

PAPER 147 – STORAGE STABILITY OF OPTIMIZED FOAM-MAT DRIED TOMATO-PEPPER-ONION POWDER UNDER DIFFERENT PACKAGING CONDITIONS

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ABSTRACT

The storage stability of optimized foam-mat dried tomato-pepper-onion powder was evaluated under different packaging conditions. The powder was prepared using a foam-mat drying technique and optimized using response surface methodology. The levels for various input variables were tomato (5 – 76%), pepper (5 – 78%), onion (5 – 80%), egg white (2 - 15%), carboxymethyl cellulose (0.15 - 0.75%) & Drying temperature: 50-80°C. Laminated aluminium foil, high density polyethylene and medium density polyethylene were three distinct packaging types used to package the optimized powder. Every five days, the storage stability of the powders was checked while they were kept at room temperature for 30 days. The amount of MC, lycopene, protein, and microbial growth were assessed in the powder sample. The findings demonstrated that, in comparison to the control group, all packing options considerably increased the powder's storage stability. The LAF was the most effective in keeping moisture from entering the package and was also able to preserve the most lycopene content (10.40%) as compared to the control value of 10.21%, while also having the lowest moisture content over the course of storage at 4.39 percent.

KEYWORDS: Storage Stability, Foam-mat Drying, Tomato-pepper-onion Powder, Packaging Conditions, Compositional Changes, Viable Load

1. INTRODUCTION

In many cuisines around the world, vegetables like tomatoes, peppers, and onions are crucial. Lycopene, a carotenoid with antioxidant qualities, is abundant in tomatoes. Lycopene, which gives tomatoes their red color, has been linked to a lower risk of some malignancies, cardiovascular illnesses, and age-related macular degeneration (AMG) (Hossain *et al.*, 2021). Vitamin C, carotenoids, and capsaicin, a bioactive substance with anti-inflammatory and analgesic qualities, are all abundant in peppers. Quercetin, a flavonoid with anti-inflammatory and antioxidant effects, is abundant in onions. (Iqbal *et al.*, 2021). These three veggies are combined to give varied dishes flavor and aroma as well as a balanced nutrient content.

Food processing and preservation are crucial for guaranteeing food safety, accessibility, and availability. Different techniques for food preservation have been created over time and implemented on a global scale. The techniques that are most frequently utilized are drying, canning, freezing, and irradiation. The nature of the product, the preservation criteria, and the planned use all factor into the preservation method selection (Liu *et al.*, 2022).

One of the earliest and most popular ways of food preservation is drying, which is how those vegetables are preserved. It entails drying out food products to eliminate moisture and stop microbial development and enzymatic activity, which could lead to spoiling. Drying is economical, uses little energy, and keeps the vegetables' nutritious content.

Traditional drying techniques including sun, air, and oven drying take a long time to dry, are of poor quality, and result in deteriorated products. As a result, the food sector has created and embraced cutting-edge drying techniques like freeze-drying, spray drying, and foam-mat drying (Bhatkar *et al.*, 2021). Foam-mat drying is a relatively new technology that has attracted attention due to its ability to produce high-quality, nutritious and shelf-stable food powders.

Proteins, surfactants and other foaming ingredients are used in foam-mat drying to create stable foam. After regulated drying, the foam transforms into a porous, stable powder. A variety of food powders, including milk, egg, fruit, and vegetable powders, have been produced using the method (Kilicli *et al.*, 2022).

However, nothing is known about the foam-mat dry tomato, pepper, and onion powder's storage stability under various packing scenarios. Therefore, it is necessary to research how different packaging materials and storage settings affect the quality indices of foam-mat dried tomato-pepper-onion powder while it is being stored. This study intends to fill up this information gap and offer important insights into the creation of packaging techniques that would increase the storage stability and shelf life of dried tomato, pepper, and onion powder packaged in foam-mats.

2. THEORETICAL ANALYSIS

Examining the effects of various packaging materials on the compositional changes and viable load in the powder during storage is a part of the theoretical analysis of the research on the storage stability of optimized foam-mat dried tomato, pepper, and onion powder under various packaging conditions. The study makes use of food science and technology principles, particularly those relating to drying and packing. Theoretical ideas like the mechanics of foam-mat drying and the elements influencing food product shelf life are also taken into account.

In order to ascertain the impacts of packing on the stability of the powder, the research also analyzes the lycopene content, moisture content, protein and the microbial growth.

3. MATERIALS AND METHODS

The tomatoes, onions, and peppers were gathered from the Kure market in Minna, Niger State, and the defective ones were separated out. The tomatoes, onions, and peppers had a diameter of 65 to 80 mm and weighed 80 to 110 g. The biomaterials were soaked in a salt solution containing 1 percent CaCl₂ and 0.2 percent potassium metabisulphite (KMS) for 10 minutes at room temperature after being cleaned with distilled water. The Federal University of Technology, Minna's department of Agricultural and Bioresources Engineering laboratory handled the preparation of the foam-mat dry powder, while the department of Food Science and Technology of Federal University of Technology Minna handled the analysis.

3.1 Experimental Design

Combining mixture variables and process variables allowed the experimental design to be constructed. The drying process for foam mats is typically impacted by a number of factors, including drying temperature (°C). The levels of these variables (drying temperature, foaming agent and binder) were collected from the literature for the current research. Different drying temperatures might result in radically different outcomes even when using the same ingredients (such as tomato, onion, and pepper). With three main components—tomato (x_1), pepper (x_2), and onion (x_3), as well as egg white (x_4) as a foaming agent and carboxyl methyl cellulose (CMC) (x_5) as a stabilizer—D-optimal design is employed in this study.

Table 3.1: Experimental Design for the Formulation Experiment

Run	X ₁ :Tomato	X ₂ :pepper	X ₃ :Onion	X ₄ :Egg White	X ₅ :CMC	Z ₁ :Drying Temp
	%	%	%	%	%	°C
1.0	36.1	51.5	5.0	7.3	0.2	65.0
2.0	20.3	56.5	21.0	2.0	0.2	57.8
3.0	5.0	74.6	5.0	15.0	0.4	50.0
4.0	25.8	67.0	5.0	2.0	0.2	80.0
5.0	45.3	28.6	21.5	4.2	0.4	50.0
6.0	22.6	70.2	5.0	2.0	0.2	50.0
7.0	74.3	5.0	5.0	15.0	0.7	80.0
8.0	63.9	6.4	27.5	2.0	0.2	80.0
9.0	9.4	41.8	40.9	7.2	0.7	65.0
10.0	5.0	14.6	78.2	2.0	0.2	80.0
11.0	61.9	18.0	5.0	15.0	0.2	80.0
12.0	7.2	78.5	11.5	2.0	0.7	65.0
13.0	62.1	11.5	10.7	15.0	0.7	50.0
14.0	76.5	5.0	5.0	13.3	0.2	50.0
15.0	15.9	5.0	76.3	2.0	0.7	50.0
16.0	15.3	46.4	35.5	2.0	0.7	50.0
17.0	69.0	16.3	8.1	5.9	0.8	65.0
18.0	69.7	17.1	10.4	2.1	0.7	80.0
19.0	7.0	5.0	72.8	15.0	0.2	80.0
20.0	23.1	5.3	55.9	14.9	0.7	65.0

21.0	5.7	9.6	70.8	13.2	0.7	50.0
22.0	52.6	26.6	5.0	15.0	0.8	65.0
23.0	41.7	42.0	9.7	5.8	0.8	50.0
24.0	76.3	5.1	16.5	2.0	0.2	50.0
25.0	5.0	74.3	18.5	2.0	0.2	65.0
26.0	56.3	5.0	36.5	2.0	0.2	57.5
27.0	62.7	5.0	23.2	8.3	0.7	50.0
28.0	29.0	50.3	5.0	15.0	0.7	80.0
29.0	26.4	13.7	51.3	8.4	0.2	80.0
30.0	47.6	21.4	28.9	2.0	0.2	65.0
31.0	54.0	32.9	5.0	7.6	0.6	80.0
32.0	26.1	15.8	55.6	2.0	0.4	65.0
33.0	5.0	26.2	53.0	15.0	0.7	80.0
34.0	37.8	40.3	19.4	2.0	0.5	80.0
35.0	73.4	11.9	8.4	6.2	0.2	65.0
36.0	61.9	18.0	5.0	15.0	0.2	80.0
37.0	5.0	31.4	48.4	15.0	0.2	65.0
38.0	13.9	6.6	73.8	5.5	0.2	65.0
39.0	5.0	26.2	53.0	15.0	0.7	80.0
40.0	27.8	37.8	19.2	15.0	0.2	50.0
41.0	32.4	5.3	59.4	2.1	0.7	65.0
42.0	29.0	50.3	5.0	15.0	0.7	80.0
43.0	24.2	5.0	55.7	15.0	0.2	50.0
44.0	5.0	74.9	5.0	15.0	0.2	80.0
45.0	48.8	13.6	22.1	15.0	0.5	72.8
46.0	13.7	65.4	14.5	5.7	0.8	80.0
47.0	12.3	5.0	80.0	2.0	0.7	80.0
48.0	66.7	19.1	11.5	2.0	0.7	50.0
49.0	42.9	9.5	35.7	11.7	0.2	65.0
50.0	5.0	74.3	5.0	15.0	0.7	65.0
51.0	5.0	12.9	80.0	2.0	0.2	50.0

3.2 Procedure for the production of optimized foam-mat dried tomato-onion-pepper powder.

The procedure involves blanching the tomato, pepper and onion samples in boiling water for 30 seconds to stop enzymatic action. Next, a home blender was used to chop and grind the biomaterials into pulp for 4 minutes, until a smooth, uniform mixture was formed. Following that, according to the combinations of the experimental treatment, 100ml of the pulp was poured into 51 small containers, and various concentrations of egg white (5%, 10% and 15%), carboxymethyl cellulose (CMC) (0.15%, 0.45% and 0.75%), tomato (5-76.5%), pepper (5-78.5%), and onion (5-80%) were added. A 400 W jug-type blender (model number FPO12A) was then used to agitate (whip) the mixture for 7 minutes to create foam. To let air into the foam, the top of the mixer was opened. The mixture was then dried using a foam-mat drying technique to form the powder.

3.3 Storage of tomato-pepper-onion composite powder in different packaging materials

This study was conducted to find out suitable packaging materials for the storage of the foam-mat dried tomato-pepper-onion powder. The powder was packed in Laminated Aluminium Foil (LAF), High Density Polyethylene (HDPE), and Medium Density Polyethylene (MDPE) and stored for 30 days. Some selected quality indices of the powder such as protein, moisture content, lycopene content and microbial loads (fungal and bacterial loads) were conducted at an interval of 5 days during the storage period of 30 days and the values of their microbial loads were recorded.

3.4 Statistical Analysis

D-optimal point exchange design was used for a storage period of 30 days with three different packaging material. The results obtained were analyzed using Design Expert Software (v13.0). The analysis of variance shows the influence of storage factors (duration of storage and packaging materials) on the foam-mat dried powder. The greater the F-value, the more significant effect. The significant effect of storage factors to the responses are characterized by p-value "Prob > F" which is less than 0.05.

4. RESULTS AND DISCUSSION

Table 4.1: Effect of Three Packaging Materials on Some Selected Quality Indices and Viable Loads of Tomato-Pepper-Onion Powder: tomato:67.25% pepper: 5.0%. onion: 20.0% egg white: 7.59% , CMC: 0.150% DT: 61.93°C

Run	Storage Duration (Days)	Packaging Materials	Moisture Content %	Protein %	Lycopene mg/100g	Viable Load (cfu/g)	
						Bacteria	Fungal
1	0	Laminated Aluminium Foil	5.38	11.47	10.21	2.46 ×10 ²	5.53×10 ²
2	0	High Density Poly Ethylene	6.95	9.02	9.8	3.24×10 ²	6.5×10 ²
3	0	High Density Poly Ethylene	6.92	10.38	10	3.15×10 ²	8.32×10 ²
4	0	Medium Density Poly Ethylene	6.03	11.64	10.43	1.69×10 ²	2.25×10 ²
5	0	High Density Poly Ethylene	6.23	11.64	10.43	1.69×10 ²	2.25×10 ²
6	5	Laminated Aluminium Foil	5.75	11.61	10.35	2.3×10 ²	3.39×10 ²
7	5	Laminated Aluminium Foil	4.65	10.98	10.12	3.03×10 ²	7.84×10 ²
8	5	Medium Density Poly Ethylene	6.82	9.55	10.15	4.78×10 ²	5.9×10 ²
9	5	Medium Density Poly Ethylene	6.07	11.5	10.42	1.85×10 ²	2.86×10 ²
10	5	Laminated Aluminium Foil	4.39	10.98	10.12	3.86×10 ²	7.99×10 ²
11	10	High Density Poly Ethylene	6.59	11.42	10.29	2.19×10 ²	3.88×10 ²
12	10	Medium Density Poly Ethylene	6.65	9.89	10.21	4.43×10 ²	7.81×10 ²
13	10	Medium Density Poly Ethylene	6.84	9.21	10.11	6.04×10 ²	9.44×10 ²
14	10	Laminated Aluminium Foil	5.35	11.14	10.18	2.72×10 ²	5.37×10 ²
15	10	Medium Density Poly Ethylene	6.16	10.98	10.39	1.99×10 ²	2.76×10 ²
16	15	Laminated Aluminium Foil	6.3	11.64	10.43	1.23×10 ²	2.25×10 ²
17	15	Laminated Aluminium Foil	5.31	11.46	10.21	2.5×10 ²	4.93×10 ²
18	15	Medium Density Poly Ethylene	6.22	10.5	10.39	2.54×10 ²	2.68×10 ²
19	15	Laminated Aluminium Foil	6.13	10.82	10.37	1.67×10 ²	3.01×10 ²

20	15	Medium Density Poly Ethylene	6.57	10.36	10.3	2.83×10^2	3.45×10^2
21	20	Medium Density Poly Ethylene	6.34	10.31	10.28	3.23×10^2	1.92×10^2
22	20	Laminated Aluminium Foil	5.14	11.05	10.15	2.96×10^2	6.11×10^2
23	20	High Density Poly Ethylene	6.58	11.55	10.3	1.86×10^2	3.65×10^2
24	20	Laminated Aluminium Foil	5.22	11.12	10.18	2.78×10^2	5.39×10^2
25	20	Medium Density Poly Ethylene	6.61	9.86	10.26	3.74×10^2	4.1×10^2
26	25	Laminated Aluminium Foil	5.96	10.8	10.36	1.89×10^2	3.26×10^2
27	25	High Density Poly Ethylene	6.58	11.53	10.29	2.1×10^2	3.92×10^2
28	25	Laminated Aluminium Foil	5.05	11.01	10.15	3×10^2	6.45×10^2
29	25	High Density Poly Ethylene	6.51	11.62	10.38	1.79×10^2	2.75×10^2
30	25	High Density Poly Ethylene	6.86	9.1	9.89	3.2×10^2	6.33×10^2
31	30	Medium Density Poly Ethylene	6.79	9.46	10.19	2.85×10^2	7.46×10^2
32	30	Laminated Aluminium Foil	5.42	11.51	10.25	2.41×10^2	4.72×10^2
33	30	Medium Density Poly Ethylene	6.63	9.8	10.26	4.1×10^2	4.28×10^2
34	30	High Density Poly Ethylene	6.78	10.75	10.15	2.86×10^2	4.54×10^2
35	30	Laminated Aluminium Foil	6.25	11.24	10.4	1.45×10^2	2.63×10^2
36	35	High Density Poly Ethylene	6.92	10.44	10.02	3.13×10^2	5.64×10^2
37	35	Medium Density Poly Ethylene	6.84	9.21	10.08	6.35×10^2	9.95×10^2
38	35	High Density Poly Ethylene	6.86	10.75	10.13	2.95×10^2	4.75×10^2
39	35	Medium Density Poly Ethylene	6.81	9.27	10.13	5.43×10^2	7.86×10^2
40	35	High Density Poly Ethylene	6.61	11.37	10.0	2.25×10^2	4.53×10^2

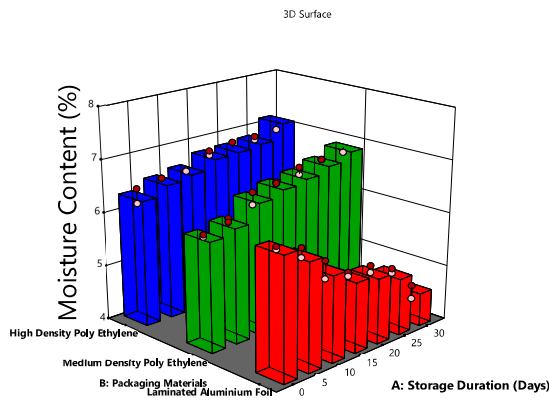


Fig 4(a): 3D Surface Diagram showing the effect of different packaging materials on the Lycopene Content of Powder tomato-pepper-onion mix during storage.

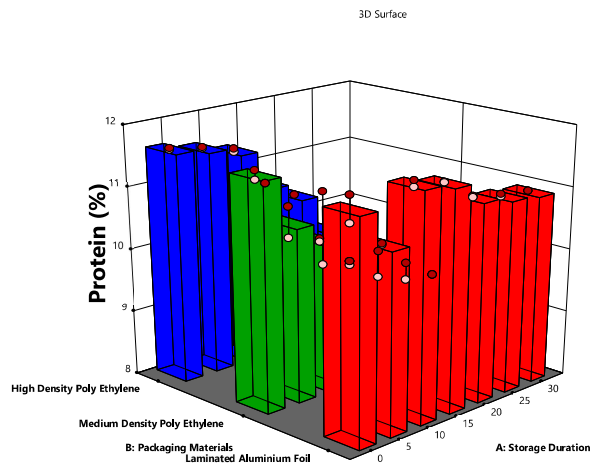


Fig 4(b): 3D Surface Diagram showing the effect of different packaging materials on the Fungal load of Powder tomato-pepper-onion mix during storage.

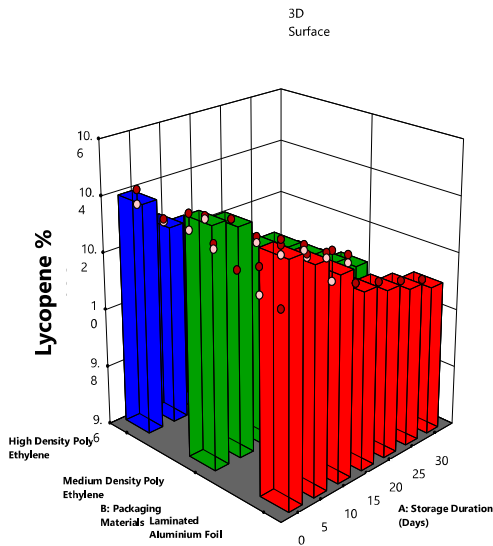


Fig 4(c): 3D Surface Diagram showing the effect of different packaging materials on the Lycopene Content of Powder tomato-pepper-onion mix during storage

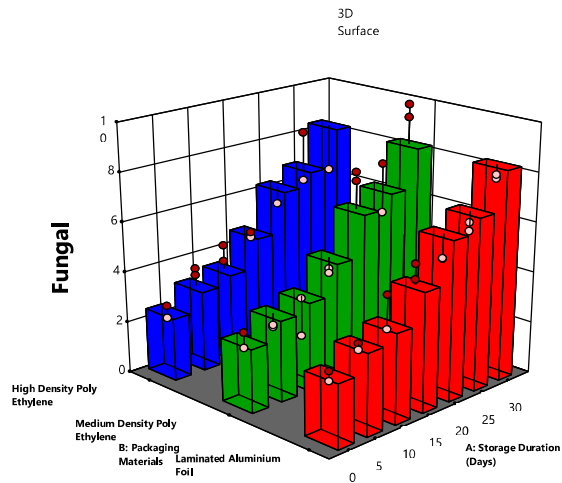


Fig 4(d): 3D Surface Diagram showing the effect of different packaging materials on the Fungal load of Powder tomato-pepper-onion mix during storage.

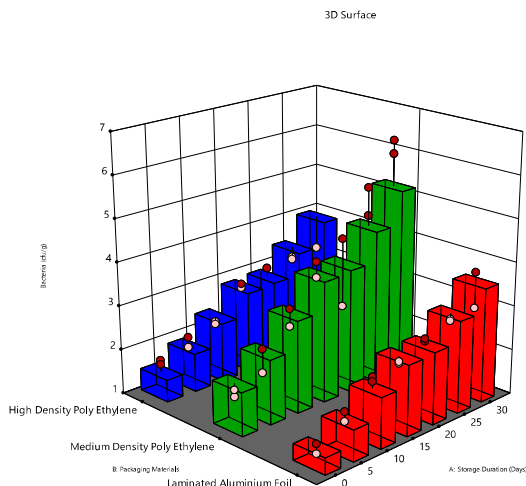


Fig 4(e): 3D Surface Diagram showing the effect of different packaging materials on the Bacterial load of Powder tomato-pepper-onion mix during storage.

4.2 Discussion

The optimized results of the foam-mat dried powder showed that 67.25% of tomato, 5.0% of pepper, 20.0% of onion, 7.59% of egg white, 0.150 of CMC with a drying temperature of 61.93°C produced foam-mat dried powder of 0.5972 desirability index. The optimized result of foam-mat dried tomato-pepper-onion powder was further subjected to storage analysis as shown in Table 4.1. Table 4.1 Shows the moisture content, protein content, lycopene and viable loads of the powdered tomato-onion-pepper stored in each packaging material was measured at different time intervals (days 0, 5, 10, 15, 20, 25, and 30). The results show that the moisture content increased over time from 5.38 to 6.92% in all the three packaging materials, but the rate of increase was higher in the MDPE compared to the other two packaging materials (LAF and HDPE). The LAF had the lowest moisture content throughout the storage period, indicating that it was the most effective in preventing moisture from entering the package. From the table, it can be observed that there is a gradual decrease in protein content over time in all three packaging materials. However, the rate of decrease is slightly different for each packaging material. The protein content in MDPE decreases more rapidly compared to HDPE and LAF. This could be due to the lower oxygen and moisture barrier properties of MDPE compared to HDPE and LAF. LAF shows the least decrease in protein content over time, which could be attributed to its high barrier properties. Overall, the results suggest that LAF is the most effective packaging material for maintaining the protein content of powdered tomato-onion-pepper during storage, followed by HDPE and MDPE. Similarly, it can be seen that the lycopene content of the powder tomato pepper and onion decreases over time. The rate of degradation varies depending on the packaging material used. The LAF packaging was able to preserve the lycopene content the most, while the HDPE packaging was the least effective in preserving the lycopene content. The MDPE packaging was also able to preserve the lycopene content to a certain extent but was not as effective as the LAF packaging.

Table 4.1 also showed that the viable load of bacteria and fungi varied throughout the 30-day storage period. The bacterial counts ranged from 1.23 to 6.35 log cfu/g, while the fungal counts ranged from 1.92 to 9.95 log cfu/g. However, the microbial counts in the product samples remained within acceptable limits for most food products throughout the storage period. These findings are consistent with previous studies that have reported that the microbial counts in dehydrated vegetables are generally low, and the storage period has a limited effect on their microbial load (Sarker et al., 2014).

5. CONCLUSION

The evaluation of the various packaging materials revealed that LAF (Laminated Aluminum Foil) packaging offered the best moisture barrier qualities, maintaining the powder's antioxidant activity and microbial loads. Although to a lesser extent than LAF packaging, HDPE (High-density Polyethylene) packaging was also helpful in maintaining the powder's quality qualities. In addition, it was discovered that MDPE (Medium-density Polyethylene) packaging performed the least well in maintaining the powder's quality attributes. To ensure the

quality and shelf life of foam-mat dried tomato-pepper-onion powder, LAF or HDPE packaging for storage and transportation are recommended. Overall, the findings of this study indicate that foam-mat drying is a promising method for processing vegetables into powder form.

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