetables is associated with decreased risk of certain cardiovascular diseases, and other age related diseases (Tortoe, 2010). In addition to serving as a critical source of micronutrient, leafy vegetables are rich sources of many carotenoids. Although they come from a very wide variety of plant, most have similar nutrients and cooking methods (Alakali *et al*., 2006). Nearly one thousand species of plant with edible leaves are known. *Vernonia amygdalina* is commonly called bitter leaf in English because of its bitter taste. The cooked leaves are staple vegetable in soup and stew of various cultures throughout equatorial Africa (Bonsi *et al*., 1995).

Dehydration of vegetable is one of the oldest forms of food preservation technique known to man. Dehydration has received consideration attention in years back in extending the shelf life of food materials. Osmosis is the spontaneous net movement of solvent molecule through semi –permeable membrane into a region of higher solute concentration in the direction that tends to equalize the solute concentration on the two sides (Khin *et al.*, 2007). Osmotic dehydration is used for partial removal of water from food material such as fruits and vegetables by immersing them in aqueous solution of higher osmotic pressure such as sugar and salt (Pandharipande *et al*., 2012). Osmotic dehydration presents some benefits such as reducing the damage of heat to the flavour, colour, inhibiting the browning of enzymes and activities of polyphenol Oxidases (John, 2009). It improves product stability and retention of nutrients during storage, energy efficiency, packaging and distribution, energy requirement is 2-3 times less as compared to the conventional drying, blanching process on osmotic dehydration may be eliminated, which reduce cost of processing (John, 2009). The deterioration of leafy vegetables is rapid due to high moisture content, which usually leads to high post-harvest loss. Dehydration, which is the most effective and common method of preservation for leafy vegetables results into loss of flavour and many heat labile nutrients. Research showed that short exposure period of leafy vegetables to high temperature reduces nutrients loss. Osmotic pretreatment is said to effect dehydration at shorter time. Therefore, this study investigated dehydration of bitter leaves using osmotic technique as pretreatment.

2. MATERIALS AND METHODS

Bitter leaves (*Vernonia amygdalina*) were obtained from Eke Market, Afikpo Ebonyi State Nigeria. All chemicals and reagents used were of analytical grades.

2.1 Osmotic dehydration

The method of Haj *et al*. (2014) was used with slight modifications. Osmotic solutions were prepared using 40% sucrose, 40% sucrose + 10% NaCl, 30% sucrose and 30% sucrose + 10% NaCl. Fresh and cleaned bitter leaves were soaked in the previously prepared osmotic solutions at 30 ^{o}C for 1 – 4 h. The solution was agitated periodical to maintain uniform concentration during the osmotic dehydration process. Thereafter, osmotically dehydrated samples were withdrawn from the solution and drained. The treated samples were oven dried at 40 ^{o}C and stored in an airtight polythene bag for further analyses.

2.2 Soluble solid, water loss and solid gain

The soluble solid was measured using total dissolved solid meter. The method of Akkas *et al*. (2007) was used for water loss and solid gain with slight modifications. Osmotic dehydrated samples were drained and adhering water was blotted using blotting paper. The drained sample was weighed and percentage water loss (WL) and solid gained (SG) were calculated as fellows;

$$WL = \frac{Wwo - Ww}{We} \text{ x } 100$$

$$SG = \frac{Ws - Ws0}{Wo} \text{ x } 100$$

Where, WL and SG are water loss and solid gain in %, respectively. W_{wo} is the initial water mass, W_w is the mass of water at time T, W_s is the solid mass at time T, W_{so} is the initial solid mass, and Mo is the initial Mass (water + solid) of the fresh bitter leaves prior to osmotic dehydration treatment (Akkaz *et al*., 2007).

2.3 Mass reduction

The mass reduction (MR) can be defined as the net weight loss of the fruit on initial basis.

$$MR \frac{Wi - Wo}{Wi} \text{ x } 100$$

2.4 pH, degree brix, total dissolved solid

The pH was measured by using a Hannaa pH meter (model HN270). The degree brix of the osmotic solution was determined using portable refractometer (uniscope). The total dissolved solid was measured using portable TDS meter.

2.5 Proximate analysis

Protein, moisture, fat, crude fibre, and carbohydrate were determined using AOAC (2000).

2.6 Rehydration

The rehydration was carried according to the method described by Huang *et al*. (2009) with slight modifications. The bitter leaves were rehydrated by immersion in distilled water using a beaker at thermostatically controlled temperature of 30 ^{O}C for 30 min, 60 min and 90 min. The leaves were removed after stipulated time and drained off the supper-facial water using blotting paper and weighed thereafter.

2.7 Sensory evaluation

A consumer acceptance test was conducted on the dehydrated bitter leaves samples by a 20 member semi-trained panaelists. The method of Larmond (1977) as described by Ojinnaka *et al*. (2013) was used. The samples were rated using a 9-point hedonic scale with 9 indicating "liked extremely", 5 indicating "neither liked or disliked” and 1 indicating “disliked extremely”. The samples were evaluated for appearance, taste, aroma, colour, texture and overall acceptability. The panelists were given water to rinse their mouth after each sampling. The evaluation was done in a well lit room.

2.8 Data analysis

Statistical differences among samples were determined by analysis of variance (ANOVA) using SPSS version 16.0 (SPSS, Chicago, IL, USA). Mean were separated using Duncan’s Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Change in pH of osmotic solution during dehydration

The results of the pH are presented in Fig 1(a). The results ranged from 5.2 - 6.0 for 30% sucrose, 5.2 - 5.7 for 30% sucrose + 10% NaCl, 6.7 - 6.9 for 40% sucrose and 5.9 - 6.8 for 40% sucrose +10% NaCl. The highest p^H 6.0, 5.7, 6.9 and 6.8 were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. The least p^H 5.2, 5.2, 6.7 and 5.9 were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. The pH value obtained from the solutions suggested that osmotic dehydration did not cause gain of organic acid and it indicated that the osmotic dehydration of bitter leaf is in acidic region (Fasogbon *et al*., 2013). The use of sucrose and NaCl cause a greater gain in mass transfer than the sucrose only.

3.2 Solid gain during osmotic dehydration

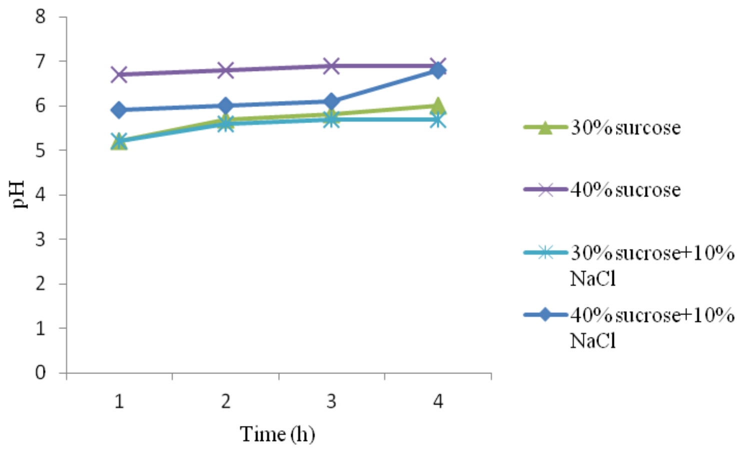
The result of the solid gain is presented in Fig 1(b). The results ranged from 17-18.35 g for 30% sucrose, 6.01-16.94 g for 30% sucrose + 10% NaCl, 6.7-6.9 g for 40% sucrose and 0-39.54 g for 40% sucrose + 10% NaCl. The highest solid gain 18.35, 16.94, 6.9 and 39.54g were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. The least solid gain 17.16, 6.01, 6.7 and 0g were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. This result is similar to the report of Erlekin and Cakaloz (2006).

3.3 Weight loss during osmotic dehydration

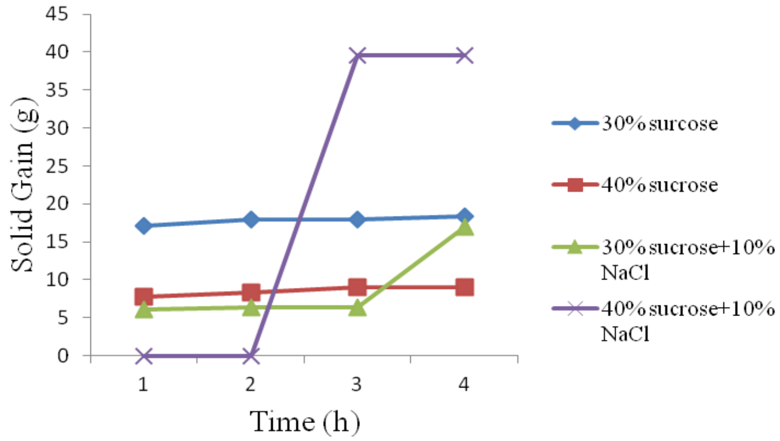
The results of the weight loss are presented in Fig 1(c). The results ranged from 3- 45 g for 30% sucrose, 17.4 – 25 g for 40% sucrose, 5 - 44.7 g for 30% sucrose + 10% NaCl and 9.6 - 33.6 g for 40% sucrose + 10% NaCl. The highest weight loss 45, 25, 44.7 and 9.6 g were recorded by 30% sucrose, 40% sucrose, 30% sucrose + 10% NaCl and 40% sucrose + 10% NaCl, respectively. The least weight loss 3, 17.4, 5 and 9.6 were recorded by 30% sucrose, 40% sucrose, 30% sucrose + 10% NaCl and 40% sucrose + 10% NaCl, respectively. The results indicated that mass reduction can be increased by either increasing the syrup temperature or concentration of solution. Similar results have been reported for osmotic dehydration of Onions by Torregiani and Bertolo (2001).

3.4 Dehydration ratio

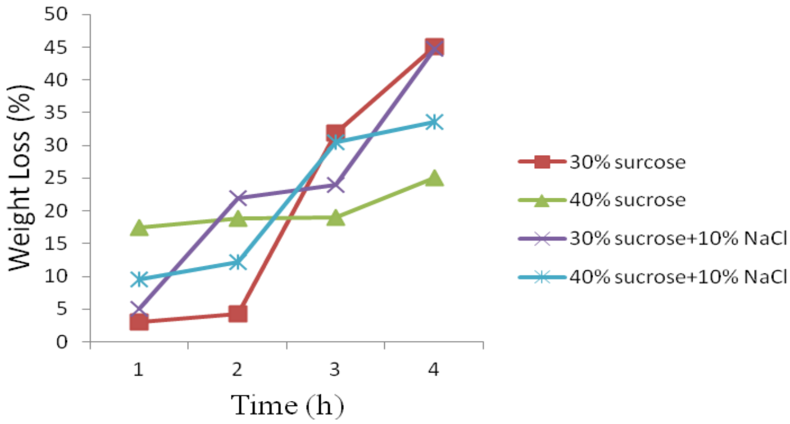
The dehydration ratio also known as water loss is the removal of water from food which implies the quantity of water loss by food during osmotic processing (Lazarides *et al*., 1995). The results of the dehydration ratio are presented in Fig 1(d). The results ranged from 0.55 - 1.05 for 30% sucrose, 0.65- 0.95 for 30% sucrose + 10% NaCl, 0.60 - 0.95 for 40% sucrose + 10% NaCl and 0.66 - 0.73 for 40% sucrose + 10% NaCl. The highest dehydration ratio 1.05, 0.95, 0.95 and 0.73 were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. The least dehydration ratio was recorded 0.55, 0.65, 0.65, and 0.66 were recorded by 30% sucrose, 30% sucrose + 10% NaCl, 40% sucrose and 40% sucrose + 10% NaCl, respectively. Similar result was reported for osmotic dehydration of banana by Ertekin and Cakaloz (1996). Similar effects have also been reported in various fruits and vegetables (Karathanos *et al*., 1995; Porkharkar and Prasad, 1998).


pH
Time (h)
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

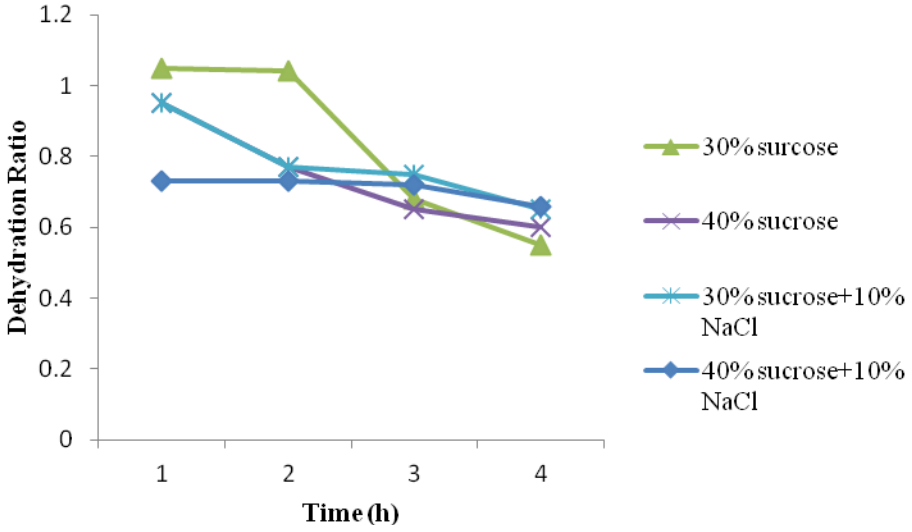
(a)


Solid Gain (g)
Time (h)
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

(b)


Weight Loss (%)
Time (h)
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

(c)



(d)

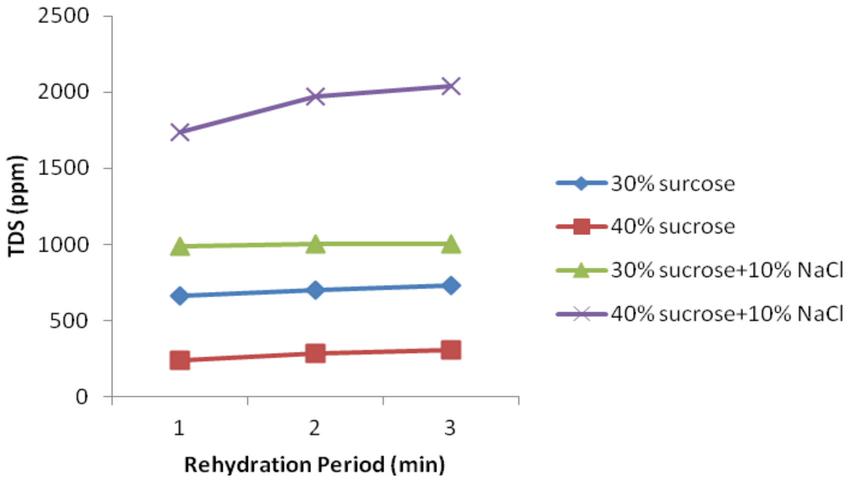
Fig 1 (a) pH as a function of time (b) solid gain as a function of time (c) weight loss as a function of time (d) dehydration ratio as a function of time during osmotic dehydration of bitter leaf

3.5 Dry matter loss during rehydration

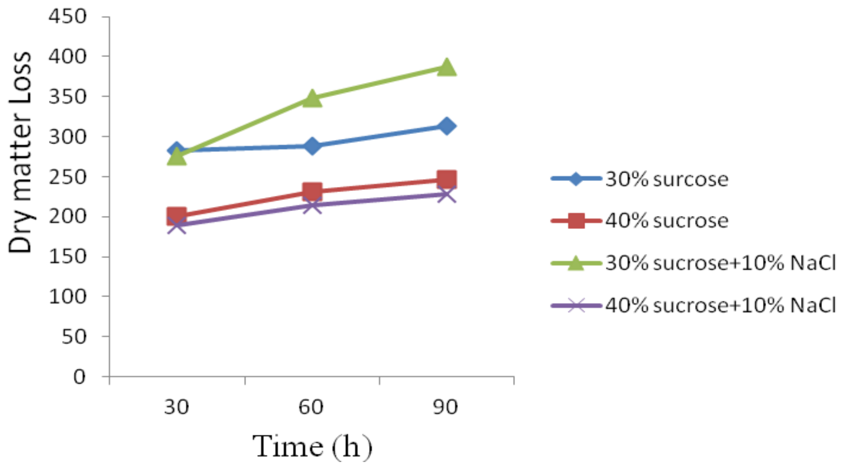
The results of the dry matter loss for samples treated for 1 h, 2 h, and 4 h are presented in Fig 2(a-d). The results ranged from 392-731 ppm for 30%sucrose, 247-356 ppm for 40% sucrose, 100-314 ppm for 30% sucrose + 10%NaCl, 204 ppm-395 ppm for 40% sucrose + 10%NaCl. The highest dry matter loss was recorded by 30%sucrose, 40% sucrose + 10%NaCl, 40%sucrose and 30% sucrose + 10%NaCl. All treatments had increased in dry matter loss with an increase in osmotic rehydration time. For samples treated for 1 h, osmotically pretreated sample in sugar/salt solution and dried under 30 ^{o}C seems to have higher dry matter loss. This was similar to the report of Fasogbon *et al*., (2013). Therefore, this showed that addition of salt had an effect on the dry matter loss than sucrose only. For samples treated for 2 h, osmotic medium with NaCl affect the rehydration capacity when rehydrated at 30 ^{o}C with maximum rehydration capacity than osmotic medium without NaCl. This was similar to the report of Taiwo *et al*. (2002). For samples treated for 3 h, samples rehydrated in sugar solution only recorded the highest increase in the dry matter loss; but DML increased till the end of the rehydration process both in sugar/salt solution and sugar solution only. which is similar to the report of Fasogbon *et al*. (2013). For samples treated for 4 h, influence of rehydration time on samples osmotically rehydrated is mainly at 90 min of rehydration process. This high in DML which was obtained at 30 ^{o}C is similar to the report of Taiwo *et al*. (2002).

3.7 Proximate composition of dehydrated vegetable

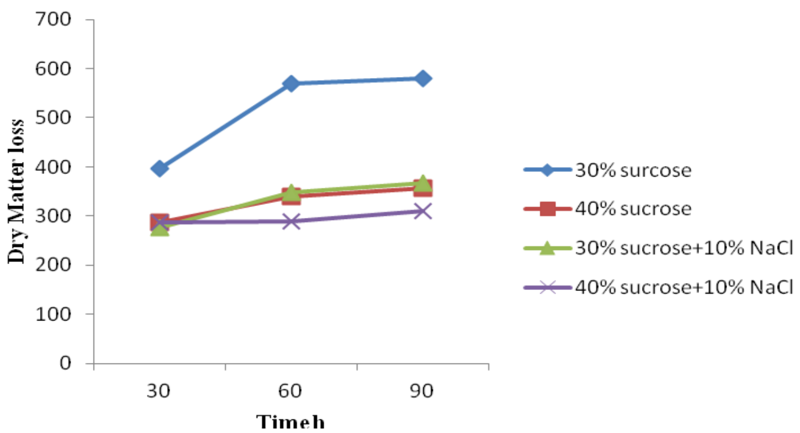
The results of the proximate are shown in Table 1. The moisture content ranged from 7.98 to 8.60%. There was no significant difference (P > 0.05) among samples. Sample treated with 30% sucrose + 10% NaCl had the highest moisture content of 8.60% while sample treated with 30% sucrose for 1h had the lowest moisture content. There was no statistical difference (P> 0.05) among the samples. High moisture content in food has been shown to encourage microbial growth (Temple *et al*., 1996). It was reported that the lower the moisture content of a product to be stored, the better the shelf stability of the food product. Hence, low moisture content of a food is indicative of the dry matter in that food.


2500
2000
1500
1000
500
0
TDS (ppm)
1
2
3
Rehydration Period (min)
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

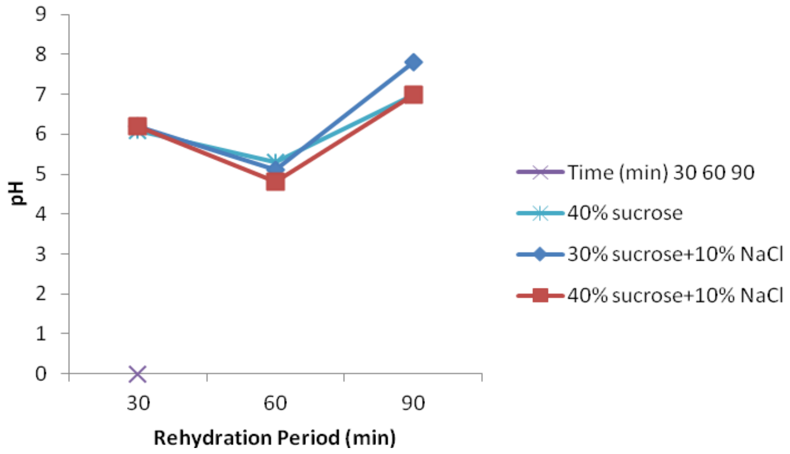
(a)


450
400
350
300
250
200
150
100
50
0
Dry matter Loss
30
60
90
Time (h)
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

(b)

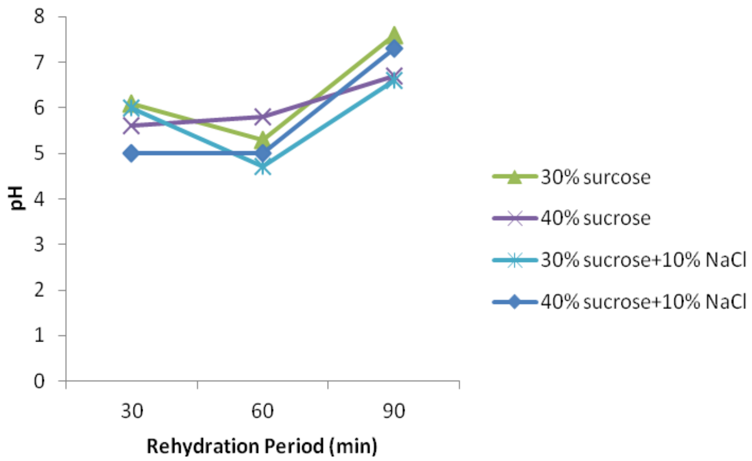

700
600
500
400
300
200
100
0
Dry Matter loss
30
60
90
Timeh
30% surcose
40% sucrose
30% sucrose+10% NaCl
40% sucrose+10% NaCl

(c)

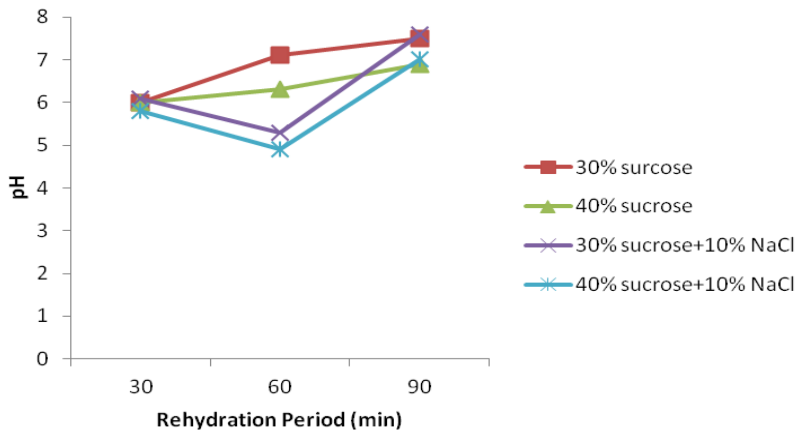


(d)

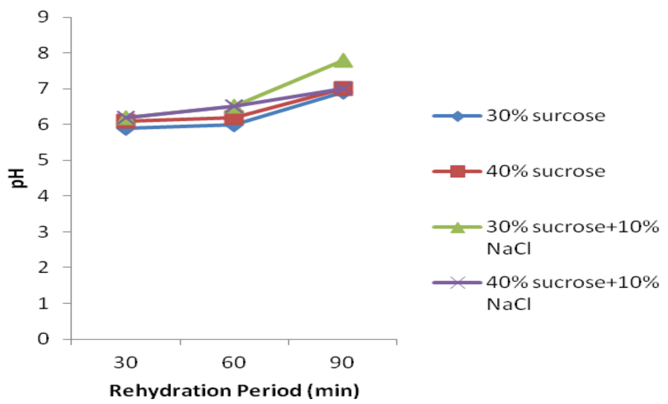
Fig 2 Effect of rehydration time on dry matter loss for bitter leaf osmotically dehydrated for (a) 1 h (b) 2 h (c) 3 h (d) 4 h



(a)



(b)



(c)

Fig 3: Effect of rehydration time on pH for bitter leaf osmotically dehydrated for (a) 1 h (b) 2 h (c) 4 h

The protein content of the osmotically dehydrated bitter leaves ranged from 41.47 to 42.32%. There was no significant difference (P > 0.05) from one another. Sample treated with 30% sucrose + 10% NaCl for 3 h had the highest protein content of 42 – 32% while non- treated sample had the lowest protein content of 41.47%. There was no statistical difference (P > 0.05) among the samples. Yakubu *et al*. (2012) reported 50.64% protein (db) for fresh bitter leaf, 38.46% (db) for blenched bitter leaf, 44.87% (db) for abased without NaCl bitter leaf.

The fat content of the osmotically dehydrated bitter leaves ranged from 11.49 to 12.28%. There was no significant difference (P > 0.05) among samples. Non-treated sample had the highest fat content of 12.28% while sample treated with 30% sucrose + 10% NaCl for 3 h had the lowest fat content of 11.49%. The results showed that the fat content of osmotically treated samples and untreated samples are statistically the same. The ash content of the osmotically dehydrated bitter leaves ranged from 11.15 to 12.33%. There was no significant difference (P > 0.05) among samples. Sample treated with 30% sucrose + 10% NaCl for 3 h had the highest ash content of 12.33% while non-treated sample had the lowest ash content of 11.15%. There was no statistical difference among the samples. The ash content of a food material could be used as an index of mineral constituent of the food since ash is the inorganic residue remaining after water and organic matter have been removed by heating in the presence of oxidizing agent. The crude fibre content of the osmotically dehydrated bitter leaves ranged from 8.49 to 11.23%. There was no significant difference (P > 0.05) among sample treated with 30% sucrose for 1 h and non-treated sample. Sample treated with 30% sucrose + 10% NaCl for 3 h was statistically difference (P< 0.05) from other samples. The carbohydrate content of the osmotically dehydrated bitter leaves ranged from 14.04 to 17.99%. There was no significant difference (P > 0.05) among samples treated with 30% sucrose for 1 h and non-treated sample.

3.8 Sensory evaluation

The results of the organoleptic properties of the osmotically dehydrated bitter leaves are shown in Table 2. All the samples had sensory scores above 5.90 out of 9-point hedonic scale used for the parameters. The appearance of the samples ranged from 6.50 to 7.80. The sample treated with 30% sucrose had the highest score while the sample treated with 40% sucrose +10% NaCl for 1 h had the lowest score of 6.50. There was no significant difference (> 0.05) among samples. Those results were in agreement with report of Patricia *et al*. (2007). There was no statistical difference (P>0.05) among samples in appearance probably because of low temperature (30 ^{O}C) used for drying.

Table 1 Proximate composition of osmotically dehydrated bitter leaves (on dry basis) per 100 g

Samples	Moisture (g)	Protein (g)	Crude fibre (g)	Ash (g)	Fat (g)	Carbohydrate (g)
AA	8.60 ± 0.44[a]	42.32 ± 0.44[a]	7.23 ± 0.24[b]	12.33 ± 0.32[a]	11.49 ± 0.57[a]	18.04 ± 0.31[b]
BB	7.98 ± 0.02[a]	41.87 ± 0.17[a]	8.49 ± 0.41[ab]	11.48 ± 0.11[a]	12.19 ± 0.12[a]	17.99 ±0.44[a]
CC	8.51 ± 0.58[a]	41.47 ± 0.47[a]	9.47 ± 0.33[a]	11.15 ± 0.20[a]	12.28 ± 0.24[a]	17.14 ± 0.23[a]

AA = Bitter leaf treated with 30% sucrose + 10% salt for 3 h; BB = Bitter leaf treated with 30% sucrose for 1 h;
CC = Untreated bitter leaf

Table 2: Sensory evaluation of osmotically dehydrated bitter leaves

Sample	Appearance	Taste	Colour	Aroma	Texture	General acceptability
A	7.80 ± 0.57[a]	7.10 ± 0.71[ab]	7.40 ± 0.28[a]	7.10 ± 1.56[a]	7.00 ± 0.57[ab]	7.70 ± 0.42[a]
B	7.20 ± 0.28[a]	6.80 ± 0.28[ab]	6.70 ± 0.99[a]	6.70 ± 1.27[a]	8.00 ± 0.28[a]	7.25 ± 1.06[a]
C	7.40 ± 1.13[a]	6.30 ± 0.42[b]	6.30 ± 0.71[a]	6.80 ± 0.57[a]	5.90 ± 1.27[b]	7.60 ± 0.28[a]
D	6.50 ± 0.99[a]	7.10 ± 0.14[ab]	7.20 ± 0.00[a]	7.10 ± 0.14[a]	7.20 ± 1.13[ab]	7.30 ± 0.42[a]
E	7.40 ± 0.09[a]	7.60 ± 0.28[a]	7.30 ± 0.42[a]	7.10 ± 0.71[a]	7.1 ± 0.71[ab]	7.25 ± 0.35[a]
F	7.40 ± 0.28[a]	7.70 ± 0.71[a]	6.70 ± 0.98[a]	6.80 ± 0.28[a]	7.50 ± 0.14[ab]	7.80 ± 0.57[a]

A = Bitter leaf treated with 30% sucrose for1 h; B = bitter leaf treated with 30% sucrose for 2 h; C= bitter leaf treated with 30% sucrose for 3 h; D= bitter leaf treated with 40% sucrose + 10% Sodium chloride for 1 h; E = bitter leaf treated with 30%sucrose + 10 % NaCl for 1 h; F = Untreated bitter leaf

The taste of the samples ranged from 6.30 to 7.70. The sample treated with 30% sucrose for 3 h had the lowest score of 6.30 and non-osmotically treated sample had the highest score of 7.70. There was no significant difference (P>0 . 05) among sample treated with 30% sucrose for 1 h, 30% sucrose for 2 h and 40% sucrose + 10% salt for 1 h. also, there was no significant difference (P > 0.05) among sample treated with 30% sucrose + 10% salt for 3 h and untreated sample. There was significant difference (P < 0.05) for sample treated with 30% sucrose 3 h compared to other samples.
The colour of the samples ranged from 6.30 to 7.40. The sample treated with 30% sucrose for 1 h had the highest score of 7.40 while the sample treated with 30% sucrose for 3 h had the lowest score of 6.30. There was no significant difference (P > 0.05) among the samples. This result was in agreement with the report of Patricia *et al*. (2009). There was no statistical difference (P > 0.05) among samples in colour probably because of low temperature (30 ^{o}C) used for drying. The results showed that there was no significant oxidation reaction that took place during processing which could degrade the colour (Dutta *et al*., 2006).
The aroma of the samples ranged from 6.70 to 7.10. The samples treated with 30% sucrose for 1h, 30%, 30% sucrose + 10% salt for 3 h and 40% + 10% NaCl for 3 h had the highest Score of 7.10 while the sample treated with 30% sucrose for 2 h had the lowest score of 6.70.
There was no significant difference (P> 0.05) among samples. This result was in agreement with the report of Shakla and Singh (2007).
The texture of the samples ranged from 5.70 to 8.00. The sample treated with 30% sucrose for 2 h had the highest score of 8.00 while the sample treated with 30% sucrose for 3 h had the lowest score. There was no significant difference (P > 0.05) among sample treated

with 30 % sucrose for 1 h, 40% Sucrose + 10% salt for 1 h, untreated sample and 30 % sucrose + 10% salt for 3 h. Also, there was significant difference (P< 0.05) for samples treated with 30 % sucrose for 2 h and 30 % sucrose for 3 h. The general acceptability of the samples ranged from 7.25 to 7.80. The untreated sample had the highest score of 7.80 while the sample treated with 30% sucrose for 2 h had the lowest score of 7.25. There was no significant difference (P > 0.05) among samples. This result was in agreement with the report of Patricia *et al*., (2007). There was no statistical difference probably because of low temperature used for drying.

4. CONCLUSION

This study examined mass transfer kinetic rehydration, proximate and sensory properties of osmotically dehydrated bitter leaves. The research showed that dehydrated period could be shortened by using osmotic technique as pretreatment. The results also showed that osmotic pretreatment does not result into significant loss of nutrients. Loss of solute during rehydration is a function of rehydration time and are directly proportional.

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