Scientific Journal Impact Factor (SJIF): 1.711

e-ISSN: 2349-9745
p-ISSN: 2393-8161

International Journal of Modern Trends in Engineering and Research
www.ijmter.com

Changes In Quality Properties And Packaging Film Characteristics For Short Time Storage Of Foam Mat Dried Chandramukhi Variety Potato Powder Under Ambient Conditions

Sreemoyee Chakraborty[1], Saikat Mazumder[2], Soumitra Banerjee[3]
[1]*Department of Food Technology, Techno India, Saltlake, Kolkata*
[2]*Department of Food Technology, Techno India University, Saltlake, Kolkata*
[3]*Department of Food Technology, Techno India, Saltlake, Kolkata*

Abstract - The aim was to study the changes in quality properties of foam mat dried Chandramukhi variety potato powder and packaging film characteristics during ambient condition storage in LDPE pouches. The storage duration was 17 weeks. Quality parameters were characterized by moisture content, co-efficient of reconstitution, water activity, and total plate count of the potato powder. Packaging film was characterized by water vapor transmission rate (WVTR) and permeability of the film. During storage a gradual increment in quality properties except coefficient of reconstitution was observed. The WVTR showed substantial increment for 13 weeks, followed by decrement and permeability was remaining constant. The relative humidity, temperature during storage and storage duration has significant effect for changes in moisture content at $p<0.05$level. The relative humidity of storage and changes in moisture content has significant effect for changes in coefficient on reconstitution, water activity, and water vapor transmission rate of packaging film at $p<0.05$ level.

Keywords: Chandramukhi variety potato powder, short time storage, ambient condition, quality properties, packaging film characteristics, response surface modeling

I. INTRODUCTION

Potatoes are commonly regarded as a bulky, perishable and a high transport cost commodity with limited export potential, confined mostly to cross-border transactions. But incorporation of proper processing and preservation methods can reduce wastage during post-harvest and storage, enhance its shelf stability, diversify its use and increase its international market. Drying is one of the cheapest and oldest methods of food processing and preservation. It decreases water activity, prevents spoilage, microbial attack and extends shelf life. More recently foam-mat drying [1], a technique developed by Morgan and others in 1959, is being employed as a method of preservation for its simplicity, economic attributes as well as for its ability to impart superior physicochemical properties to the finished dried product [2]. For marketing a product it is important to study both its physicochemical properties as well as its change in its quality characteristics and microbiological profile during storage.

Packaging plays an important role of protecting food products from outside influences and damage. Packaging does not only ensure that food contains and maintains the amount and form of the required ingredient and nutrients but also improves sensory quality and color stability [3]. It has been demonstrated that food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life and maintain or increase the quality and safety of food [4],[5]. In this front, packaging is critical in maintaining product quality while offering protection from microbial and chemical contamination, as well as from oxygen, water vapor and light [6],[7],[8],[9]. The extent of food protection by packaging, however, is dependent on type of materials used which varies between countries. For instance, the major packaging material for potato crisps in Kenya has been polyethylene bags and only recently has aluminium foil packs been introduced [10].

Moisture content of powder is very important regarding its quality, lower the moisture, the better its storage stability. Higher lipolytic and proteolytic activities are related to higher moisture content, which further lead to

loss in nutrients (protein and fat) and production of more FFA resulting in inferior sensory characteristics. Moisture content is also an important criterion in controlling growth of micro-organisms [11].
Another important parameter for making a product shelf stable is to control its water activity (a_w). Water activity is a measurement of the availability of water for biological reactions. It determines the ability of micro-organisms to grow. If water activity decreases, micro-organisms with the ability to grow will also decrease. By lowering water activity, food can be made safe to store.
This study was done to observe the changes in physicochemical properties and microbial characteristics of the product and the effectivity of LDPE pouches in storing potato powder under ambient conditions. This process exposed the product to a wide range temperature and humidity variations and the subsequent changes in quality was noted.
The easiest and most widely used approach to study linear and interaction of different factors have been response surface methodology (RSM). RSM is a collection of mathematical and, statistical technique useful for analyzing and optimizing the response of multivariate system. In RSM, generally attempts are made to identify the responses of system as a function of explanatory variables. In this study, different linear and interactive effect of different factors has been studied.

II. MATERIAL & METHODS

2.1. Collection and Preparation of Raw material

Potatoes used in this study were of Chandramukhi variety freshly collected from local market of South Kolkata (cultivated in Tarakeswar, Hoogly district, West Bengal, India). The potatoes had initial moisture content of 82.34gm of moisture/100gm wet weight. The potato samples were washed with running tap water and distilled water respectively to make it free from dirt and soil and blotted with a tissue paper for removal of excess surface water. The potato samples were then peeled and cut into slices of equal thickness of 10±0.3 mm each. The sliced potato samples were blanched in hot water (Temperature- 90±2ºC) containing 2 gm NaCl/100 gm of water of sodium chloride (NaCl) and 2mg of potassium meta-bisulphate/1000gm of water for 10 minutes and followed by preparation of mash in a mixer grinder. The potato mash was gelatinized in an autoclave at 10 psig pressure for 15 minutes [12]. Then 2% wt/wt glycerol monostearate (GMS) was weighed and mixed with a refined vegetable oil and water in a ratio of 2:1:10 respectively and heated in boiling water bath (90-100ºC) and stirred till GMS gets evenly dispersed to form slurry. The potato mash and water was added (in a ratio of 10:1 respectively) and stirred at 300 rpm for 10 minutes in a magnetic stirrer (Eltek, Model – 2011) to form a thick foam slurry. The foam mat drying experiment was carried out in a batch type tray drier (Suan Scientific Instruments & Equipments). The drier was equipped with an electrical heater, blower (230rpm) and temperature indicators. It consisted of trays (800X400X30mm) with perforations of diameter 7mm and a temperature controller (0-200ºC). The tray drier was run intermittently in order to stabilize the desired temperature (i.e. 60ºC) inside the chamber. The homogeneous foamed potato slurry was poured over muslin cloth and spread to an equal thickness of 10 mm. and kept over the drying trays for 2hrs 15mins [13]. A crispy powder was obtained which was grounded to a fine powder and packed in LDPE zip pouches (0.06mm film thickness) each containing 10gms of powder and stored under ambient conditions.

2.2. Determination of Qualitative Changes of Foam Mat Dried Powder

Pouches were taken out at an interval of 7 days and the keeping quality and microbiological quality of the potato powder was checked. Quality parameters were characterized by the rate of moisture absorption measured by the change in moisture content of the potato powder, co-efficient of reconstitution and water activity. The microbiological quality was determined by measuring the number of colony forming units per gram of potato powder as observed by taking the total plate count on nutrient agar media. All the experiments were performed on a triplicate basis.

2.2.1. Determination of Moisture Content.

The moisture content was determined according to A.O.A.C method [14], gravimetrically at 130^0C for 2 hours and then to constant weight.

2.2.2. Determination of Co-efficient of Reconstitution.

1gm of dried potato powder sample was taken in a previously weighed and dried centrifuge tube mixed thoroughly with 25ml of distilled water for 5 minutes by a vortex mixer and finally centrifuged at 3000rpm for 15 minutes. The supernatant was drained off and the final weight was taken. The co-efficient of reconstitution can be calculated by the following formulas:

Co-efficient of reconstitution = [Rehydration Ratio / Dehydration Ratio]

Rehydration Ration = [Weight of Rehydrated Material / Weight of Dehydrated Material]

Dehydration Ratio = [Weight of prepared material before drying / Weight of dried material]

2.2.3. Determination of Water Activity.

Water activity (a_w) was measured by water activity meter (Novasina LabSwift-AW, Novatron Scientific)

2.2.4. Determination of Microbiological Quality of Potato Powder by Total Plate Count.

Total plate count was obtained by serial dilution method on nutrient agar media for 24hrs and 48hrs incubation period at 37°C [15]. 1gm sample was taken and added to 10ml of saline water and serial dilutions upto 10^{-3} was made. 1ml of solution from each of the three test tubes were taken and plated in three different nutrient agar plates. The plate count was taken and the actual CFU was calculated with the following formula:

CFU/Amount Platter x Dilution factor = CFU/ml

2.3. Determination of Characteristics of Packaging Film

Since the pouches were kept under ambient conditions, it was subjected to change in weather conditions. Changes in relative humidity and temperature can affect the characteristic properties of the packaging film.

2.3.1. Determination of Water Vapor Transmission Rate.

Water vapor transmission rate (WVTR) was determined based on the change in moisture content and area of the zip pouch and was plotted against time and moisture content to observe its change during storage.

2.3.2. Determination of Permeability of Packaging Film.

Permeability (B) of the packaging film was calculated with the following equation:

B = {(amount of gas * thickness)/(area * time * pressure difference)}

2.4. Determination of Regression Equation (RSM)

Functional relationships between the independent variables (duration of storage, temperature, and relative humidity) and dependent variables (percentage of moisture content) was studied from which percentage of moisture content at any week during storage can be predicted. The functional relationship between dependent variables (coefficient of reconstitution, water activity, and water vapor transmission rate) with independent variable (percentage of moisture content, percentage relative humidity) was also established. The regression equations were determined (using Statistica, version 7, Stat Soft, Inc., USA) using multiple regression technique by fitting second order regression equation [16] of the following type

$$Y=\beta_o + \sum_{i=1}^{n} \beta_i X_i + \sum_{i=1}^{n} \beta_{ii} X_i^2 + \sum_{i=1}^{n} \sum_{j=i+1}^{n-1} \beta_{ij} X_i X_j + e \qquad (1)$$

where β_{0}, β_i, β_{ii}, β_{ij} are regression coefficients of variables for intercept, linear, quadratic and interaction terms, respectively, X_i, X_j are the independent variables, Y is the dependent variables n is number of independent variables.

The significance of the regression equation was judged by multiple R, and multiple R^2 which indicates the value of correlation coefficient and co-efficient of determination between the experimental and predicted data. The significance or p-value was decided at a probability level of 0.05. The significance of different effects of different independent variable was judged by student t test (t value) and p value.

III. RESULT & DISCUSSIONS

3.1. Determination of Quality of Potato Powder

The potato flours were kept at ambient conditions subjected to change in conditions that is dry-cold to hot-humid as observed from January to April and the quality characteristics were measured at an interval of 7 days. The initial and final quality parameters are reported in Table 1. A rise in moisture content from 2.53±0.021% to 4.97±0.032% was observed as in Fig 1. There is a gradual increase of moisture content after 6-7 weeks of storage but after certain percentage rise the curve gradually starts to flatten indicating a drop in the rate of moisture absorption. Similar findings for moisture content were observed by Hrušková and Machová in 2002 for wheat flour [17] and Abong et. al. in 2011 for potato crisps [18]. This fact is also supported by Fig 2 which shows the change in co-efficient of reconstitution i.e. with increase in moisture content the reconstitutability slightly decreases. Co-efficient of reconstitutability ranges from 0.902±0.003 to 0.855±0.006 in this four months.

From Fig 3 the change in water activity (a_w) was noted to be in the range of 0.243±0.003 and 0.484±0.001. Though there was a change in water activity but it was still within the range where there cannot be any microbial growth. The change in water activity (a_w) also shows a similar nature to the moisture content curve. Since the water activity level is well below the level of growth for micro-organisms there is no immediate threat to microbial stability. Total colony forming units was found to be around 50 cfu/gm for an incubation period of 48hours after 17 weeks of storage. The total plate count result obtained is well within limit of the standard of 40,000cfu/gm of different kinds of dehydrated fruits and vegetable products (BIS, Prevention of Food Adulteration Rules, 1956,Appendix D, Table 2, Microbiological Requirements of Food Products).

Table 1. Change in Quality Characteristics after 6 months

Time	Moisture Content (%)	Co-efficient of Reconstitution	Water Activity (a_w)	Total Plate Count (cfu/gm)
Initial	2.53±0.021	0.902±0.003	0.243±0.003	0
After 4 months	4.97±0.032	0.855±0.006	0.484±0.001	50

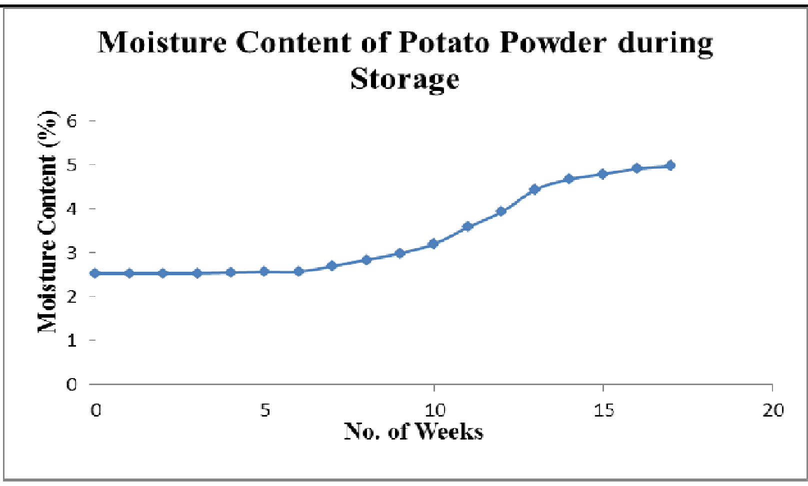

Figure 1. Moisture content of potato powder during storage

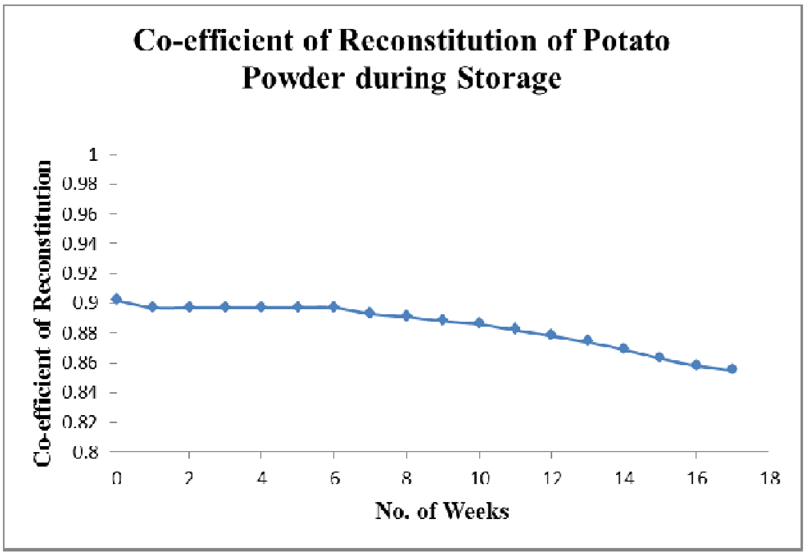

Figure 2. Co-efficient of reconstitution of potato powder

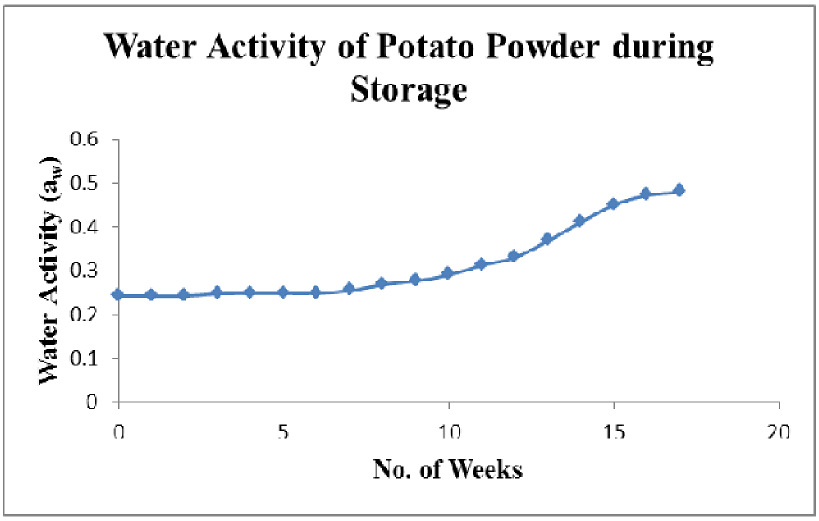

Figure 3. Water activity (a_w) of potato powder during storage

3.2. Study of Characteristics of Packaging Film

The quality of the packaging material is mainly judged by its permeability to moisture which in this case is measured by the change in water vapor transmission rate (WVTR). Fig 4 demonstrates the change in transmission rate w.r.t to time and moisture content. Permeability of the packaging film is affected by temperature and % RH, hence since the pouches are stored in ambient conditions, the change in permeability was noted throughout the storage period. But the permeability remains almost constant in the range of 2 x 10^{-4} to 3 x 10^{-4} cc.mm/m^2sec^{-1}mmHg (Fig 5).

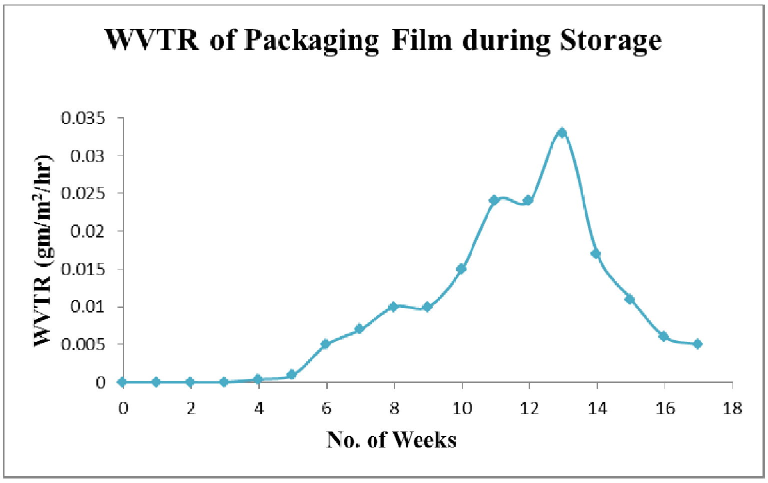

Figure 4. WVTR of packaging film during storage

The moisture content remained constant up to a period of 6-7 weeks then increased afterwards. The initial effect was due to relatively lower temperature and relative humidity. After 7 weeks moisture levels started to increase till the end of the storage period due to rise in temperature and relative humidity. Another important reason of moisture uptake can be attributed to their extremely low initial moisture content. It is also observed that as the as the rate of moisture absorption decreased after a certain period the WVTR of the packaging film decreased and this phenomenon is unaffected by the permeability of the packaging film which remained almost constant throughout the period. So it can be concluded that this change in moisture content was due to the hygroscopic properties of the powder. These findings are collaborated by the earlier studies by Rehman and Shah [19], Kirk and Sawyer [20], and Butt, Aldridge and Sawyer [11].

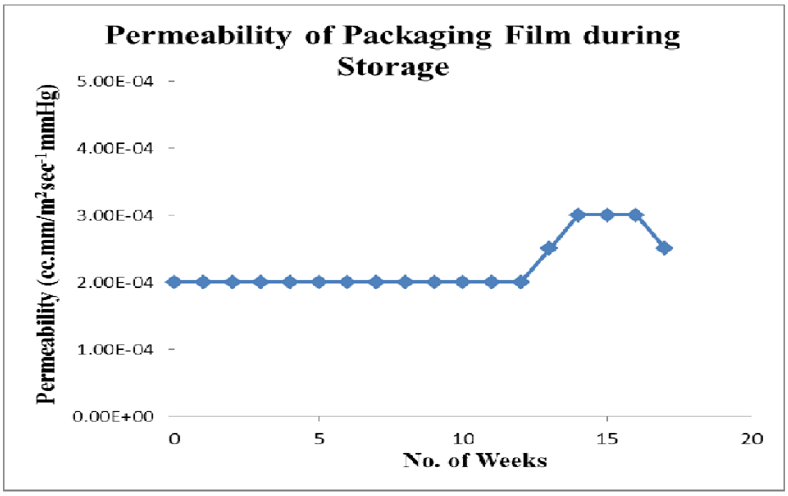

Figure 5. Permeability of packaging film during storage

3.3. Determination of Regression Equation (RSM)

Table 2. Changes in quality parameters and packaging film characteristics during storage

No. of Weeks	Temperature (°C)*	Relative humidity (%)*	Moisture content (%)**	Coefficient of reconstitution**	Water activity**	Water vapor transmission rate
Initial	18.68	60.24	2.53	0.902	0.243	0
1	19	66	2.53	0.897	0.243	0
2	19.19	66.59	2.53	0.897	0.243	0
3	19.15	67.31	2.53	0.897	0.248	0
4	19.37	67.99	2.55	0.897	0.249	0.0004
5	20.21	67.97	2.57	0.897	0.249	0.001

6	20.5	68.2	2.57	0.897	0.249	0.005
7	23.04	68.93	2.7	0.893	0.255	0.007
8	24.43	69.03	2.84	0.891	0.269	0.01
9	25.33	69.11	2.99	0.888	0.277	0.01
10	25.81	70.94	3.2	0.886	0.291	0.015
11	28.53	71.7	3.58	0.882	0.313	0.024
12	29.12	73.72	3.93	0.878	0.331	0.024
13	29.07	73.58	4.44	0.874	0.369	0.033
14	29.63	74.06	4.67	0.869	0.412	0.017
15	31.44	76.63	4.79	0.863	0.451	0.011
16	33.19	78.38	4.91	0.858	0.473	0.006
17	34.8	60.24	4.97	0.855	0.48	0.005

** Mean values of 7days, ** Mean values of triplicate analysis*

The second order model was fitted to response data of percentage of moisture content, co-efficient of reconstitution, water activity respectively, and water vapor transmission rate during the storage of dried powder at a significance level of 0.05 (Table 2). Where the no of weeks for storage, relative humidity, temperature are the independent variable for dependent response variable percentage moisture content, and moisture content and relative humidity are the independent variable for dependent response variable co-efficient of reconstitution, water activity, and water vapor transmission rate respectively and individually.

The student's t-test was performed to determine the significance of the regression co-efficient. The results of statistical analysis including the regression co-efficient, t and p values for linear, quadratic and combined effects of the variables were given in the Table 3. The larger the magnitude of the t-value and the smaller the p-value, indicate more significant of the corresponding coefficient and its effect on shelf life properties as well as storage of potato powder. The p-values and t values are used as a tool to check the significance of each of the coefficients and to understand the interactions between the best variables.

Table 3. Estimation of Regression Parameters, p value and t value

Percentage of Moisture Content			
Effect	Parameter	p	t
Intercept	-177.143	0.003996	-3.99160
Week No.	-7.036	0.014142[b]	-3.12404
Week No.*Week No.	-0.023	0.515882[a]	-0.67969
Temperature	5.186	0.026979[b]	2.70228
Temperature* Temperature (°C)	0.015	0.605306[a]	0.53786
% Relative Humidity	4.088	0.004969[b]	3.83690
% Relative Humidity* % Relative Humidity	-0.019	0.028878[b]	-2.65839
Week No.*Temperature	0.028	0.646865[a]	0.47591
Week No.*% Relative Humidity	0.098	0.009450[b]	3.39355
Temperature (°C)*% Relative Humidity	-0.088	0.017300[b]	-2.99129
Co-efficient of Reconstitution			
Effect	Parameter	p	t
Intercept	0.534318	0.001362	4.14374
% Moisture content	-0.058189	0.000345[b]	-4.93529
% Moisture content * % Moisture content	-0.002476	0.026265[b]	-2.53320
% Relative Humidity	0.014796	0.004919[b]	3.43727
% Relative Humidity * % Relative Humidity	-0.000140	0.002069[b]	-3.91086
% Moisture content * % Relative Humidity	0.000960	0.000096[b]	5.72285
Water Activity			
Effect	Parameter	p	t
Intercept	2.509605	0.001687	4.02419
% Moisture content	0.093575	0.126726[a]	1.64101
% Moisture content * % Moisture content	0.026563	0.000113[b]	5.61931
% Relative Humidity	-0.076340	0.003225[b]	-3.66686
% Relative Humidity * % Relative Humidity	0.000667	0.002278[b]	3.85774
% Moisture content * % Relative Humidity	-0.003254	0.001731[b]	-4.00964
Water Vapor Transmission Rate			
Effect	Parameter	p	t

Intercept	-0.866401	0.010523	-3.02712
% Moisture content	0.058001	0.046751[b]	2.21627
% Moisture content * % Moisture content	-0.014030	0.000031[b]	-6.46693
% Relative Humidity	0.023225	0.031692[b]	2.43070
% Relative Humidity * % Relative Humidity	-0.000197	0.028727[b]	-2.48438
% Moisture content * % Relative Humidity	0.000824	0.047160[b]	2.21142

a- not significant at $p<0.05$ level, b- significant at $p<0.05$ level

It has been found that linear terms of storage time (in terms of no. of weeks), temperature, square term of relative humidity, interaction of storage time (in terms of no. of weeks) with relative humidity, and Storage temperature with relative humidity have a significant effect (at $p< 0.05$) on change in moisture content (Table 3).

For change in coefficient of reconstitution and water vapor transmission rate (i.e. dependent variables) all linear, quadratic and interaction of terms of independent variable have a significant effect (at $p< 0.05$) (Table 3).

For change in water activity except linear terms of moisture content all other linear, quadratic, and interaction terms of independent variable have a significant effect at $p< 0.05$ (Table 3).

The model equations from Table 3 are

Percentage moisture content (PMC)= $-177.143 + 7.036*WN - 0.023*WN^2 + 5.186*T + 0.015*T^2 + 4.088*PRH - 0.019*PRH^2 + 0.028*WN*T + 0.098*WN*PRH - 0.088*T*PRH$……… (2)

Where in equation 2

WN denotes week number of stages, T denotes temperature (^oC), PRH denotes percentage of relative humidity.

Co-efficient of Reconstitution= $0.534318 - 0.058189*PMC - 0.002476*PMC^2 + 0.014796*PRH - 0.000140*PRH^2 + 0.000960*PMC*PRH$…… (3)

Water Activity= $2.509605 + 0.093575*PMC + 0.026563*PMC^2 -0.076340*PRH + 0.000667PRH^2 - 0.003254*PMC*PRH$………… (4)

Water Vapor Transmission Rate= $-0.866401 + 0.058001*PMC - 0.014030*PMC^2 + 0.023225*PRH - 0.000197*PRH^2 + 0.000824*PMC*PRH$………. (5)

In equations 3, 4, and 5, PMC denotes percentage of moisture content, and PRH denotes percentage of relative humidity.

The value multiple R and multiple R^2 of different regression model are found to be very good which indicates that the models are very effective for prediction of different responses (Table 4).

Table 4. Multiple R, Multiple R^2, and Adjusted R^2 of Different Regression Equation

Regression Model Equation of	Multiple R	Multiple R^2
Percentage of Moisture Content	0.997722	0.995449
Co-efficient of Reconstitution	0.995957	0.991930
Water Activity	0.997101	0.994210
Water Vapour Transmission Rate	0.952647	0.907535

Joglekar and May have suggested for a good fit of a model, regression coefficient (R^2) should be at least 80% [21]. All the R^2 values are the proportion of variation in the response attributed to the model was > 0.80 (Table 4), this means that the predicted values fitted well with the experimental data.

IV. CONCLUSION

From the above study it can be concluded that LDPE pouches can be effectively used in preservation of foam-mat dried potato powder under ambient conditions. The change in quality of potato flour samples depended significantly on the temperature and percentage relative humidity course during the storage period. As the change in characteristic properties of the powder is low so the stored powder can be incorporated in different food material as a substitution for wheat or corn flour.

REFERENCES

1. A.I. Morgan, R.P. Graham, L.F. Ginnette and G. Williams, "Recent developments in foam-mat drying", Food Technology, 15: 37–39, 1961.
2. D.M. Kadam, R.T. Patil, and P. Kaushik, Foam Mat Drying of Fruit and Vegetable Products, in Drying of Foods, Vegetables and Fruits - Volume 1, Ed. S.V. Jangam, C.L. Law, and A.S. Mujumdar, ISBN - 978-981-08-6759-1, Published in Singapore, pg. 111-124, 2010
3. D.K. Balev, A.S. Staykov, G.Y. Ivanov, S.G. Dragoev and E.H. Filizov, "Color stability improvement of chilled beef by natural antioxidant treatment and modified atmosphere packaging". Am. J. Food Technol., 6: 117-128, 2011.
4. K. Marsh, and B. Bugusu, "Food packaging-roles, materials and environmental issues". J. Food Sci., 72: 39-55, 2007.
5. P. Singh, and G.K. Goyal, "Combined effect of refrigeration and modified atmosphere packaging on the shelf life of ready-to-serve pizza: Biochemical and sensory attributes", Am. J. Food Technol., 6: 202-214, 2011.
6. A.S. Silva, J.L. Hernandez and P.P. Losada, "Modified atmosphere packaging and temperature effect on potato crisps oxidation during storage", Anal. Chim. Acta., 524: 185-189, 2004.
7. N. Bibi, A.B. Khattak, Aurang Zeb and Z. Mehmood, "Irradiation and packaging-food safety aspects and shelf life extension of solar dried garlic (Allium sativum) powder", Am. J. Food Technol., 3: 118-126, 2008.
8. V.O. Adetunji, and J. Chen, "Effect of temperature and modified vacuum packaging on microbial quality of wara a West African soft cheese", Res. J. Microbiol., 6: 402-409, 2011.
9. R. Rajkumar, K. Dushyanthan, R.A. Rajini and S. Sureshkumar, "Effect of modified atmosphere packaging on microbial and physical qualities of Turkey meat", Am. J. Food Technol., 2: 183-189, 2007.
10. G.O. Abong, M.W. Okoth, J.K. Imungi and J.N. Kabira, "Characteristics of the potato crisps processing industry in Kenya", J. Anim.Plant Sci., 8: 936-943, 2010.
11. A.A. Butt, K.E. Aldridge, and C.V. Sanders, "Infections related to the ingestion of seafood Part I: viral and bacterial infections", Lancet Infect. Dis. 4, 201–212, 2004.
12. S. Chakraborty, S. Banerjee, and S. Mazumder, "Statistical optimization of process parameters for gelatinization of potato (Chandramukhi variety)", IJRET, Volume 2, Issue 11, Pages 170-179, 2013.
13. S. Chakraborty, S. Banerjee and S.Mazumder, "Functional Properties based Statistical Optimization of Foam Mat Drying Parameters for Potato (Kufri Chandramukhi)", Global Journal of Science Frontier Research: C Biological Science, Volume 14, Issue 2, Pages 1-10, 2014.
14. AOAC, Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists, Washington, DC., USA, 1984.
15. H. J. Benson, Bacterial Population Counts, Microbiological Applications 8th Edition. New York: McGraw Hill, Fig. 21-1. Pg. 87, 2002.
16. A. I. Khuri, and J. A. Cornell, Response Surfaces, Marcel Dekker, New York, NY, 1987.
17. M. Hrušková, D. Machová, "Changes of wheat flour properties during short term storage", Czech J. Food Sci., 20: 125–130, 2002.
18. G.O. Abong, M.W. Okoth, J.K. Imungi and J.N. Kabira, "Effect of Packaging and Storage Temperature on the Shelf Life of Crisps from four Kenyan Potato Cultivars", American Journal of Food Technology, 6: 882-892, 2011.
19. Z. U. Rehman, and W. H. Shah, "Biochemical changes in wheat during storage at three temperatures", Plant Food for Human Nutri, 54 (2): 109-117, 1999.
20. S.R. Kirk, and R. Sawyer, Pearson's Composition and Analysis of Foods, Addison-Wesley Longman Ltd. Edinburg Gate, Harlow, England, 1991.
21. A. M. Joglekar, A. T. May, "Product excellence through design of experiments", Cereal Foods Word, 32: 857 - 868, 1987.

