Osmotic dehydration of banana (Musa acuminata) in ternary osmotic system

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Abstract

Osmotic dehydration, which permits water to exit fruit tissue and solute from the solution to enter the tissue, facilitates mass transfer. This process improves and extends the fruit's shelf life by preserving its nutritional value and organoleptic qualities. This paper applies the osmotic dehydration process to bananas in ternary solution. The sensory evaluation, ratings, and characteristics of the finished osmosed banana fruit are also provided. One popular preservation method for extending the freshness of food ingredients or goods is osmotic dehydration. Fruits, vegetables, and animal meat will all preserve for a longer period of time. This method is used in many countries that cultivate a range of fruits and vegetables in order to extend the shelf life of food products. In the food industry and allied areas, this process is essential for food preservation. The food industry is one of the most important sectors in many countries. Keep in mind that two crucial strategies to support a country's economy are expanding international trade and raising the value of food products relative to their cost. Increasing trade and a country's economy requires a greater understanding and appreciation of food goods. Thus, preserving food goods' freshness for a long time is essential to raising their worth in the food industry. To maintain their freshness and extend their shelf life, food products must be preserved using specific methods. Thus, osmotic dehydration is an excellent preservation technique that increases food goods' shelf life. This procedure requires the production of a number of osmotic solutions, including honey, malt dextrin, calcium chloride, sodium chloride, sugar, and salt. For a specified period of time, the food item needs to be immersed in the solutions. For the food product to remain fresh for a long time, it is further dried to lower its moisture content. The food material absorbs solute from the osmotic fluid during this phase, which leads to solid formation. The weight and water content of the food material are obtained by subtracting its own water content. To increase its freshness and shelf life, the moisture content is reduced after it has lost water. This method not only enhances the economy and sustainability of the global food market, but it is also a crucial preservation technology in the food sectors of many countries.

Keyword: Banana, osmotic dehydration, osmosis, weight reduction, solid gain, water loss

1. Introduction

The most popular banana variety in the world is the Cavendish banana. This cultivar, which belongs to the Musa acuminata species, is distinguished by its long, curved shape and, when mature, its golden peel. After a fungal illness decimated the Gros Michel banana, the Cavendish banana emerged as the dominant type in the 1950s [1]. Cavendish bananas are a popular choice for eating fresh because they are often sweeter and have a milder flavor than other varieties [2]. They are frequently used in baking, pastries, and smoothies. The susceptibility of Cavendish bananas to illness, particularly the Tropical Race 4 (TR4) strain of Panama disease, which poses a threat to banana crops across the globe, is one of major problems.

Osmotic dehydration is reportedly a popular technique for reducing the moisture content of fruits and vegetables [3]. The fundamental principle underlying this process is osmosis, which is initiated by osmotic pressure. Numerous mathematical models can be used to depict kinetics and mass transfer. By reducing the sample product's water activity without totally stopping microbiological development, osmotic dehydration increases its shelf life. Coated fruit can be protected from microbial development or incidence. Chitosan coating is an excellent barrier against microbial contamination. It also prevents food product surfaces from deteriorating.

Osmotic dehydration is the process by which plant tissues lose moisture content when submerged in a hypertonic liquid with a high osmotic pressure. For this process to be finished, a specific temperature and time must be reached. Mass transfer, which moves water from the fruit tissue to the solution and the solute from the solution to the fruit tissue, is said to be a part of the process [4].

Eliminating moisture from the material is the primary goal of the drying process. Convective drying, freeze drying, microwave drying, vacuum drying, and infrared drying are just a few of the many methods for drying materials. The most appropriate technique for the osmotic dehydration process is convective drying. Convective drying can be done with a tray dryer. In order to guarantee that any residual moisture on the trays is removed, hot air is blown around the sample product at a rate of five meters per second. Bananas' nutritional and sensory qualities are preserved while their shelf life is increased using the osmotic dehydration process [5]. The results of this study may help prolong the shelf life of other fruits and vegetables in binary and ternary osmotic systems, in addition to bananas.

2. Materials and Methods

2.1 Prior to osmosis

By improving permeability to the fruit tissue, blanching pre-treatment efficiently and accurately prepares the fruit. Despite the availability of alternative pre-treatment methods such vacuum impregnation, gamma irradiation, centrifugal force, ultrasonication, pulsed electric field, and microwave assistance, blanching was employed as a pre-treatment in this osmotic dehydration process. This procedure involved weighing the appropriate sample, which consisted of banana fruit pieces, and cooking it for two minutes at 90°C on a heating mantle in a 500 ml Erlenmeyer flask with 250 ml of distilled water. By increasing pore size, this method makes fruit tissues more permeable.

2.2 Sample readiness

Freshly ripened bananas that were pale yellow were subjected to osmotic dehydration. The portions were sliced into circular, 4 mm thick slices after the fruit's peel was removed. The cooled banana fruit pieces were gathered and used as needed for the OD experiment.

2.3 Addition of osmotic agents

The primary component of the osmotic dehydration process, osmotic agents, have a major impact on the organoleptic characteristics of the extracted banana sample pieces. Osmotic agents like salt and sugar were used to prepare the ternary solution for osmotic dehydration. These osmotic agents were chosen because they were less expensive than other possible osmotic agents that may be employed in the process, including lactose, calcium chloride, honey, high fructose corn syrup, malt dextrin, starch, invert sugar, and sucrose. The osmotic agent solution was heated to 25, 30, 35, and 40°C prior to the osmosis process starting.

2.4 Process of osmotic dehydration

When the osmotic dehydration solution was removed, the fruit pieces were gently blotted with tissue paper to remove any remaining fragments, and then they were dried in a tray dryer set to 72 °C to remove the majority of the moisture. The sample setup was removed and left outside for processing periods of 15, 30, 45, 60, and 75 minutes.

2.5 Experimental design

The osmotic dehydration technique was used for 15, 30, 45, 60, and 75 minutes after the raw fruit pieces were blanched in boiling water at 90°C for two minutes to increase the permeability of the fruit tissue by enlarging the pores on the fruit sample. The fruit sample was then incubated in a water bath for an hour at different temperatures (ºC) of 25, 30, 35, and 40. After the setup was taken out of the water bath, the banana fruit pieces were carefully wiped with tissue paper to remove the osmotic solution that had formed on their surface.

After that, it was dried for four hours at 72 degrees Celsius in a tray dryer. During this period, hot air is pushed around the sample at a speed of five meters per second. Any temperature increase over 72°C may result in significant tissue shrinkage, even though this is the optimal temperature for removing up to 90% of moisture. Following that, a number of formulas were used to calculate the important factors (weight loss, water loss, and solid growth). The product was osmotically dehydrated, then bagged and its shelf life evaluated.

2.6 Drying the fruit sample

By removing moisture, the drying process helps produce fruit products of superior quality, claim Kedarnath et al. [6]. The fruit pieces that underwent osmotic dehydration acquire their final shape through convective drying. Convective drying of the fruit pieces was done using a tray dryer. Five meters per second of hot air was forced around the fruit pieces to remove any remaining moisture [7]. The fruit pieces were hot air dried at 72°C for four hours in order to extract as much moisture as possible.

2.7 Osmotically processed fruit

Because the sugar, salt, and vitamin and mineral content of the fruit are retained throughout the drying process, the osmotically dehydrated banana method yields a higher-quality food product. Next, the fruit's shelf life is ascertained. The product's expected shelf life has been extended by keeping it in a room with a refrigerator for shelf life analysis. Mass transfer takes place both between the food product and the solution and between the solution and food product during the osmotic dehydration process, as shown in Figure 1.

2.8 Calculation parameters

1.Solid gain

In the osmotic dehydration process, after the fruit pieces were subjected to osmotic dehydration, the total solid gain in the fruit was calculated. The solid gain was obtained from the expression

$$\mathbf{SG = \{m - m_0 / M_0\} \times 100}$$

Where,

SG – Solid Gain (%)

$M_\circ$ - Initial mass of sample (g)

M -Mass of sample after dehydration (g)

$m_\circ$ - Initial mass of solids in sample (g)

m -Mass of solids in sample after dehydration (g)

2.Weight reduction

After the osmotic dehydration process, the total weight reduced in the fruit sample was to be calculated. This weight reduction data and values were obtained from the expression,

$$WR = \{M_0 - M / M_0\} \times 100$$

Where,

WR – Weight Reduction (%)

3. Water Loss

The total water loss from the banana fruit pieces was calculated after the osmotic dehydration process. The water loss data was obtained using the expression,

$$WL = WR + SG$$

Where,

WL – Water Loss (%)

VARIABLES	RANGE AND LEVELS				
TEMPERATURE (°C)	**25**	**30**	**35**	**40**	
PROCESSING TIME (Mins)	**15**	**30**	**45**	**60**	**75**
SUGAR + SALT CONC	**10%**	**15%**	**20%**	**25%**	
SOLUTION TO SAMPLE RATIO	**1:1**	**0.6:1.5**	**0.5:2**	**0.4:2.5**	

Table: variable ranges and levels for ternary osmotic dehydration of banana

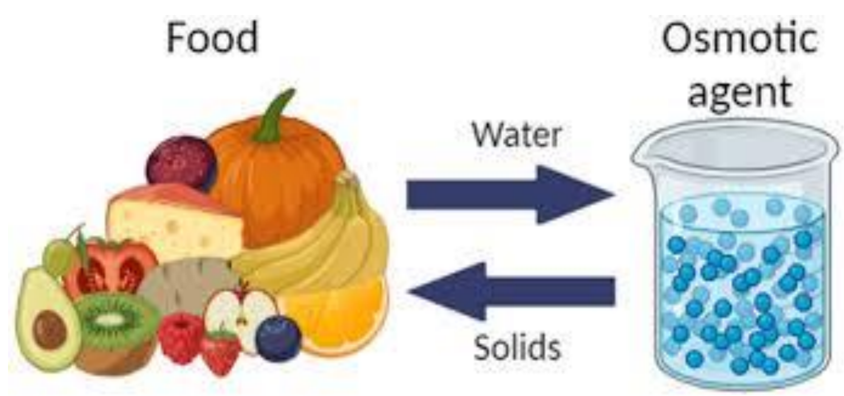

Fig 1: Scheme of mass transfer during osmotic dehydration process

2.9 Sensory scores to the osmosed banana

The final osmosed banana's sensory qualities were assessed by 25 panel members using a 9-point hedonic scale, describing its sensory qualities and scores in accordance with Damanpreet et al.'s recommendations. A score of nine indicates extreme liking, eight indicates very much like, seven indicates moderate liking, six indicates liking, five indicates neither liking nor disliking, four indicates minor dislike, three indicates moderate dislike, two indicates very much dislike, and one indicates strongly disliking, according to the hedonic scale.

3. Results and Discussion

Osmotic dehydration of banana

To increase the shelf life of bananas, osmotically dehydrating them with a sugar and salt solution was the method employed in this investigation. A specific quantity of fruit is immersed in the osmotic solution for 15, 30, 45, 60, and 75 minutes, among other durations, prior to examination. In comparison to the control sample, an estimate of the extended shelf life was calculated. The final details on shelf life and sensory characteristics are provided at the end. Tables 1 through 16 display the experimental values for water loss (WL), solid gain (SG), and weight reduction (WR) for various immersion times in minutes.

OSMOTIC DEHYDRATION IN BANANA – TERNARY (SUGAR + SALT + WATER)
Table 1 Osmotic dehydration of pineapple, Temp 25°C, sample concentration 10g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	5.46	4.46	5.66
	30	9.99	6.76	15.71
	45	20.18	9.66	28.79
	60	28.46	13.95	38.41
	75	28.73	14.35	42.16
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	8.14	4.93	12.09
	30	11.08	7.43	17.48
	45	17.21	10.26	26.43
	60	23.26	12.99	35.23
	75	29.83	14.78	44.52
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.20	7.85	11.06
	30	8.95	11.46	20.43
	45	14.94	13.42	27.39
	60	22.23	15.83	36.08
	75	33.08	17.92	47.03
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	8.85	7.44	13.26
	30	12.22	12.45	23.70
	45	16.46	16.67	33.47
	60	23.03	17.46	39.47
	75	32.65	17.99	48.62

Table 2 Osmotic dehydration of pineapple, Temp 25°C, sample concentration 15g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	4.42	3.55	5.97
	30	11.70	4.40	15.04
	45	22.67	6.73	27.33
	60	28.42	7.99	36.44
	75	34.63	11.28	42.87
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	11.60	4.07	13.70
	30	17.55	5.46	20.99
	45	27.24	9.06	35.35
	60	33.05	10.44	40.42
	75	35.05	12.08	47.15
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.67	5.50	8.05
	30	13.35	8.03	19.38
	45	20.20	10.92	27.20
	60	30.52	11.99	41.52
	75	35.88	13.36	49.25
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	6.36	4.73	8.10
	30	13.86	6.65	19.55
	45	15.70	10.99	25.66
	60	23.42	13.05	35.42
	75	36.52	15.60	50.20

Table 3 Osmotic dehydration of pineapple, Temp 25°C, sample concentration 20g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	6.10	3.77	8.85
	30	20.13	5.03	22.16
	45	25.21	6.22	30.65
	60	33.42	9.21	42.52
	75	33.93	12.12	45.04
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	10.65	4.88	13.56
	30	16.19	7.09	21.29
	45	26.92	8.52	35.56
	60	33.20	12.03	42.17
	75	36.70	13.88	48.69
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.94	5.77	8.73
	30	13.93	8.66	20.56
	45	22.13	12.06	31.16
	60	33.58	14.04	45.70
	75	34.58	16.07	49.74
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	8.62	4.55	12.20
	30	18.44	8.92	26.33
	45	30.43	11.15	40.60
	60	32.93	17.62	48.58
	75	33.96	17.05	52.41

Table 4 Osmotic dehydration of pineapple, Temp 25°C, sample concentration 25g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	2.18	3.65	3.78
	30	12.05	4.03	14.13
	45	12.09	5.11	15.17
	60	28.08	7.28	33.33
	75	39.06	9.95	48.03
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	3.14	4.83	6.03
	30	11.88	6.32	16.26
	45	15.99	9.93	23.80
	60	26.53	10.93	36.58
	75	40.54	12.15	51.41
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	10.05	5.33	13.37
	30	12.05	7.15	16.23
	45	23.30	10.57	32.32
	60	30.30	12.00	40.37
	75	37.95	14.45	52.35
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	13.52	5.65	17.26
	30	27.92	7.07	32.97
	45	37.97	12.15	50.12
	60	38.05	14.27	53.29
	75	40.05	15.09	55.05

Table 5 Osmotic dehydration of pineapple, Temp 30°C, sample concentration 10g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	6.21	4.41	8.75
	30	8.64	5.96	12.59
	45	14.47	6.98	20.42
	60	20.46	9.80	29.26
	75	35.72	11.33	48.14
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	3.08	4.95	6.05
	30	6.72	6.57	13.17
	45	13.77	10.30	20.48
	60	16.82	13.65	29.60
	75	32.72	15.48	47.18
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	4.60	6.73	10.32
	30	7.72	9.22	15.92
	45	9.98	12.93	21.29
	60	14.46	15.93	29.45
	75	32.83	17.47	48.32
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.03	8.72	9.72
	30	6.42	11.22	15.82
	45	11.60	13.43	24.06
	60	15.20	16.92	32.13
	75	32.98	19.76	49.72

Table 6 Osmotic dehydration of pineapple, Temp 30°C, sample concentration 15g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	7.82	2.59	7.40
	30	11.46	5.33	14.42
	45	20.27	8.04	27.23
	60	25.77	11.63	25.22
	75	38.95	12.73	49.05
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	8.12	4.69	9.82
	30	11.69	5.57	16.26
	45	20.53	8.37	27.93
	60	27.99	12.72	37.74
	75	40.65	13.39	52.04
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	4.99	6.09	9.03
	30	9.28	8.69	14.99
	45	15.75	12.03	25.83
	60	22.92	13.28	35.22
	75	39.67	16.60	55.26
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.14	6.98	8.12
	30	6.72	9.92	14.13
	45	17.32	12.62	30.99
	60	21.05	16.03	36.03
	75	39.80	17.65	57.49

Table 7 Osmotic dehydration of pineapple, Temp 30°C, sample concentration 20g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	8.50	3.72	10.22
	30	17.83	4.03	20.74
	45	28.54	5.10	33.20
	60	40.32	8.17	47.67
	75	46.39	9.20	52.47
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	46.57	4.03	48.67
	30	12.83	7.16	17.97
	45	29.20	9.07	36.30
	60	37.83	12.43	47.60
	75	46.57	12.87	57.67
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	8.83	4.92	10.82
	30	19.95	8.56	26.53
	45	23.19	11.08	33.27
	60	32.49	15.17	46.59
	75	44.83	16.03	58.82
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	6.97	4.23	10.27
	30	13.85	9.15	20.97
	45	24.27	12.09	34.32
	60	32.16	15.64	46.82
	75	44.21	18.54	60.74

Table 8 Osmotic dehydration of pineapple, Temp 30°C, sample concentration 25g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	4.97	3.08	6.03
	30	10.91	4.22	14.12
	45	16.71	7.93	23.62
	60	25.83	10.17	34.27
	75	45.37	12.08	55.44
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	7.03	4.99	10.04
	30	15.17	6.06	20.25
	45	29.87	8.83	37.80
	60	32.03	10.24	40.03
	75	42.53	12.08	57.58
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	9.88	4.09	12.96
	30	12.22	7.12	18.34
	45	23.54	11.07	34.58
	60	29.67	13.20	41.86
	75	46.09	15.09	60.17
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.98	6.24	10.21
	30	17.83	10.39	29.20
	45	25.51	12.90	33.39
	60	29.97	16.13	46.14
	75	45.17	17.27	60.15

Table 9 Osmotic dehydration of pineapple, Temp 35°C, sample concentration 10g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	4.52	3.42	6.12
	30	10.42	4.62	13.85
	45	13.12	7.42	19.67
	60	15.98	9.42	26.37
	75	43.22	10.43	53.45
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	3.27	4.72	4.92
	30	8.23	5.97	14.20
	45	9.25	10.47	20.43
	60	16.23	12.13	27.82
	75	42.33	13.72	54.03
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.08	4.62	8.72
	30	9.57	7.17	15.72
	45	13.98	10.92	23.94
	60	19.93	13.93	32.86
	75	42.72	14.95	57.18
025% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.63	7.17	10.86
	30	11.72	10.77	21.55
	45	17.28	13.97	30.36
	60	22.56	16.97	38.52
	75	44.24	17.42	60.64

Table 10 Osmotic dehydration of pineapple, Temp 35°C, sample concentration 15g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	9.03	3.44	10.47
	30	16.25	4.67	20.97
	45	24.23	6.67	29.97
	60	29.02	9.62	37.69
	75	43.42	11.05	55.44
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	5.94	3.62	9.62
	30	8.73	6.72	14.46
	45	15.21	8.73	24.08
	60	20.27	11.88	30.16
	75	45.93	12.39	57.34
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	4.82	5.39	9.52
	30	13.16	6.72	14.46
	45	20.04	8.77	24.03
	60	25.59	11.90	30.20
	75	47.72	12.40	56.34
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	3.75	6.71	7.45
	30	10.28	10.32	19.60
	45	15.27	13.33	27.59
	60	23.84	15.03	37.87
	75	42.26	16.96	61.19

Table 11 Osmotic dehydration of pineapple, Temp 35°C, sample concentration 20g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	4.33	4.55	6.03
	30	12.82	5.64	17.46
	45	21.33	9.08	28.42
	60	34.87	10.62	44.52
	75	46.96	11.82	56.97
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	7.83	3.05	9.87
	30	18.82	6.08	23.72
	45	29.20	7.63	36.82
	60	37.18	10.11	48.25
	75	46.06	12.08	57.08
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.94	5.20	9.36
	30	13.78	8.12	20.94
	45	22.15	11.73	33.27
	60	33.08	13.18	44.25
	75	47.04	14.16	60.16
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	7.98	4.65	11.62
	30	13.55	8.15	20.69
	45	25.17	11.32	35.52
	60	30.49	15.60	45.08
	75	47.87	15.65	63.47

Table 12 Osmotic dehydration of pineapple, Temp 35°C, sample concentration 25g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)8.89	0	0	0	0
	15	10.91	2.22	11.12
	30	14.50	4.06	17.60
	45	19.91	5.20	24.11
	60	26.50	10.52	35.50
	75	47.15	11.08	57.22
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	6.12	4.95	9.03
	30	11.05	6.10	15.08
	45	14.03	9.06	22.16
	60	22.12	11.99	33.11
	75	47.03	13.36	58.40
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	12.50	4.09	15.56
	30	20.03	8.17	26.17
	45	26.64	11.08	35.67
	60	29.83	12.03	41.69
	75	48.51	13.99	62.50
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.62	5.08	9.75
	30	17.53	10.03	28.87
	45	22.51	12.83	36.38
	60	33.20	14.97	47.05
	75	49.87	17.05	64.94

Table 13 Osmotic dehydration of pineapple, Temp 40°C, sample concentration 10g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	6.25	3.82	8.22
	30	11.37	4.47	13.83
	45	15.56	8.70	23.25
	60	20.06	9.77	29.83
	75	46.28	11.45	53.62
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	3.65	3.92	6.47
	30	9.03	6.43	13.49
	45	14.03	8.24	22.97
	60	18.15	11.73	30.20
	75	48.16	13.43	57.53
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	5.14	4.77	8.92
	30	10.93	6.18	15.17
	45	13.13	10.45	23.60
	60	18.18	12.46	32.34
	75	43.62	15.22	59.85
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	4.12	4.87	9.05
	30	8.82	7.43	15.27
	45	12.25	12.35	23.70
	60	17.50	13.22	30.72
	75	47.95	16.46	63.45

Table 14 Osmotic dehydration of pineapple, Temp 40°C, sample concentration 15g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	7.22	3.72	8.95
	30	17.30	4.05	18.62
	45	20.65	9.91	27.06
	60	28.99	10.62	37.62
	75	50.19	12.03	60.23
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	4.82	4.62	8.64
	30	4.92	6.33	10.35
	45	13.85	8.95	22.83
	60	17.72	11.67	28.40
	75	48.72	12.70	60.42
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	3.12	5.03	5.12
	30	8.99	7.35	15.32
	45	17.22	10.46	25.06
	60	23.18	12.43	34.62
	75	47.75	15.03	63.82
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	8.12	3.40	9.50
	30	11.04	5.69	13.64
	45	17.44	9.83	25.94
	60	23.44	13.16	39.12
	75	48.25	14.85	66.20

Table 15 Osmotic dehydration of pineapple, Temp 40°C, sample concentration 20g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	5.72	3.65	7.40
	30	14.20	4.03	17.30
	45	23.75	5.08	25.82
	60	38.20	7.72	46.95
	75	52.14	11.05	61.09
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	11.33	4.53	12.56
	30	20.43	6.53	25.94
	45	27.23	8.14	35.37
	60	40.14	11.04	50.19
	75	52.04	13.03	63.15
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	11.42	4.62	14.13
	30	24.42	5.13	29.55
	45	34.65	9.36	43.14
	60	43.05	12.92	55.06
	75	52.59	13.50	64.35
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	9.54	4.34	12.97
	30	14.32	7.62	21.92
	45	26.47	10.03	35.57
	60	35.45	12.34	46.55
	75	53.35	15.73	67.12

Table 16 Osmotic dehydration of pineapple, Temp 40°C, sample concentration 25g

Sugar/Salt concentration	Time (Mins)	WR (%)	SG (%)	WL (%)
10% (13g SUGAR + 12g SALT)	0	0	0	0
	15	10.03	2.17	12.22
	30	18.16	2.21	18.42
	45	31.13	4.03	35.17
	60	41.04	6.05	46.12
	75	56.03	9.18	65.22
15% (19g SUGAR + 18g SALT)	0	0	0	0
	15	5.33	3.92	8.17
	30	11.04	4.08	13.08
	45	18.83	7.09	25.96
	60	39.62	8.32	48.83
	75	56.67	12.03	67.79
20% (25g SUGAR + 25g SALT)	0	0	0	0
	15	8.03	4.08	12.08
	30	10.05	7.05	17.12
	45	29.72	10.37	39.34
	60	32.70	12.14	42.83
	75	55.03	14.07	67.07
25% (37g SUGAR + 25g SALT)	0	0	0	0
	15	3.22	4.13	7.42
	30	11.33	6.03	16.10
	45	36.65	10.64	47.32
	60	47.70	13.05	60.34
	75	55.12	15.52	70.33

Effect on shelflife and study report

Using a ternary osmotic system (sugar, salt, and water), the expected shelf life of a fresh, ripened, and osmotically treated banana sample was calculated at room temperature (20°C) and refrigerator temperature (4°C). After being subjected to osmotically treated samples, control samples were examined to see how the results and shelf life differed.

To enhance mass transfer, the temperature aid was given at a range of temperatures (25°C, 30°C, 35°C, and 40°C). Longer shelf life and improved mass transfer are the outcomes of higher temperatures.

Control sample

The osmotically treated control sample had a 23-day shelf life at ambient temperature and a 26-day shelf life at refrigerator temperature.

Temperature 25°C

Under 25°C temperature assistance, samples kept at room temperature have a 24-day shelf life, but samples kept at refrigerator temperature have a 30-day shelf life.

The control sample is one day younger than the room temperature sample, while the refrigerator-stored sample is four days older.

Temperature 30°C

When stored at 30°C, samples stored at room temperature have a 24-day shelf life; whereas, samples stored at refrigerator temperature have a 29-day shelf life.

The room temperature sample is one day older than the control sample and remains constant at 25°C.

Furthermore, the refrigerator's temperature is three days above and one day below 25°C.

Temperature 35°C

The shelf life of samples kept at room temperature is 25 days when maintained at 35°C, and 30 days when refrigerated.

The room temperature samples are one day older than the control samples and two days older than the samples at 25°C and 30°C.

Furthermore, the refrigerator maintains a consistent temperature that is one day above 25°C and four days above 30°C.

Temperature 40°C

Under 40°C of assistance, a room temperature sample has a 25-day shelf life, whereas a refrigeration temperature sample has a 30-day shelf life.

The room temperature sample is two days older than the control sample and one day older than the 25°C sample, but it remains the same when stored at 30°C and 35°C.

It is also five days higher, one day higher, and remains the same in the refrigerator than 25°C, 30°C, and 35°C.

Shelflife contrast

At room temperature and at refrigeration temperature, the osmotic system ternary (sugar + salt) has a longer shelf life than the control sample at all four temperatures (25°C, 30°C, 35°C, and 40°C).

Additionally, this osmotic system has a longer shelf life at room temperature (20°C, 35°C, and 40°C) and in the refrigerator (35°C and 40°C).

TEMPERATURE	Room Temperature	Refrigeration Temperature
Control sample	23 Days	26 Days
25°C	24 Days	30 Days
30°C	24 Days	29 Days
35°C	25 Days	30 Days
40°C	25 Days	30 Days

Table 17: Shelf life (in Days) obtained when treated under various temperatures for ternary osmotic system.

Evaluation of sensorial assets

The fresh control pieces and the osmosed banana chunks were compared in order to provide the sensory evaluation, as well as its sensory attributes and ratings. The average scores of the panel members are revealed. The final osmosed banana was smelled to determine its odor and scent, the texture's physical appearance was evaluated, the color was determined by comparing it to a fresh white banana, and the flavor was identified by the organoleptic properties. The sensory scores for each attribute are shown in Table 18.

Osmotic system	Attributes and Scores				
	Texture	Taste	Color	Aroma	Sweetness
Ternary	6	5	7	4	6

Table 18: Sensory hedonic scale and its results

A nutritious culinary product with an improved sensory quality is created from the sugar, salt, and nutrients present in the shrunken flesh of the finished osmosed banana.

4. Conclusion

The experiment's findings support the idea that fruits that experience osmotic dehydration have a longer shelf life. Bananas have a longer shelf life because of its ternary osmotic system. When left at room temperature, 25°C, 35°C, and 40°C have longer shelf lives (25 days each), but when refrigerated, 25°C, 35°C, and 40°C have longer shelf lives (30 days each) than when left at other temperatures. This suggests that food products' shelf lives can be successfully increased by the osmotic dehydration process. A further indication that osmotic dehydration (OD) is an effective food preservation technique for food products is the fact that the shelf life is longer than expected.

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