Selection of best packaging method to extend the shelf life of rice crackers

Thejani M. Gunaratne, Nadeesha M. Gunaratne and S. B. Navaratne

Abstract

In this study, Sweet and Savory rice crackers with a shelf life of 6 months were packed separately under four categories as with desiccant, with oxygen absorber, with both desiccant and oxygen absorber and without any of them. These packets were stored at high temperature (47ºC) and room temperature (28ºC) with saturated conditions to conduct accelerated shelf life testing. Moisture content, pH and TBA value of these crackers were determined using Moisture analyzer, pH meter, distillation method respectively. Dried silica gel containing triple laminated pouches were stored under normal atmospheric conditions (28ºC, 70 – 75% RH) until a constant weight was gained to determine WVTR. A sensory test was done using a five point hedonic scale and was statistically analyzed using MINITAB 14. Results revealed that Moisture content, pH and TBA values increased gradually with time. WVTR was 0.2242 g m^{-2} day^{-1}. There was a significant difference of sensory properties with time. The packets containing both desiccant and oxygen absorber was the best and it gained the longest shelf life of 9.2 - 11 months.

Index terms – Accelerated shelf life test, Oxygen absorber, Packaging, Rice crackers, Sensory evaluation, Shelf life, Thiobarbituric acid test

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1. INTRODUCTION

RICE flour is used for several snack food production out of which rice cracker is one. It is produced by using rice, staple food of Sri Lanka as the major ingredient. Rice crackers have several benefits when compared to ordinary biscuits produced from wheat flour as rice flour has a higher nutritional value.

- T.M. Gunaratne is currently a Research Officer in Food Science and Technology in University of Sri Jayewardenepura, Sri Lanka, PH-0094777913339. E-mail: thejanigunaratne@gmail.com
- N.M. Gunaratne is currently a Research Officer in Food Science and Technology in University of Sri Jayewardenepura, Sri Lanka, PH-0094774311512. E-mail: nadeesha.usjp.fst@gmail.com
- S.B. Navaratne is currently a Senior Lecturer in Food Science and Technology in University of Sri Jayewardenepura, Sri Lanka, PH-0094775095610. E-mail: sbnava1234@yahoo.com

Initially a common base cracker is produced and it is flavored using several varieties of flavors to produce different types of rice crackers. After drying and baking of the crackers, oil is prayed to them for flavor adherence. This residual oil eventually contributes to rancidity of the product [28]. The other factor of concern to producers is the decrease in crispiness due to moisture absorption. These problems led the researchers to examine the use of different packaging systems to decrease the rate of deterioration.

Shelf life is a critical factor in food industry. It is the time during which the food product will remain safe, be certain to retain desired sensory, chemical, physical and microbiological characteristics and comply with any label declaration of nutritional data, when stored under the recommended conditions [10]. Several factors influence the shelf life of the product. Therefore it is important to analyze those factors and take required action to improve the keeping quality of food products.

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Shelf life of the product can be extended by modifying the packaging method. This is a better way of extending the shelf life of products rather than adding preservatives to food, as it does not cause harm to consumers. As a result it will increase the product quality and acceptability.

The main objective was to determine the best packing method with longest shelf life of rice crackers. Chemical and Physical tests were conducted in order to find out the best method out of the four packing methods; with desiccant, with oxygen absorber, combination of desiccant and oxygen absorber and none.

2. MATERIALS AND METHODS

2.1 Determination of WVTR

Water Vapor Transmission Rate (WVTR) was calculated for the triple laminated packing material used for packaging. Initially three pouches of known dimensions were prepared using this packing material and were sealed by incorporating dried silica gel. Initial weight was recorded. They were stored under normal atmospheric conditions and weights were recorded weekly until a constant weight was gained.

2.2 Accelerated shelf life testing

Sweet and Savory rice crackers were packed in four different ways using triple laminated packing material {Polyethylene terephthalate (PET) + Metalized Polyethylene terephthalate (METPET) + Linear low density polyethylene (LLDPE)}. One type was packed by incorporating a silica gel packet as a desiccant (DE), other type by incorporating an oxygen absorber (OA), other type by incorporating both oxygen absorber and desiccant (OA+DE) and final type without incorporating any of them (Control). Meanwhile accelerated conditions (47°C, 100% RH) were created manually and half of above packets from all four types were stored there. Balance packets were stored at room temperature (28°C, 100% RH). Accelerated shelf life testing was conducted for those rice crackers every 2 weeks up to 3 months. Moisture content, pH and Thiobarbituric acid (TBA) value were determined under chemical properties.

2.3 Determination of moisture content

The moisture content of crackers was measured using the moisture analyzer. A sample was ground using mortar and pestle and 1g was added onto the tray of the moisture analyzer to get the direct reading.

2.4 Determination of pH

Rice crackers were ground using mortar and pestle. Then 5g was weighed and distilled water was added up to 50g. pH value of the solution was measured using the pH meter.

2.5 Determination of TBA value

Distillation method was used for TBA value determination. Initially 10g of rice crackers were macerated with 50ml of distilled water for about 2 minutes using a blender. It was then washed into a distillation flask with 47.5ml of distilled water. Then 2.5ml of 4M HCl was added to bring pH to 1.5 and few pumice stones were also added. The flask was connected to a water condenser and was heated using a heating mantle so that 50ml of distillate is collected in 10 minutes from the time boiling commences. Next 5ml of distillate was mixed with 5ml of TBA reagent in a stoppered test tube and was heated in a boiling water bath for 35 minutes. Finally absorbance of cooled samples was measured at 532nm using the UV – VIS Spectrophotometer (Serial no A 109347).

A standard curve was also developed using 1,1,3,3-tetra-methoxypropane (TMP) to evaluate the results of TBA test. It was developed by measuring the absorbance values at 532nm of a series of TMP solutions with concentrations varying from 10^{-9} to 10^{-6}.

2.6 Sensory evaluation

Sensory test was conducted by the sensory panel using a 5 point hedonic scale. 30 untrained panelists were taken for the test. The measured qualities included the taste, odour, appearance, color, crispiness and overall acceptability.

Results were analyzed using Randomized Complete Block Design (RCBD) with MINITAB 14.

2.7 Quantitative determination of shelf life

The shelf life was calculated based on the results gained by the sensory analysis. Since the samples were stored under the temperatures of 28°C and 47°C, the reduction of quality was determined at these respective temperatures with respect to each sensory parameter and was plotted in graphs of $\ln(A/A_0)$ vs. time.

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k values obtained were used to give the Arrhenius plot as a plot of ln(k) against 1/T. the plot was obtained by taking logarithms and rearranging the linear equation $k=k_0e^{-E_A/RT}$ as shown in the equation below.

$$\ln(k) = \ln(k_0) - \frac{E_A}{R}.\frac{1}{T} \quad (1)$$

The intercept in this equation is ln (k_0) and the slope is E_A/R

The Arrhenius plots for each sensory parameter are drawn using 'k' values for respective parameters stored in different temperatures. The 'k' values are the gradient values of respective graphs.

The Arrhenius plot was used to calculate shelf life of a food product at room temperature. A/A_0 at the failure point should be known for this calculation, corresponding to the parameter of interest. The failure point of the sensory test was considered as 2, because it is the point at which the panelists dislike the products.

Finally shelf life was calculated by substituting the values to the following equation.

$$-\ln\frac{A_e}{A_o} = k\theta_s \quad (2)$$

A_o – Amount left at time
θ_s – Shelf life
A_e – Amount left at end of shelf life θ_s
k – Rate constant in units of reciprocal time

TABLE 1

MOISTURE CONTENT (%) OF RICE CRACKERS

Flavour	Packaging method	Time (weeks)					
		2	4	6	8	10	12
Savoury	OA + DE	4.73	6.52	6.81	6.14	7.36	9.89
	Control	5.02	5.67	6.29	6.57	7.75	9.76
	OA	5.11	5.75	7.86	6.89	9.24	10.82
	DE	3.27	5.40	5.11	7.05	3.20	9.73
Sweet	OA + DE	4.26	5.10	4.77	5.71	5.92	6.41
	Control	3.41	4.85	4.91	5.46	6.00	7.67
	OA	5.08	5.43	5.54	5.90	7.24	7.64
	DE	4.88	5.17	5.61	5.66	5.58	5.88

3. RESULTS AND DISCUSSION

3.1 WVTR

Water vapor transmission rate of packing material was 0.2242 g m^{-2} day^{-1}. Therefore according to the results, 0.2242 g of water vapor is transmitted through a square meter of packing material per day.

3.2 Moisture content

The moisture content increases gradually with time due to absorption of moisture through packing material. Table 1 gives the results obtained from moisture determination.

3.3 pH value

pH value does not show major variations with time. Values do not vary significantly based on packing material. Table 2 gives the pH values obtained.

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TABLE 2

pH VALUES OF RICE CRACKERS

Flavour	Packaging method	Time (weeks)					
		2	4	6	8	10	12
Savoury	OA + DE	6.12	6.10	5.82	5.39	5.78	6.10
	Control	6.12	5.95	6.40	5.90	5.84	6.04
	OA	6.11	6.15	6.30	5.42	5.82	6.08
	DE	6.17	6.12	6.33	5.41	5.66	6.10
Sweet	OA + DE	6.61	6.56	6.82	6.16	5.76	5.43
	Control	6.25	6.46	6.90	5.64	6.02	6.23
	OA	6.57	6.21	6.62	5.85	5.60	6.11
	DE	6.47	6.34	6.63	5.56	5.59	6.66

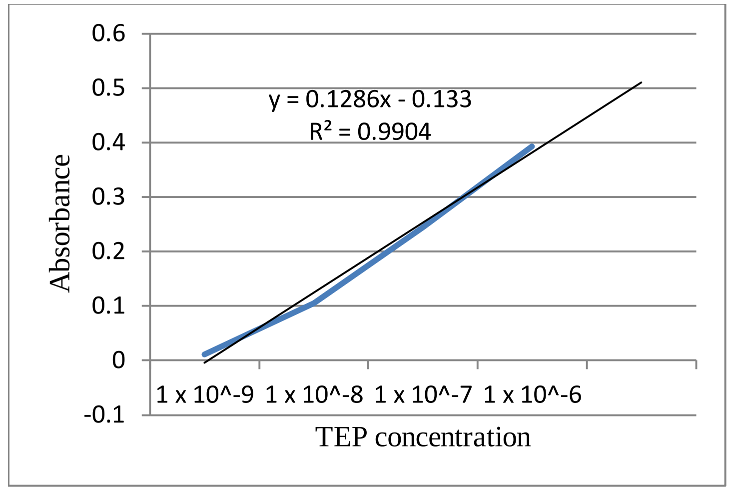

Fig. 1. Standard curve for TBA test

The equation obtained from the standard curve is as follows;
$y = mx - c$
$y = 0.128x - 0.133$
The malonaldehyde values must be calculated by substituting the absorbance values obtained from TBA test, to the y value. Results obtained are shown in Table 3.

3.4 TBA test

According to the standard curve drawn for TBA value determination test, higher the absorbance, higher the TMP (1,1,3,3-tetramethoxypropane) concentration. TMP is a precursor of malonaldehyde which is an end product of oxidative decomposition. Therefore higher absorbance indicates higher rancidity. Fig. 1 shows the standard curve drawn for the experiment.

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TABLE 3

CALCULATED MALONALDEHYDE CONCENTRATIONS (μmol/kg) OF TBA TEST OF RICE CRACKERS

Flavour	Packing method	Time (months) 1	2	3
Savoury	OA + DE	1.6719	1.7031	1.9688
	Control	2.2344	3.0391	5.4531
	OA	1.8203	2.4688	3.5234
	DE	2.0078	3.0313	3.6953
Sweet	OA + DE	2.3594	5.4063	9.3125
	Control	6.7578	10.2266	20.4297
	OA	2.7244	6.9453	9.8281
	DE	5.5625	9.9688	18.3438

According to the table, TBA value increases in rice crackers packed in all four methods and stored under accelerated conditions. the control has a highest malonaldehyde concentration. So it has the highest possibility of oxidative rancidity. OA + DE has lowest malonaldehyde concentration. So it has the lowest probability of oxidative rancidity.

3.5 Sensory evaluation

Taste, Odor, Color, Appearance, Crispiness and Overall acceptability were the sensory parameters evaluated. According to results of sensory evaluation analyzed using MINITAB 14, the highest rank was obtained by packets containing both oxygen absorber and desiccant when compared to other packing methods. The web diagrams drawn for those packets are shown in fig. 2 and 3. According to the web diagrams, sensory parameters gradually deteriorate with time.

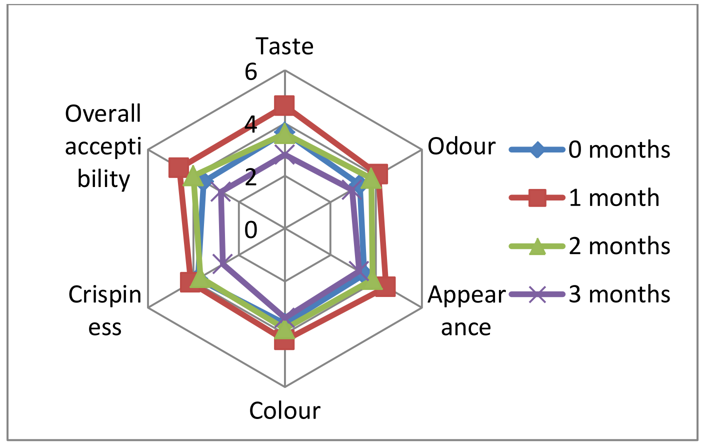

Fig. 2. Web diagram of Savoury rice crackers (OA + DE)

Fig. 3. Web diagram of Sweet rice crackers (OA + DE)

3.6 Quantitative determination of shelf life

Labuza [26] shows, for a first order reaction, the rate loss is, $-dA/dt = KA$ and integration of above equation is, $\ln A/A_0 = -kt$. Therefore quality loss can be plotted as $-\ln (A/A_0)$ against time that gave a straight line passing through the origin with slope k. The shelf life was calculated based on the results gained by the sensory analysis. Since the samples were stored under the temperatures of 28°C and 47°C, the reduction of quality was determined at these respective temperatures. Calculations for Savory and Sweet rice crackers are shown in Table 4 and 5 respectively.

TABLE 4

QUANTITATIVE DETERMINATION OF SHELF LIFE FOR SAVORY RICE CRACKERS

Taste	For taste at 28°C, k = 0.064 $\boldsymbol{\theta_s = 13.18\ months}$	For taste at 47°C, k = 0.153 $\boldsymbol{\theta_s = 5.51\ months}$
Odor	For odor at 28°C, k = 0.065 $\theta_s = 11.04\ months$	For odor at 47°C, k = 0.095 $\theta_s = 7.56\ months$
Appearance	For appearance at 28°C, k = 0.041 $\theta_s = 19.51\ months$	For appearance at 47°C, k = 0.103 $\theta_s = 7.76\ months$
Color	For color at 28°C, k = 0.042 $\theta_s = 17.95\ months$	For color at 47°C, k = 0.072 $\theta_s = 10.47\ months$
Crispiness	For crispiness at 28°C, k = 0.063 $\theta_s = 11.39\ months$	For crispiness at 47°C, k = 0.122 $\theta_s = 5.88\ months$
Overall acceptability	For overall acceptability at 28°C, k = 0.066 $\theta_s = 12.62\ months$	For overall acceptability at 47°C, k = 0.160 $\theta_s = 5.21\ months$

4. CONCLUSION

Water vapor transmission rate of packing material was 0.2242 g m^{-2} day^{-1}.

The moisture content and TBA value of rice crackers increased with time while pH value did not show major variations.

With respect to both TBA test and statistical analysis of sensory evaluation, the best method for packaging was by incorporating both desiccant and oxygen absorber into the packet.

The critical factor in determining the shelf life was odor. The shelf life of Savory rice crackers will be 11 months, and Sweet rice crackers will be 9.2 months under normal atmospheric storage when packed incorporating both desiccant and oxygen absorber.

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