RESEARCH ARTICLE OPEN ACCESS

Effect of Packaging materials on Quality Parameters of Garlic

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ABSTRACT
Studies were carried out to evaluate the effect of storage period and different packaging material on the quality of garlic flakes dried by convective-cum-microwave (CCM) and fluidized-cum-microwave (FCM) hybrid drying. Garlic flakes were packaged and stored in high density polyethylene (HDPE), low density polyethylene (LDPE) and laminated aluminium foil for 3 months under ambient conditions. Samples were investigated to observe for change in rehydration ratio, colour, physiological loss in weight % and overall acceptability. Among the hybrid drying techniques adopted, the garlic flakes developed under optimized condition of fluidized bed-cum-microwave was found better in terms of shelf life and quality attributes. The aluminium packaging was adjudged to be the best in retaining the quality of dried garlic flakes up to 3 months of storage. Overall, it can be concluded that the fluidized bed cum microwave dried garlic flakes packed in Aluminium package were the best, and can be stored safely up to 3 months.

Key Words: Garlic flakes, colour, storage, quality, packaging.

I. INTRODUCTION

Garlic (*Allium sativum* L.) is a bulbous perennial plant of the lily family lilliaceae. It is a rich source of carbohydrates, proteins and phosphorous. The fresh peeled garlic cloves contains 60-65 % (w.b.) moisture, 6.30% protein, 0.10% fat, 1% mineral matter, 0.80% fiber, 29% carbohydrates, 0.03% calcium, 0.31% phosphorous, 0.001% iron, 0.40 mg/100g nicotinic acid and 13 mg/100g vitamin C (Brondnitz et al. 1971).These varieties of garlic are grown worldwide-Hard neck, Soft neck and Creole. Hard neck varieties have fewer cloves and have little or no papery outer wrapper protecting the cloves. Soft neck varieties are white, papery skins and multiple cloves that are easily separated. There are two types of soft neck varieties: artichoke and silver skin. Creole variety has eight to twelve cloves per bulb arranged in a circular configuration. Garlic has been used 'time memorial, for the treatment of a wide variety of ailments, including hypertension, headache, bites worms, tumours etc. In history, Hippocrates, Aristotle and Pliny cited numerous therapeutic uses for garlic. Although garlic has been reported to have wide range of pharmacological effects; but it's most important clinical uses are in the area of curing infections, prevention of cancer and cardiovascular disease (Lau1 et al. 1990).

Presently convective, fluidized bed and sun drying of garlic is in practice, which damage the sensory characteristics and nutritional properties due to the surface case hardening and the long drying duration. Main disadvantages of convective drying are long drying duration, damage to sensory characteristics and nutritional properties of foods and solute migration from interior of the food to the surface causing case hardening. Severe shrinkage during drying also reduces the rehydration capacity of the dehydrated products. Fluidized bed drying of garlic cloves has also been tried but it was not effective in reducing the drying time and energy consumption appreciably in comparison to convective drying process (McMinn and Magee 1999).

Microwave drying is regarded as fourth generation drying technology. Microwave waves can penetrate directly into the material; heating is volumetric (from inside out) and provides fast and uniform heating throughout the entire product. The quick energy absorption by water molecules causes rapid water evaporation, creating an outward flux of rapidly escaping vapour. Microwaves penetrate the food from all direction. This facilitates steam escape and speed up the heating process (Khraisheh et al. 1997; Prabhanjan 1995). Microwave processes offer a lot of advantages such as less start up time, faster heating, energy efficiency (most of the electromagnetic energy is converted to heat), space savings, precise process control and food product with better nutritional quality. Thus, to develop high quality dried garlic flakes with minimum drying exposure time, the optimum drying process conditions for the selected hybrid drying techniques (microwave assisted convective and microwave assisted fluidized drying) and storage stability of dried product need to be studied, which could be a significant contribution to the garlic drying industry. Keeping in view the above discussed aspects, the present investigated had been conducted to study storage behavior of garlic flakes packed in different packaging material.

II. MATERIAL AND METHODS

2.1 Selection of garlic

Fresh garlic was procured from local market, Ludhiana (India). The garlic bulbs were sorted with hand for its size uniformity and were peeled manually with the help of knives and then sliced uniformly (Avg. size 3mm) with the help of garlic slicer. The colour and moisture content (222.58 ±1 % db) of fresh garlic slices were noted before started experiment. The samples were pretreated with different concentrations of KMS as per the procedure reported by Abano *et al* (2011).

2.2 Experimental design for study of drying characteristics of garlic slices

The experiments to study drying characteristics of garlic slices, for both the hybrid drying techniques i.e. convective-cum-microwave (CCM) and fluidized-cum-microwave (FCM) drying, were planned as completely randomized design (CRD). The range of process parameters selected for the study of drying characteristics was:
KMS Concentration: 0.1% to 0.5%
Process temperature: 55°C to 75°C
Microwave power level: 810 W to 1350 W
Twenty seven experiments for the study of drying characteristics of garlic slices (CCM & FCM) were selected and each experiment has three replicates.

2.3 Experimental set up for convective tray drying

The mechanical drying of garlic slices was conducted in a Kilburn make laboratory tray dryer which could attain maximum temperature of 200ºC. The drier has electric heaters vertically fitted at the inlet of the dryer to heat fresh air. A centrifugal blower circulates air inside the dryer with a maximum air velocity of 0.8m/s in the drying chamber. The blower is powered by 0.25HP, three-phase 440V electric motor with a direct online starter.

2.4 Experimental set up for fluidized bed drying

The experimental set up for fluidized bed drying of garlic slices consists of three basic parts: a system for provision of air, a section for heating the air and a drying chamber. A 0.75 KW, 3 phase electric motor controlled by a simple general- purpose AC Drive (Model: VFD007L21A, Delta electronics, Inc. Taiwan) was used to drive the blower. Air flow can be controlled by varying the frequency of AC supply to motor. Circuit diagram (Fig. 2.1) of AC Drive, PID 518 temperature controller, temperature sensor, heaters and contactors.

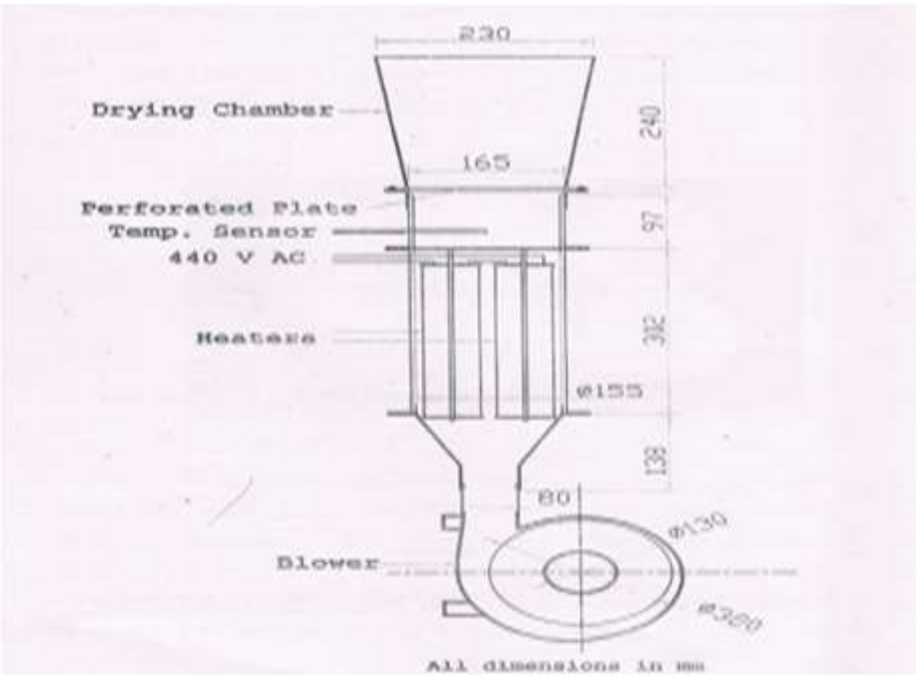


Fig.2.1 Circuit diagram for fluidized bed drying

2.5 Experimental set up for microwave drying

The experimental set up for microwave drying of garlic slices by microwave dryer (Power range 0-1350 W and frequency 2450 MHz). It consists of a high voltage power source, transformer and a cooking chamber. Basically, the transformer passes the energy to the magnetron which converts high voltage electric energy to microwave radiations. The magnetron usually controls the direction of the microwaves with the help of microcontroller.

The final moisture content of thin layer drying 63.0 (±1) % db was the initial moisture content for microwave drying. In microwave drying, the final moisture content of product is 6 (±1) % db.

2.6 Determination of quality parameters

The dried samples were evaluated for rehydration ratio, colour, physiological loss in weight % and overall acceptability and the procedure adopted are mentioned below:

2.6.1 Rehydration ratio: Rehydration ratio (RR) was evaluated by soaking known weight (5-10 g) of each sample in sufficient volume of water in a glass beaker (approximately 30 times the weight of sample) at 95°C for 20 minutes. After soaking, the excess water was removed with the help of filter paper and samples were weighed. In order to minimize the leaching losses, water bath was used for maintaining the defined temperature (Rangana 1986). Rehydration ratio (RR) of the samples was computed as follows:

$$\text{Rehydration ratio, RR} = W_r / W_d \quad (1)$$

Where,
W_r = Drained weight of rehydrated sample, g
W_d = Weight of dried sample used for rehydration, g

2.6.2 Colour: Colour is one of the important parameters, which is an indicative of the commercial value of the product. The basic purpose was to get an idea of the comparative change in colour of fresh, dried and rehydrated material. Colour was determined using Hunter Lab Miniscan XE Plus Colourimeter (Hunter 1975).

$$\text{Colour change } \Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \quad (2)$$

Where ΔL, Δa and Δb are deviations from L, a and b values of fresh sample.
ΔL = L dried sample – L fresh sample; + ΔL means sample is lighter than fresh, - ΔL means sample is darker than fresh.
Δa = a dried sample- a fresh sample, + Δa means sample is redder than standard, - Δa means sample is greener than standard Δb = b dried sample –b fresh sample, + Δb means sample is yellower than standard, - Δb means sample is bluer than standard.

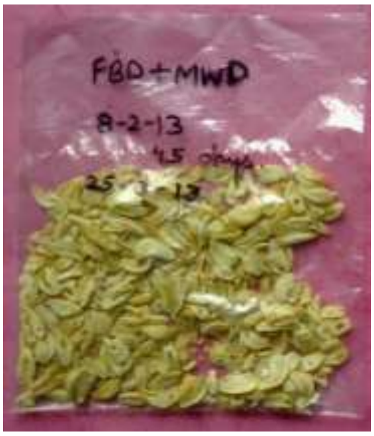
2.6.3 Overall acceptability: Organoleptic quality of developed product was conducted on a 9-point hedonic scale. Semi-trained panels of ten judges were selected for the evaluation. The samples were evaluated on the basis of appearance (colour), texture, odour and overall acceptability. Overall acceptability (OA) was evaluated as an average of appearance (colour), odour and textural score and is expressed in percent. The average scores of all the panellists for different characteristics were averaged.

2.7 Experimental design for optimization of hybrid drying process parameters for dried garlic slices

For the optimization of hybrid drying process for garlic slices, the experimental plan was chosen from the family of three level designs, as suggested by Box and Behnken (1960). The design is a three-level incomplete factorial design for the estimation of the parameters in a second-order model. The process variables for development of dried garlic flakes were optimized by response surface methodology (RSM). In order to optimize the process variables, only those responses were selected for optimization, which were found to have non-significant lack of fit. The three dimensional plots and contour plots (graphical method) were drawn according to the fitted model and fixed variable. To localize an optimum condition, the superposition technique was employed for optimization of different process variables by response surface methodology.

2.8 Storage of garlic flakes

Dried garlic flakes developed under optimized process conditions of CCM and FCM under optimized process parameters were packed in three different packaging materials (Aluminium, HDPE and LDPE) and were stored under ambient conditions (18˚C to 35˚C temperature, 45 to 55 % RH) for 3 months (Fig.2.2). The quality parameters viz. rehydration ratio (RR), colour (L-value), physiological loss in weight % (PLW) and overall acceptability (OA) were evaluated at regular interval of 15 days. The statistical analysis of the data was done by univariate analysis of variance (UNI-ANOVA) in general linear model using Statistical Package for Social Science (SPSS, version 11.1). Analysis was done considering the main effects interactions and testing those at 5 % level of significance.



(LDPE) **(Aluminium)** **(HDPE)**

Fig 2.2 Dried garlic flakes in different packaging materials

III. RESULTS AND DISCUSSION

The optimum operating conditions for thin layer convective-cum-microwave drying of garlic slices were 0.5 % KMS, 59.41ºC and 810 W and for thin layer fluidized-cum-microwave drying of garlic slices were 0.10 % KMS, 63.92ºC temperature and 810 W, which is further packed in different packages for 3 months.

3.1 Physicochemical properties of dried garlic flakes under storage

3.1.1 Effect of storage process parameters on rehydration ratio

The rehydration ratio of the stored product decreased with the increase in storage period (Fig. 3.1). Initially the FCM product has comparatively low rehydration ratio than CCM dried packed samples (Table 3.1 and 3.2). The maximum variation (2.875 to 2.42) in rehydration ratio with storage period was observed in CCM dried HDPE packed samples and (2.61.to 2.42) for FCM dried, HDPE and LDPE packed samples. The minimum variation (2.875 to 2.45) in rehydration ratio was observed in ratio CCM dried, packed samples and (2.61 to 2.43) FCM dried, aluminium packed samples (Table 3.1& 3.2). The univariate ANOVA also corroborated the results showing the storage period and packaging material has significant effect on rehydration ratio at 5 % level of significance (Table 3.3). Overall the minimum variation in rehydration ratio with storage period was observed for aluminium packed samples throughout storage period irrespective of the hybrid drying adopted for the sample preparation.

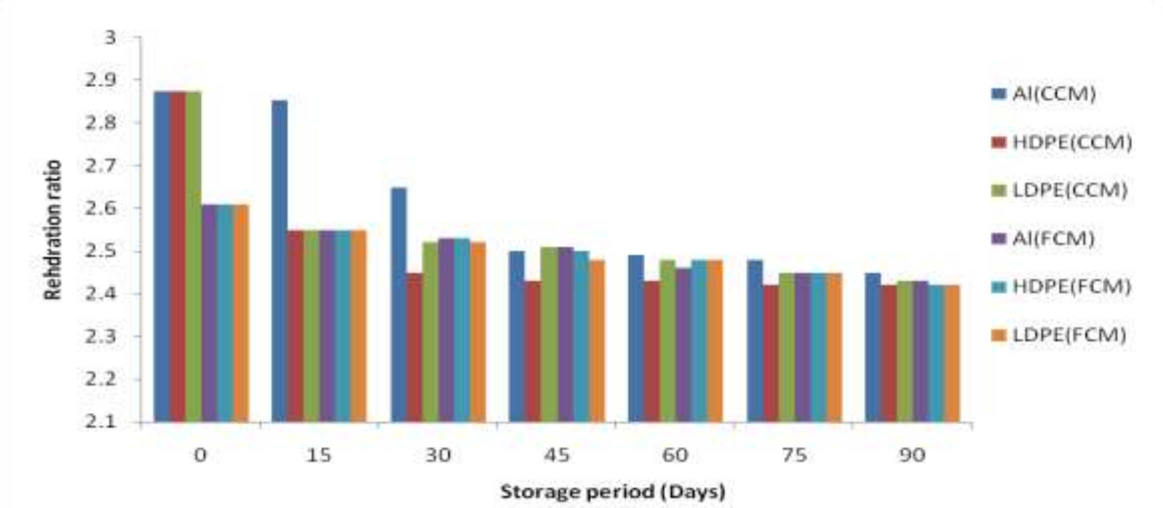


Fig: 3.1 Variation in rehydration ratio with storage period

Table 3.1 Quality attributes for garlic slices (CCM) packed in Aluminium, HDPE & LDPE bags with storage period (convective-cum-microwave)

Packaging material						
ALUMINIUM	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR (AR) After rehydration**	**OA**	**PLW (%)**
	0	2.88	67.41	68.83	7.0	
	15	2.85	63.03	64.29	6.6	0
	30	2.65	61.09	61.43	6.6	0
	45	2.50	56.42	61.54	6.3	0
	60	2.49	55.36	61.23	6.0	0
	75	2.48	55.23	60.45	6.0	0
	90	2.45	54.89	60.06	6.0	0

Packaging material						
LDPE	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR (AR) After rehydration**	**OA**	**PLW (%)**
	0	2.88	67.41	68.83	7.0	
	15	2.55	64.85	65.01	6.6	0
	30	2.52	63.01	64.89	6.6	0
	45	2.51	62.12	63.12	6.3	0
	60	2.48	60.35	62.35	6.3	0
	75	2.45	59.68	61.23	6.0	0
	90	2.43	59.12	61.03	6.0	0

Packaging material						
HDPE	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR (AR) After rehydration**	**OA**	**PLW (%)**
	0	2.88	67.41	68.83	7.0	
	15	2.55	65.47	66.11	6.6	0
	30	2.45	61.79	62.29	6.6	0
	45	2.43	58.32	59.87	6.3	0
	60	2.43	57.36	58.64	6.3	0
	75	2.42	57.25	58.24	6.0	0
	90	2.42	54.65	58.13	6.0	0

Table 3.2 Quality attributes for garlic slices (FCM) packed in Aluminium, HDPE & LDPE bags with storage period (fluidized bed-cum-microwave)

Packaging material						
Aluminum	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR(AR) After rehydration**	**OA**	**PLW (%)**
	0	2.61	67.27	69.26	7.3	
	15	2.55	65.93	69.03	7.0	0
	30	2.53	64.46	65.26	6.6	0
	45	2.51	62.27	63.03	6.3	0
	60	2.46	61.58	62.43	6.3	0
	75	2.45	61.42	61.94	6.0	0
	90	2.43	60.31	61.04	6.0	0

Packaging material						
HDPE	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR(AR) After rehydration**	**OA**	**PLW (%)**
	0	2.61	67.27	69.26	7.3	
	15	2.55	67.13	69.15	7.0	0
	30	2.53	65.89	66.75	6.6	0
	45	2.50	62.98	63.06	6.6	0
	60	2.48	62.46	62.78	6.0	0
	75	2.45	61.78	62.12	6.0	0
	90	2.42	60.45	61.45	6.0	0

Packaging material						
LDPE	**Storage period (Days)**	**RR**	**COLOUR(BR) Before rehydration**	**COLOUR (AR) After rehydration**	**OA**	**PLW (%)**
	0	2.61	67.27	68.29	7.3	
	15	2.55	67.12	68.26	7.0	0
	30	2.52	66.15	67.12	7.0	0
	45	2.48	65.21	66.47	6.6	0
	60	2.48	64.46	65.23	6.0	0
	75	2.45	62.35	63.12	6.0	0
	90	2.42	59.12	61.81	5.6	0

Table 3.3 ANOVA sheet for rehydration ratio of stored garlic flakes

Dependent Variable: RR

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1.866[a]	43	0.043	3.259E3	0.000
Intercept	807.911	1	807.911	6.068E7	0.000
Package	0.060	2	0.030	2.239E3	0.000
Method	0.073	1	0.073	5.494E3	0.000
StrgDys	1.251	6	0.209	1.566E4	0.000
Replication	0.000	2	5.574E-5	4.186	0.019
Package * Method	0.064	2	0.032	2.390E3	0.000
Package * StrgDys	0.076	12	0.006	473.363	0.000
Method * StrgDys	0.263	6	0.044	3.287E3	0.000
Package * Method * StrgDys	0.080	12	0.007	500.338	0.000
Error	0.001	82	1.332E-5		
Total	809.777	126			
Corrected Total	1.867	125			

a. R Squared = 0.999 (Adjusted R Squared = 0.999)

3.1.2 Effect of storage throughout storage period in colour L-value

The colour (L-value) of the stored product decreased with the increase in storage period (Fig. 3.2). Initially the CCM product has comparatively low Colour (L-value) than FCM dried packed samples (Table 3.1 and 3.2). The maximum variation (67.41 to 54.65) in colour (L-value) with storage period was observed in CCM dried, HDPE packed samples and (67.41 to 54.65) for FCM dried, LDPE packed samples. The minimum variation (67.41 to 59.12) in colour (L-value) was observed in ratio CCM dried, packed samples and (67.27 to 60.31) FCM dried, aluminium packed samples (Table 3.1& 3.2). The univariate ANOVA also corroborated the results showing the significant of storage period and packaging material has significant effect on colour (L-value) at 5 % level of significance (Table 3.4). Overall the minimum variation in colour (L-value) with storage period was observed for aluminium packed samples throughout storage period irrespective of the hybrid drying adopted for the sample preparation.

The colour (after rehydration) of the stored product decreased with the increase in storage period (Fig. 3.3). Initially the CCM product has comparatively low Colour (L-value) than FCM dried packed samples (Table 3.1 and 3.2). The maximum variation (68.83 to 58.13) in colour (L-value) with storage period was observed in CCM dried, HDPE packed samples and (69.26 to 61.04) for FCM dried, HDPE packed samples. The minimum variation (68.83 to 60.06) in colour (L-value) was observed in ratio CCM dried, packed samples and (69.26 to 61.81) FCM dried, LDPE packed samples (Table 3.1& 3.2). The univariate ANOVA also corroborated the results showing the significant of storage period and packaging material has significant effect on colour (L-value) at 5 % level of significance (Table 3.5). Overall the minimum variation in colour (L-value) with storage period was observed for LDPE packed samples throughout storage period irrespective of the hybrid drying adopted for the sample preparation.

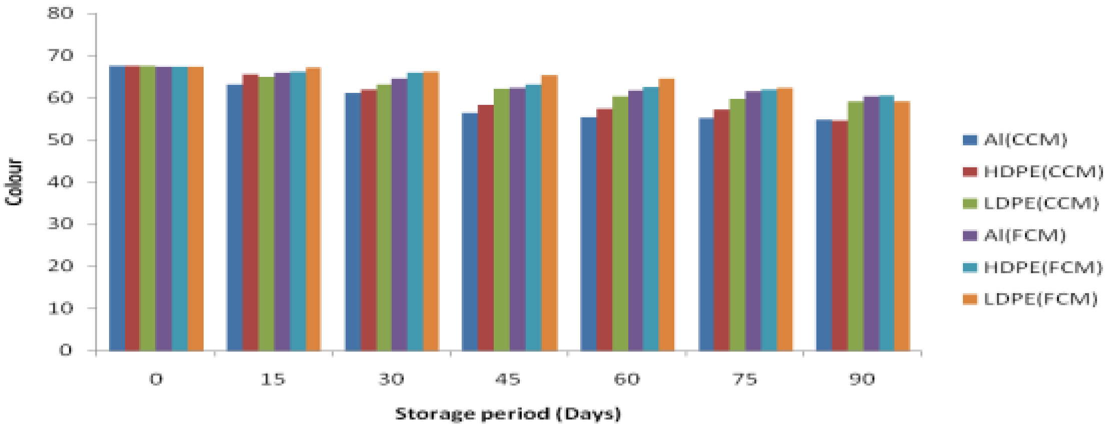


Fig: 3.2 Variation in Colour with storage period

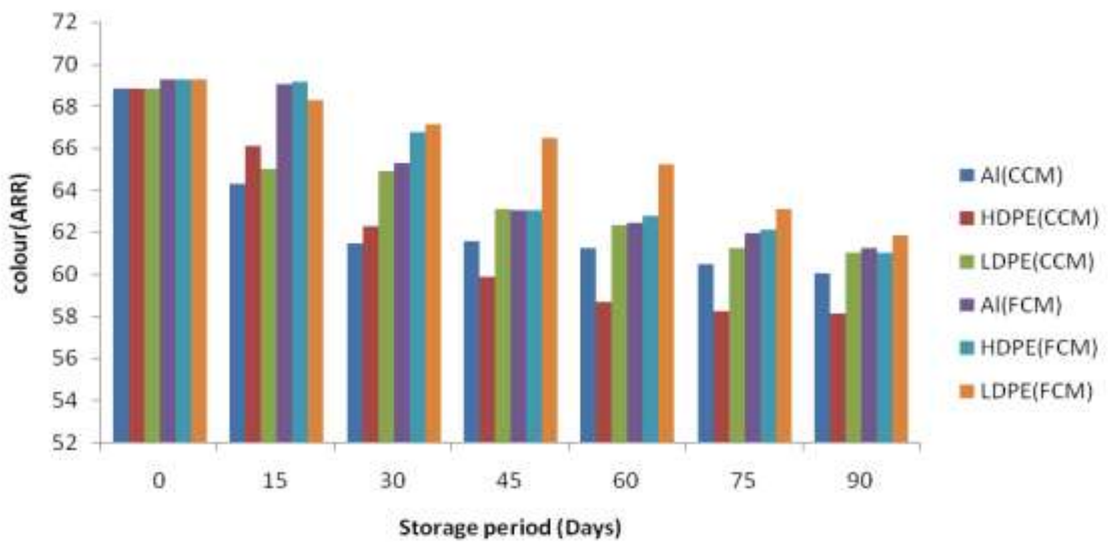


Fig: 3.3 Variation in Colour(ARR) with storage period

Table 3.4 ANOVA Sheet for colour (L-value) of stored garlic flakes

Dependent Variable: Colour(L-value)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1878.258[a]	43	43.680	3.776E3	0.000
Intercept	488594.083	1	488594.083	4.223E7	0.000
Method	355.085	1	355.085	3.069E4	0.000
Package	106.955	2	53.478	4.623E3	0.000
StrgDys	1223.914	6	203.986	1.763E4	0.000
Replication	.038	2	.019	1.638	0.201
Method * Package	21.845	2	10.922	944.116	0.000
Method * StrgDys	90.479	6	15.080	1.303E3	0.000
Package * StrgDys	47.725	12	3.977	343.776	0.000
Method * Package * StrgDys	32.217	12	2.685	232.068	0.000
Error	0.949	82	0.012		
Total	490473.290	126			
Corrected Total	1879.207	125			

a. R Squared = 0.999 (Adjusted R Squared = 0.999)

Table 3.5 ANOVA Sheet for colour (L-value) after rehydration of stored garlic flakes

Dependent Variable: Colour (L-value)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1392.338[a]	43	32.380	1.199E3	0.000
Intercept	514669.787	1	514669.787	1.906E7	0.000
Method	186.442	1	186.442	6.905E3	0.000
Package	47.899	2	23.949	887.040	0.000
StrgDys	1028.206	6	171.368	6.347E3	0.000
Replication	0.040	2	0.020	0.746	0.478
Method * Package	10.375	2	5.188	192.142	0.000
Method * StrgDys	41.352	6	6.892	255.264	0.000
Package * StrgDys	58.469	12	4.872	180.464	0.000
Method * Package * StrgDys	19.555	12	1.630	60.355	0.000
Error	2.214	82	0.027		
Total	516064.339	126			
Corrected Total	1394.552	125			

a. R Squared = 0.998 (Adjusted R Squared = 0.998)

3.1.3 Effect of storage throughout storage period in overall acceptability

The overall acceptability of the stored product decreased with the increase in storage period (Fig. 3.4). Initially the CCM product has comparatively low overall acceptability than FCM dried packed samples (Table 3.1 and 3.2). The same variation (7.0 to 6.0) in overall acceptability with storage period was observed in CCM dried, Aluminum, HDPE & LDPE packed samples and (7.3 to 6) for FCM dried, LDPE packed samples. The univariate ANOVA also corroborated the results showing the significant of storage period and packaging material has significant effect on overall acceptability at 5 % level of significance (Table 3.6). Overall the minimum variation in overall acceptability with storage period was observed for LDPE packed samples throughout storage period irrespective of the hybrid drying adopted for the sample preparation.

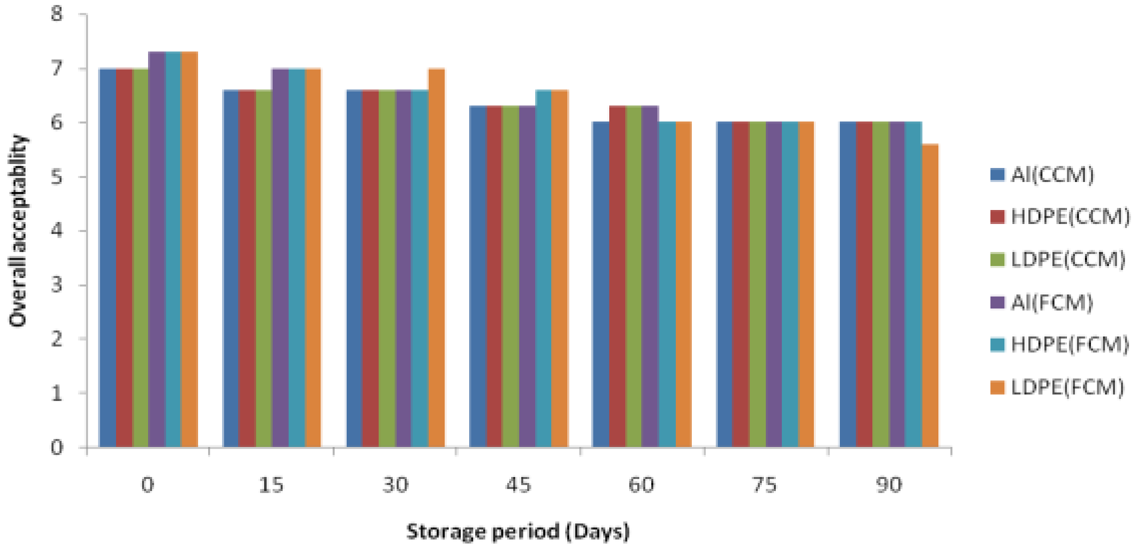


Fig: 3.4 Variation in overall acceptablity with storage period

Table 3.6 ANOVA Sheet for overall acceptability of stored garlic flakes

Dependent Variable: OA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.178[a]	43	0.586	384.700	0.000
Intercept	5261.541	1	5261.541	3.457E6	0.000
Method	0.651	1	0.651	428.014	0.000
Package	0.028	2	0.014	9.038	0.000
Replication	0.024	2	0.012	7.860	0.001
StrgDys	22.426	6	3.738	2.456E3	0.000
Method * Package	0.010	2	0.005	3.179	0.047
Method * StrgDys	0.958	6	0.160	104.940	0.000
Package * StrgDys	0.428	12	0.036	23.414	0.000
Method * Package * StrgDys	0.653	12	0.054	35.752	0.000
Error	0.125	82	0.002		
Total	5286.844	126			
Corrected Total	25.303	125			

a. R Squared = 0.995 (Adjusted R Squared = 0.992)

3.1.4 Effect of storage conditions physiological on weight loss

It was observed that the no weight loss (Table 3.1&3.2) for all samples irrespective of storage period; that stored at room temperature in Al, HDPE & LDPE packaging materials for both CCM & FCM respectively.

IV. CONCLUSION

It can be concluded from the present study that for the garlic flakes stored under ambient condition (18 -35 ^{0}C, 45-55% RH) for 3 months, the quality parameters i.e. rehydration ratio, colour (L-value) and overall acceptability reduced with storage period irrespective of packaging material used. Among the hybrid drying techniques adopted, the garlic flakes developed under optimized condition of fluidized bed-cum-microwave was found better in terms of shelf life and quality attributes. Among the selected packaging materials, the aluminium packaging proved best in retaining the quality of dried garlic flakes. Overall, it can be said that garlic flakes made by fluidized bed cum microwave technique and packaged in Aluminium packs can be stored safely up to 3 months.

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