Original Research Article

Development of novel micronutrient rich Drumstick *(Moringa oleifera)* pod pulp chutney and its shelf life prediction

ABSTRACT

Novel micronutrient rich Drumstick *(Moringa oleifera)* pod pulp chutney was developed and optimized by sensory evaluation and viscosity. The effects of moringa pulp, coriander leaves, mint leaves and xanthan gum over the chutney was studied. Central composite design of Response surface methodology was adopted for designing the experiments. Quality parameters like chemical composition and nutritional parameters of optimized chutney were estimated. The optimized chutney was analyzed for accelerated storage study. The shelf life of drumstick chutney is 137 days at 7^{o}C and 83 days at 30^{o}C.

Keywords: Chutney, Drumstick, Pod pulp, Micronutrient, Shelf life prediction

1. INTRODUCTION

Drumstick (*Moringa oleifera)* is valued as a medicinal and functional food, therefore known as “miracle vegetable”. The drumstick pods are rich in minerals (Ca, Mg, K, Mn, P, Zn, Na, Cu, and Fe) and vitamins such as A, B_1, B_2, B_3, B_6 and B_9, C, D, E and K. It has more than 40 natural antioxidants (Chaudhary *et al.,* 2023). *Moringa oleifera*, also known as the “tree of life” or “miracle tree,” is classified as an important herbal plant due to its immense medicinal and non-medicinal benefits. The plant is used to cure wounds, pain, ulcers, liver disease, heart disease, cancer, and inflammation (Pareek *et al.,* 2023). Drumstick is also known as *Sajjan Ki Phalli* in Hindi, *Sargavo* in Gujarati, *Munagakaya* in Telugu, *Murungakkai* in Tamil and Nuggekai in Kannada. Moringa is mainly used in curries, kormas, dals, sambhar, making tea, savory cutlets, soups. It gives a distinct palatable taste and is a rich source of glutamic acid. It is used as a flavoring agent for various non-vegetarian dishes to enhance the flavour of chicken or meat as well as a thickening agent for sambhar and chutney preparation, instant soup powder and in *paratha* along with potato. Also, it can be utilized in fortifying sauces, juices, spices, milk, bread, and instant noodles to improve its nutritional and medicinal values (Mahmood *et al.,* 2010). The *moringa* processed pulp was added in *gujarati dal*. Moringa pulp can replace the pigeon pea up to 11.27 % to improve the nutritional value of product. The product will be enriched with essential amino acids, phytochemicals and iron along with other nutritional enrichment (Ravani *et al.,* 2020a). Technology for moringa fortified lassi was standardized with 0.7% moringa leaves powder and 1.63 % moringa pod powder and was found organoleptically acceptable (Mistry, 2016).

There are opportunities to explore the possibilities of moringa as a novel source of nutrients, phytochemicals as well as functional food ingredient. Chutney is an important dish in Indian cuisine and they are made from fruits or vegetables, or a mixture of the two, which are chopped, cooked, mixed with spices, vinegar and other ingredients and reduced to a smooth pulp. Drumstick pod pulp can be used as ready to use food for enhancing functional and sensory properties in various products. Current research work is carried out to develop micronutrient rich Drumstick *(Moringa oleifera)* pod pulp chutney and determination of its shelf life with following objectives:

- Standardization of level of ingredients to develop drumstick chutney
- Accelerated shelf life evaluation drumstick chutney using Arrhenius equation

As per Food Safety and Standards Authority of India (FSSAI), (2019); the vegetable chutney means the product prepared from vegetable, salt, spices, condiments and preserved by thermal processing or other means. Chutney has minimum 25 % TSS, minimum fruits and vegetable content should be 40 %, pH not more than 4.6 and ash not more than 5.0 % (Nijhawan, 2019).

Sensory evaluation and viscosity of developed chutney was carried out s to standardize level of ingredients to develop drumstick chutney. The developed chutney is preserved with standardised technology and analysed for Accelerated shelf life evaluation drumstick chutney using Arrhenius equation. Quality kinetics is defined as rate of change quality parameters. It used to predict the time span for which a newly developed product will maintain its wholesomeness at a specified temperature. Kinetics provides the mechanism of changes involved in active ingredients and predicts the degree of change that will occur after a given period of time. Storage stability and shelf life characteristics of *Korean savory sauce* products was carried out by the Arrhenius equation, which can estimate the shelf life at any arbitrary limit as a function of temperature Yun *et al.,* (2007). The activation energies for changes in the primary quality indices of the meat extract solution, the soybean paste seasoning, and the sandwich spread were 20.3, 27.2, and 43.5 kJ/mol, respectively. Shelf life was determined with accelerated shelf life testing method and Arrhenius equation for apple brownies (Pulungan *et al.,* 2018). The shelf life of the apple brownies based on FFA was 110, 54, and 28 days at temperature of 25, 35, and 45^{o}C, respectively.

2. EXPERIMENTAL DETAILS

2.1 Materials

The optimized packed drumstick pod pulp (var. PKM 1) was utilized for this study (Ravani *el al.,* 2023). The other raw materials (coriander leaves, mint leaves, sugar, salt, lemon juice and cumin powder) were procured from local market of Anand city, Gujarat. The xanthan gum was procured from Astrone chemicals, Ahmedabad. The level of ingredients for production of drumstick chutney are mentioned in Table 1. Central composite experimental design was used to optimize level of drumstick pod pulp, coriander, mint and xanthan gum (Table 2).

Table 1 Ingredients for drumstick *chutney*

Ingredients	Quantity	Ingredients	Quantity
Drumstick pod pulp	50-70 g	Salt	3 g
Coriander leaves	30-50 g	Lemon juice	13 ml
Mint leaves	5-15	Cumin powder	2.5 g
Sugar	14 g	Xanthan gum	0.1 – 0.5 g

Table 2 Codes and actual values of variables for moringa chutney

Independent variables	Levels		
	-1	0	+1
Moringa pulp (g)	50	60	70
Coriander leaves (g)	20	30	40
Mint leaves (g)	5	10	15
Xanthan gum (g)	0.1	0.3	0.5
Dependent variables			
Sensory characteristics			
Viscosity			

2.2 Process for preparation of drumstick chutney

Coriander leaves and mint leaves were separated from stem and washed under tap water. The required quantity of drumstick pod pulp, coriander leaves, mint leaves and xanthan gum were mixed properly. Predetermined level of sugar, salt, lemon juice, cumin powder were added and grinded.

2.3 Quality evaluation of developed chutney

The developed chutney was evaluated for sensory characteristics using nine-point hedonic scale. The score-card suggested by Lawless and Haymann, (2010) was used for judging. A semi trained panel (10 members) was constituted among the faculty members of the institute. The experimental samples were served to the judges and the panelists were instructed to rate each sample on nine-point hedonic scale for appearance & colour, flavor, consistency and overall acceptability. The judges were also requested to give comments for each attributed of the samples. The final score for each attribute was calculated by averaging the scores of all the panelists.

Viscosity measurements of chutney were carried out using Brookfield viscometer. The measurements were carried out at ambient temperature 30± 2 ºC. The Brookfield viscometer

was leveled on the platform and the spindle S64 was attached to the viscometer by screwing them onto the lower shaft. The spindle was dipped into the sample and the rheological data were recorded at the speeds 12 rpm by pressing the enter key on the equipment. Viscosity was displayed in centipoise (cP) and torque was displayed in percentage. This viscosity was converted into pa.s. Temperature of sample during experiment was measured by dipping the temperature probe in the sample which was coupled to the viscometer (Swami *et al.,* 2013). Optimized chutney was evaluated for nutritional and biochemical parameters as per AOAC methods. The cost of the drumstick chutney was analyzed.

2.4 Shelf life evaluation of moringa chutney

Accelerated methods can used to determine the shelf life of a product. The changes in product quality will be accelerated by incubating products in extreme conditions for establishing the rate quality changes. In the present investigation Arrhenius approach was used to know the relationship between storage time and temperature.

The optimized moringa chutney was prepared with class II preservative i.e. sodium benzoate (at 250 ppm) and packed in metalized laminated polyester pouches and thermally processed at 85^{o}C for 10 min. The packed chutney was stored at ambient (30±2^{o}C), refrigerated (7±2^{o}C) and accelerated (55±2^{o}C) storage conditions. The product was analyzed for colour value, sensory attributes and microbial attributes at an interval of 5 days.

For determination of shelf life of chutney, sensory attributes were considered as a subjective quality index. The unacceptable chutney was the point when the overall acceptability was below 5. The changes in L* value was chosen as another quality attribute. The shelf life was determined as time required for reaching the limits which can be estimated at different temperatures. The data obtained of L* value were plotted against time and three equations for different product storage temperatures y = bx + a was obtained, (where x is the storage time (day), y is the characteristic value of moringa chutney, 'a' is the initial characteristic value of chutney, and 'b' is the rate of characteristic change (slope)). From every linear regression equation, the value of quality change rate (k) obtained. When the ln k value was plotted with 1/T (K^{-1}), the intercept and slope value of the linear regression equation ln k = ln k_0 - (E / R) (1 / T) was obtained. The activation energy characteristic to the moringa chutney and the constant value k_0 was obtained and the Arrhenius equation was calculated as below:

$$k = k_0 . e^{-RT}$$

Where: k = quality change constant, k_0 = constant (independent of temperature), E = activation energy, T = absolute temperature (K), R = gas constant (1.986 cal / mol K).

With Arrhenius equation, the rate of reaction (k) and the quality changes of chutney at a predetermined temperature (T) can be calculated. Shelf life determination of chutney was done by choosing parameters that have the highest correlation coefficient (R^2). The shelf life can be predicted from following equation:

$$A_0 = A_t + kt$$

Where, A_0 = A value at the beginning of shelf life,
A_t = A value at end of shelf life,
t = shelf life,
k = quality change constant.

Shelf life evaluation was done for all the storage temperatures (7±2^{o}C, 30±2^{o}C and 55±2^{o}C).

3. RESULTS AND DISCUSSION

3.1 Effect of drumstick pod pulp on sensory characteristics of drumstick chutney

The colour and appearance score of the drumstick chutney prepared during experiments ranged from 6.14 and 8.51 (Table 3). The flavour score of the drumstick chutney prepared during experiments ranged from 6.25 and 8.61. The results showed that among linear effects, drumstick pod pulp had highly significant effect on flavour of drumstick chutney ($p<0.01$) at 1% level. The consistency score of the drumstick chutney prepared during experiments ranged from 6.58 and 8.54. The results showed that among linear effects, drumstick pod pulp had significant effect on consistency ($p<0.05$) at 5% level.

The overall acceptability score of the drumstick chutney prepared during experiments ranged from 6.49 and 8.61 (Figure 1). The highest overall acceptability score was observed on experiment no. 15 and the lowest score was noticed in experiment no. 7 (Table 3). The results showed that among linear effects, drumstick pod pulp had significant effect ($p<0.05$) at 5% level.

The level of drumstick pod pulp influenced more effect on overall acceptability of drumstick chutney compared to other variables. Gradual increase in overall acceptability scores was

observed with increase of drumstick pod pulp upto 60g, and thereafter overall acceptability score decreased on further increase of drumstick pod pulp.

3.2 Effect of drumstick pod pulp on viscosity of drumstick chutney

The viscosity of the drumstick chutney prepared during experiments ranged from 0.91 and 2.15 (Figure 2). The highest viscosity was observed for experiment no. 12 and the lowest score was noticed in experiment no. 7. The results showed that among linear effects, drumstick pod pulp had highly significant effect ($p<0.01$) at 1% level.

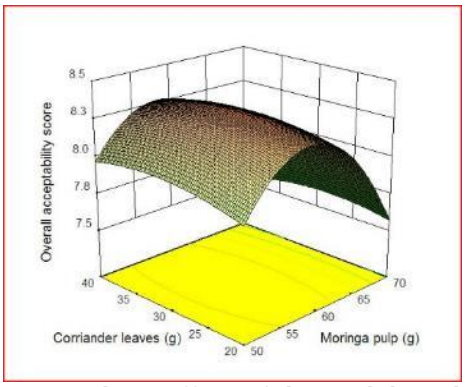

Fig 1. Effect of drumstick pod pulp on overall acceptability of drumstick chutney

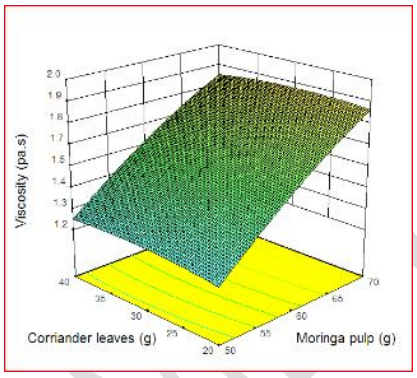

Fig 2. Effect of drumstick pod pulp on viscosity of drumstick chutney

3.3 Optimization of variable for production of drumstick chutney

The dependent parameters which affected drumstick chutney were drumstick pod pulp, coriander leaves, mint leaves and xanthan gum. The important quality parameters for drumstick chutney are maximum colour and appearance, flavour, consistency and overall acceptability score and optimum viscosity. Hence, these dependent parameters were taken into consideration for optimization. With the help of statistical analysis by Response Surface Central Composite Design and the Design-Expert 10.0.1.0, optimization was done.

The optimized conditions are.

1. Drumstick pod pulp : 61.78 g
2. Coriander leaves : 28.35 g
3. Mint leaves : 9.68 g
4. Xanthan gum : 0.19 g

The validation of the optimized solution was done by conducting the experiment at above levels of variables and quality evaluation was done for this product.

Table 3 Variables and responses for optimization of drumstick chutney

Experiment no.	Drumstick pod pulp (g)	Coriander leaves (g)	Mint leaves (g)	Xanthan gum (g)	Colour and appearance score	Flavor score	Consistency score	Overall acceptability score	Viscosity (pa.s)
1	50	40	15	0.4	7.84	7.88	7.95	7.93	1.25
2	60	30	10	0.3	8.12	8.19	8.1	8.14	1.55
3	70	40	5	0.2	7.30	7.23	7.21	7.29	1.60
4	60	30	10	0.3	8.13	8.15	8.07	8.12	1.69
5	70	20	15	0.4	7.14	7.25	7.09	7.12	1.79
6	70	40	5	0.4	7.14	7.16	7.20	7.17	1.75
7	40	30	10	0.3	6.50	6.47	**6.58**	**6.49**	**0.91**
8	60	30	10	0.3	8.12	8.14	8.16	8.16	1.60
9	70	20	15	0.2	7.15	7.16	7.18	7.14	1.69
10	50	20	5	0.4	7.80	7.89	7.74	7.75	1.19
11	70	40	15	0.2	7.21	7.26	7.14	7.20	1.71
12	80	30	10	0.3	**6.14**	**6.25**	6.64	6.65	**2.15**
13	70	20	5	0.4	7.20	7.14	7.21	7.19	1.79
14	50	40	15	0.2	7.42	7.47	7.85	7.90	1.01
15	60	30	10	0.3	8.23	**8.61**	**8.54**	**8.61**	1.58
16	50	40	5	0.2	7.81	7.41	7.86	7.83	1.21
17	70	20	5	0.2	7.15	7.26	7.24	7.23	1.65
18	60	30	0	0.3	8.20	8.14	8.26	8.19	1.51
19	50	20	5	0.2	7.41	7.65	7.72	7.72	1.06
20	60	50	10	0.3	8.16	8.13	8.17	8.12	1.60
21	60	30	10	0.5	**8.51**	8.52	8.52	8.54	1.65
22	50	40	5	0.4	7.92	7.91	7.95	7.92	1.15
23	50	20	15	0.2	7.75	7.71	7.70	7.75	1.05
24	60	10	10	0.3	8.45	8.41	8.36	8.45	1.59
25	70	40	15	0.4	7.19	7.14	7.18	7.19	1.80
26	60	30	20	0.3	8.25	8.07	8.09	8.20	1.55
27	60	30	10	0.1	8.49	8.36	8.47	8.49	1.49
28	50	20	15	0.4	7.78	7.76	7.49	7.79	1.20
29	60	30	10	0.3	8.47	8.55	8.36	8.47	1.52
30	50	20	15	0.2	7.72	7.70	7.21	7.35	1.10

3.4 Chemical composition of drumstick chutney

Chemical composition of drumstick chutney was analysed (Table 4). Drumstick chutney had moisture content of 72.78%. The fat and crude fibers were 0.88 and 1.63 %, respectively. Protein, ash and carbohydrate were found to be moderately high i.e. 2.99, 3.73 and 17.82 %, respectively. Drumstick pod pulp chutney contains beta carotene (1653 µg /100 g) and vitamin C (68.92 mg/100 g) in good amount and minerals such as Ca, P and Fe were also present in considerable amounts.

Table 4 Chemical composition of drumstick chutney

Constituent	Optimized sample
Moisture (%)	72.78 ± 0.05
Carbohydrate (%)	17.82 ± 0.12
Protein (%)	2.99 ± 0.04
Fat (%)	0.88 ± 0.02
Crude fiber (%)	1.63 ± 0.07
Ash (%)	3.73 ± 0.05
Carotene (µg/100g)	1653 ± 1.69
Calcium (mg/100g)	76.85 ± 1.47
Phosphorous (mg/100g)	83.73 ± 1.24
Iron (mg/100g)	2.98 ± 0.07
Vitamin C (mg/100g)	68.92 ± 1.23

3.5 Shelf life evaluation of moringa chutney

The moringa chutney was thermally processed and stored at refrigerated (7±2^{o}C), ambient (30±2^{o}C), and accelerated (55±2^{o}C) storage conditions. Accelerated testing was done to predict the shelf life of a moringa chutney. The food product quality changes can be accelerated by keeping products in extreme conditions for establishing the rate of changes and in the present study samples were kept at 55^{o}C. The products were analyzed for colour value (L*) and sensory attributes (overall acceptability) at an interval of 5 days during storage.

Changes in colour value (L*) is shown in Table 5. Significant reduction in colour value L* was observed with respect to storage period and temperature. However, rate of changes in lightness of moringa chutney was slower at refrigerated condition followed by ambient and accelerated storage. This decrease in L* values can be attributed to the maillard's reaction. During storage degradation in pigments resulted in reduction in lightness of the product. Loss of colour in thermally processed samples is due to the fact that green vegetables contain chlorophyll, which breaks down on exposure of heat during thermal processing. Shin and Bhowmik, (1995) observed similar changes while studying thermal kinetics in pea puree. Yun *et al.,* (2007) observed decrease in L* value towards a dark brown colour during storage at higher temperatures in sauce samples. Mishra *et al.,* (2011) observed darkness of the chutney was gradually increased during storage. They observed significant decrease in L* value of chutney at room temperature and no significant changes in L* value of chutney at refrigerated temperature.

Table 5 Changes in colour of moringa chutney during storage

Storage period (days)	Storage temperature (^{o}C)	L* value
0	7±2	26.06±0.01
	30±2	26.06±0.02
	55±2	26.06±0.02
5	7±2	25.16±0.08
	30±2	25.04±0.04
	55±2	21.15±0.02
10	7±2	24.18±0.01
	30±2	24.10±0.04
	55±2	19.61±0.06
15	7±2	24.10±0.02
	30±2	23.64±0.04
	55±2	18.62±0.07
20	7±2	24.02±0.08

	30±2	23.14±0.02
	55±2	17.52±0.01
25	7±2	23.94±0.01
	30±2	23.02±0.07
	55±2	19.94±0.06
30	7±2	23.55±0.07
	30±2	22.41±0.01
	55±2	16.40±0.04

Statistical analysis			
Source	SEm	CD (0.05)	CV (%)
Storage period (P)	0.003	0.009	0.04
Storage temperature (T)	0.002	0.006	
P * T	0.006	0.016	

Overall acceptability of moringa chutney significantly reduced with respect to storage conditions (Table 6). It was observed that at refrigerated storage, overall acceptability was almost 8.0 till 30 days where as at 55^{o}C the overall acceptability was less than 7.0 in 15 days and was 5.0 in 30 days indicating drastic reduction in acceptance score. Celik *et al.,* (2006) observed consistent decrease in overall acceptability of yoghurt with cornelian cherry paste. The product stored at refrigerated condition was more acceptable (Mishra *et al.,* 2011). Pulungan *et al.,* (2018) observed decrease in overall acceptability of apple brownies with the length of storage time at various storage temperatures (25, 35 and 45^{o}C) during shelf life prediction using accelerated shelf-life evaluation.

Total viable bacteria, yeast and molds as well as coliforms were absent initially after thermal processing and they were absent throughout the storage period at ambient storage conditions, which indicate the sterility of the products throughout storage.

Table 6 Changes in overall acceptability of moringa chutney during storage

Storage period (days)	Storage temperature (^{o}C)	Overall acceptability score
0	7±2	8.46±0.01
	30±2	8.46±0.02
	55±2	8.46±0.01
5	7±2	8.44±0.04
	30±2	8.43±0.11
	55±2	8.11±0.01
10	7±2	8.43±0.23
	30±2	8.40±0.21
	55±2	7.56±0.01
15	7±2	8.34±0.11
	30±2	8.14±0.01
	55±2	6.97±0.12
20	7±2	8.16±0.01
	30±2	8.09±0.05
	55±2	6.45±0.03
25	7±2	8.07±0.02
	30±2	7.69±0.04
	55±2	5.95±0.15
30	7±2	7.94±0.17
	30±2	7.48±0.19
	55±2	5.1±0.13

Statistical analysis			
Source	SEm	CD (0.05)	CV (%)
Storage period (P)	0.003	0.008	0.11
Storage temperature (T)	0.002	0.005	
P * T	0.005	0.014	

3.6 Kinetics of quality of moringa chutney on colour value L*

Colour value L* is one of the parameters used to determine the rate of changes which effects the quality of chutney. It was observed that the L* value of moringa chutney decreased during storage. The decrease was noted high at storage temperature of 55°C than the other two temperatures (Figure 3). The least changes were noted at 7°C. The reduction in lightness of chutney was a function of temperature and storage period.

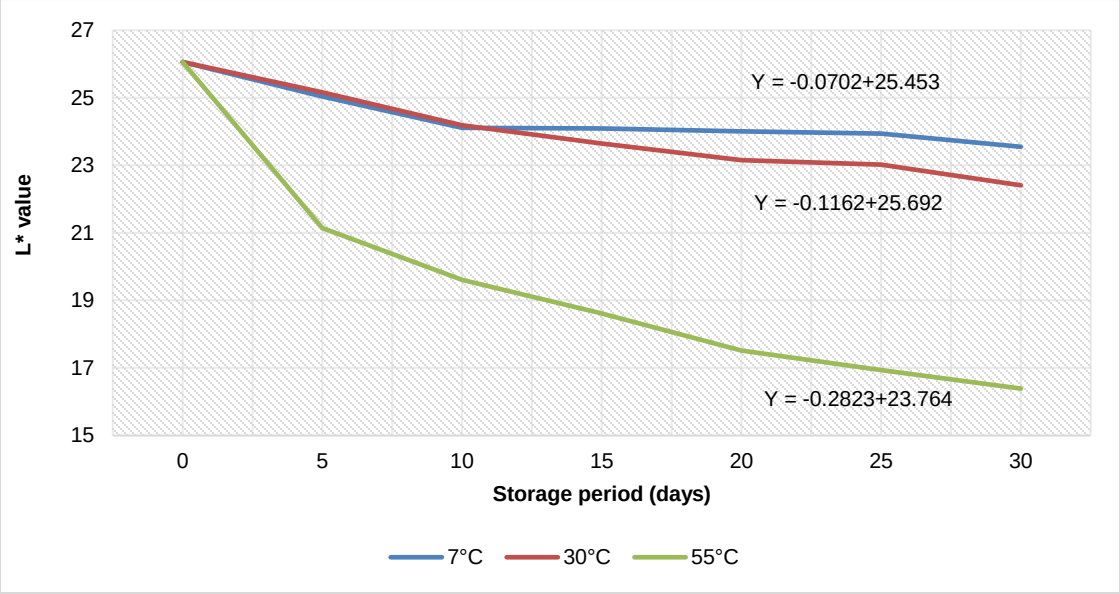

Figure 3 Changes in colour value (L*) of moringa chutney during storage

The choice of the reaction order kinetics of L* value was done by comparing the value of R^2 in each of linear regression equation at the same temperature of zero and first order. The chosen reaction order was the reaction order with a larger R^2 value. Table 7 shows the change in L* value of moringa chutney based on zero order and first order kinetics. The R^2 value of first order kinetics > zero order kinetics at 7°C, 30 °C and 55°C.

Table 7 Linear regression equation for colour value L* of moringa chutney

Storage temperature	Linear regression equation		R^2	
	Zero order	First order	Zero order	First order
7±2°C	Y = -0.0702+25.453	Y = -0.00028+3.2367	0.7787	0.7866
30±2°C	Y = -0.1162+25.692	Y = -0.00048+3.2469	0.9511	0.9586
55±2°C	Y = -0.2823+23.764	Y = -0.0139+3.1661	0.8365	0.8849

The relationship between the time taken to reach a defined quality limit and temperature was shown (Arrhenius equation) below;

$$\ln\left(\frac{dL^*}{dt}\right) = -9.8998\left(\frac{1}{T}\right) - 4.523,\ R^2 = 0.7824$$

Above equation can be used to predict the storage time to reach a particular quality limit at any temperature. The activation energy, i.e., the parameter for temperature dependence, was calculated from Arrhenius plot as 0.288, 1.11, 1.63 kJ/mol for chutney stored at 7°C, 30°C and 55°C. The higher activation energy showed that moringa chutney was sensitive to storage temperature.

Table 8 Predicted shelf life of moringa chutney

Storage temperature	Shelf life (d)
7±2°C	137
30±2°C	83

The temperature dependence of the primary quality attribute i.e colour value L* can be predicted by Arrhenius equation, for shelf life. It was observed that the shelf life of moringa chutney can be predicted for 137 days at 7°C and 83 days at30°C (Table 8).

Quality characteristics of fresh and stored drumstick pod pulp chutney is depicted in Table 9.

Table 9 Quality characteristics of fresh and stored drumstick pod pulp chutney

Constituent	Optimized Chutney (Fresh)	Chutney (Stored at 4°C)	Chutney (Stored at 37°C)
Bio chemical characteristics			
Moisture (%)	72.78 ± 0.05	70.14 ± 0.11	69.16 ± 0.02
Carbohydrate (%)	17.99 ± 0.12	20.81 ± 0.04	21.76 ± 0.14
Protein (%)	2.99 ± 0.04	2.85 ± 0.01	2.81 ± 0.21
Fat (%)	0.88 ± 0.02	0.85 ± 0.04	0.83 ± 0.07
Crude fiber (%)	1.63 ± 0.07	1.61 ± 0.04	1.60 ± 0.15
Ash (%)	3.73 ± 0.05	3.74 ± 0.14	3.84± 0.09
Carotene (µg/100g)	1653 ± 1.69	1415 ± 2.45	1357 ± 1.41
Calcium (mg/100g)	76.85 ± 1.47	68.23 ± 5.47	65.27 ± 2.67
Phosphorous (mg/100g)	83.73 ± 1.24	81.26 ± 2.45	80.54 ± 3.47
Iron (mg/100g)	2.98 ± 0.07	2.98 ± 0.07	2.98 ± 0.07
Vitamin C (mg/100g)	68.92 ± 1.23	45.35 ± 2.68	39.87 ± 1.69
pH	3.4 ± 0.45	3.3 ± 0.14	3.21 ± 0.12
TSS	25.9 ± 1.23	26.23 ± 1.24	26.45 ± 1.30
Viscosity (pa.s)			
Viscosity (pa.s)	1.58 ± 0.02	1.69 ± 0.09	1.64 ± 0.07
Colour value			
L* value	26.06 ± 0.01	18.45	16.98
a* value	-2.54 ± 0.66	-2.33 ± 0.62	-2.16 ± 0.41
b* value	18.54 ± 0.14	20.66 ± 0.54	21.47 ± 0.32
Sensory parameters			
Colour and appearance score	8.15	6.50	6.23
Flavour score	8.21	6.21	6.15
Consistency score	8.20	6.19	6.17
Overall acceptability score	8.23	6.74	6.54
Microbial analysis			
Total plate count (log cfu/g)	1.47	1.08	1.26
Yeast and mould count (log cfu/g)	0.69	0.48	0.65
Coliform count (log cfu/g)	Nil	Nil	Nil

Total cost for production of drumstick pod pulp chutney is depicted in Table 10

Table 10 Total cost for production of drumstick pod pulp chutney

Raw material	Cost (Rs/ kg)	Raw material quantity required (g)	Total Cost (Rs.)
Drumstick pulp	120	854	102.48
Coriander leaves	80	392	31.36
Mint leaves	40	132	5.28
Xanthan gum	3500	1.3	4.55
Green chillies	80	121	9.68
Sugar	50	20.8	1.04
Salt	25	90	2.25
Cumin powder	255	17.3	4.41
Lemon juice	160	166	25.56
Raw material cost (Rs/kg)			187.61

Total processing cost (20%)	37.52
Packaging cost (10%)	18.76
Total cost (Rs/ Kg)	243.89
Total cost (Rs/ 200g)	48.77

4. CONCLUSION

Drumstick is most valued nutritional and medicinal crop. There are vast opportunities for value addition and utilisation od moringa in food products. Drumstick chutney was developed as functional food product. In drumstick chutney, increase in sensory attributes, were observed with increase in drumstick pod pulp. Gradual increase in viscosity was observed with increase of drumstick pod pulp and xanthan gum. The optimized combinations for chutney were 61.78 % drumstick pod pulp, 28.35 % coriander leaves, 9.68 % mint leaves and 0.19 % xanthan gum. The chutney was found to be rich source of β-carotene and micronutrients. The xanthan gum can be replaced with drumstick pod pulp to meet rheological properties of chutney as well as to improve sensory and nutraceuticals properties. Drumstick chutney was stored at refrigerated (7±2^{o}C), ambient (30±2^{o}C) and accelerated (55±2^{o}C) storage conditions and evaluated for shelf life. As per the Arrhenius equation, the shelf life of drumstick chutney can be predicted as 137 days at 7^{o}C and 83 days at 30^{o}C.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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