

Studies on the Replacement of Sodium Chloride with Magnesium Chloride in Black Gram *Papad*

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Abstract. *Papad* is one of the favorite snack food liked by all age groups where use of sodium chloride is greatly varied. Consumption of high amount of sodium chloride is the major cause of hypertension. In this study a thorough investigation was carried out to determine the optimal salt combinations when MgCl₂ was used to partially replace NaCl. Five different treatments were performed using various percentages of salt with the addition of herb and spices. The developed *Papads* were analyzed for physiochemical, colour and sensory properties. Storage study was conducted at room temperature (25±5°C) in low and high density polyethylene. According to the results the black gram *Papads* made with 25% replacement of sodium chloride with magnesium chloride obtained higher overall acceptability score and they remained good up to 135 days and 255 days in low density polyethylene and high-density polyethylene respectively in raw form.

KEY WORDS: Common salt, sodium, raw *Papads*, high density polyethylene.

1. INTRODUCTION

Papad is one of the favourite food item comes under snack category. Since the raw material used to make snack foods is bland, flavouring is required for every snack food. Usually, they are seasoned majorly with cost effective ingredient salt and often with other flavourings. As like various foods made using high amount of sodium/salt *Papad* is also one which made using varying level of sodium chloride. *Papad* is well liked snack food of Indian diets due to its deliciousness. It is consumed either in roasted form or deep fat fried form or as adjunct along with vegetable soups and curries. *Papads* are generally made of dough of various grains, millets, pulses and edible starch flour either separately or combined with ingredients such salt, spices, additives and edible oil [1]. Basically, *Papads* are prepared from black gram dhal and such *Papads* are the largest selling *Papads* in the local and national market [2]. There are five basic types of taste including salty, bitter, sour, sweet, and umami. Among them salty taste is one of commonly liked taste by the population. The food without salt can't be imagined. The basic ingredient added in food for saltiness is table salt that is sodium chloride. Salt also offers several other functions in human nutrition. The salt is required by the body to perform regular physiological function. Salt is having distinctive flavour and also having the ability to enhance the flavour of other ingredients. Salt also influences texture and aids in food preservation to increase shelf life [3].

The salt contains sodium atom of about 39.33% and a chlorine atom about 60.67%. Thus, salt that is sodium chloride is the major source of sodium ion in the diet [4]. According to reports nearly all of our sodium intake is from salt added to food. About 75 percent of salt is thought to come from processed foods, 10 to 15 percent is added by customers when

cooking or at the table, and 10 to 15 percent is found naturally in food [5]. Small amount of sodium is required by the human beings including all mammals to regulate blood pressure and volume at required level. Even though sodium plays vital functions in metabolism of proteins and carbohydrates, in the transmission of nerve impulses its consumption beyond the limit resulted in various serious health effects including hypertension, stomach cancer, neurological, kidney disorders, osteoporosis, asthma, stroke, cardiovascular disease and obesity [6].

The limit for daily sodium chloride consumption set by World Health Organization is 5g salt (2000mg sodium). However, according to the current reported studies salt intake of Indian population is to be more than double the recommended level. On consideration of many health drawbacks of excessive sodium consumption, it becomes primary responsibility of food manufacturer to reduce the sodium content of processed food items. This reduction of sodium is achieved by many ways like by a) lowering the amount of salt while food preparation b) replacing salt with other chloride salts c) using flavour enhancers like monosodium glutamate, naturally brewed soya sauce d) the salt reduction through public awareness e) the using organic acids such as citric acid, lactic acid, acetic acid f) the addition of dried bonito in egg custard g) changing the form of salt h) using some herbs & spices and i) stealth. Among all those salts other than sodium including magnesium chloride, potassium chloride and calcium chloride have been tried by various researchers in variety of products like Italian salami, dry cured lacon, lemon pickle, processed cheese and bread. Present study was carried out to reduce the salt content in black gram *Papad* by substituting NaCl with MgCl₂ in different proportions along with addition of herbs like curry leaves and tamarind pulp as a natural source of acid.

2. MATERIALS AND METHODS

2.1 Materials

The reported work was carried in the Laboratories of the Department of Food Science and Technology, Shivaji University, Kolhapur (MH). The clean black gram dhal of variety B.D.U-1 was purchased from local Kolhapur market & grinded to make fine flour. The prepared black gram flour was stored in high density polyethylene bags until further use. Table salt- Tata brand sodium chloride, Mega brand sodium bicarbonate, premium quality spices like Arjun brand cumin seed, Navjeevan brand asafoetida, Satvyk brand black pepper and cinnamon, Fortune brand refined groundnut oil were purchased from local market. Fresh curry leaves and ripe tamarind were collected from local vegetable market. Food grade magnesium chloride, sodium carbonate and analytical grade chemicals were made available from Balaji Scientific Traders, Kolhapur.

2.2 Preparation of raw materials

Fresh curry leaves were dried in a tray dryer at 50°C for 4 hours until they become brittle and crisp. The dried leaves were then grind in mortar pestle and sieved through a sieve with a mesh size of 60. The dried cinnamon pieces were grinded and sieved similarly. The ripe tamarind seeds were sorted from fresh and 4 g of pulp was homogenized properly into 20 ml of water. After straining the paste along with further 25ml of water was used to make dough of 100 g black gram flour.

2.3 Formulations of Papad

Four different formulations of sodium chloride replaced *Papads* using magnesium chloride coded as PM₁, PM₂, PM₃ and PM₄ were prepared where sodium chloride was replaced at 25, 50, 75 and 100% respectively. The sample prepared with using sodium chloride only was considered as control. The detailed composition is as given in Table 1.

Table 1: Different formulations for Papad preparation

Ingredients	Control <i>Papad</i>	MgCl ₂ used <i>Papad</i>
Black gram flour (g)	100	100
Common salt (g)	0.6	25,50,75,100%
Cumin seed (g)	1.0	1.0
Black pepper (g)	1.0	1.0
Asafoetida (g)	1.0	1.0
Carbonate mixture (g)	1.0	1.0
Curry leaves powder (g)	1.0	1.0
Cinnamon (g)	0.5	0.5
Tamarind pulp (g)	4.0	4.0
Groundnut oil (g)	2.0	2.0
Water (ml)	45	45

2.4 Preparation of Papad

The black gram flour was mixed with weighed quantity of other ingredients according to procedure mentioned below. The carbonate mixture, sodium chloride and magnesium chloride were first dissolved properly as per formulations and then

using this water the uniform dough was prepared. The dough was then divided into 10 g balls and rolled into thin circular disc of about 0.8-1mm thickness using wooden rolling pin. The rolled *Papads* were then moulded using lid of 9 cm diameter. The *Papads* were dried in drier at 50°C up to 13-14% moisture and packed in polythene bags.

2.5 Frying of Papad

Before sensory analysis all *Papads* of different formulations were fried in refined groundnut oil at 180±5°C for 10 to 15 seconds and kept in airtight condition.

2.6 Physical analysis of Papads

The fried *Papad* samples made using magnesium chloride in place of sodium chloride were analysed for physical properties like weight, thickness, diameter, expansion percentage and oil absorption capacity along with control formulation. The weight was measured using electronic weighing balance. The thickness and diameter were determined using Vernier calliper and measuring scale respectively. The expansion percentage and oil absorption capacity in terms of increased weight percentage were calculated as per method described [2]. Every determination was done in triplicate and the result expressed as the average value.

2.7 Sensory analysis

The developed sodium chloride replaced *Papad* formulations were fried and subjected to sensory evaluation using a group of 10 semi-trained panellists. Panellist members evaluated the sensory quality of all those for their sensory parameters like colour, flavour, taste, texture and overall acceptability based on a 9 point Hedonic Scale.

2.8 Chemical analysis of control and selected sodium chloride replaced Papad

As per sensory evaluation results the selected *Papad* formulation made by replacing NaCl with MgCl₂ along with control sample were evaluated for chemical parameters like moisture, crude protein, crude fat, ash, crude fibre, total carbohydrate, pH and ash alkalinity. The moisture, crude protein, crude fat and ash were determined [7]. By deducting the determined amounts of moisture, protein, fat, crude fibre and ash from 100 the total carbohydrate content was calculated. The pH of the solution was recorded with a digital a pH meter. The alkalinity of ash as sodium carbonate was calculated as per formula. The same *Papads* were also accessed for mineral content namely sodium and magnesium content. The sodium content was measured using flame photometric method with Microprocessor Flame Photometer - Model 1381 and magnesium content was through colorimetric method on digital photo colorimeter- Model 312.

2.9 Colour measurement

Hunter colour parameters (L^* , a^* , b^*) for control and selected sodium chloride replaced *Papad* formulations in both raw and fried forms were measured with the help of ColorFlex EZ 45/0 HunterLab Spectrophotometer, Serial No. CFEZ3978. The data was recorded with D-65 illuminant with a 10° view angle. The average of three measurements was reported [8].

2.10 Storage studies

Storage stability of control and developed *Papad* formulation made with using magnesium chloride in place of sodium chloride were studied at room temperature ($25\pm 5^\circ\text{C}$) by storing them in flexible pouches of low density polyethylene (LDPE) and high density polyethylene (HDPE) for a period of 270 days. The *Papad* samples were analysed at 15 days interval for the parameters like moisture content, peroxide value (PV), free fatty acid content (FFA), overall acceptability and texture to check their keeping quality. Among those texture and overall acceptability were checked on frying at intervals using fresh refined groundnut oil every time. At intervals the samples were also analysed for microbiological quality in terms of Total Plate Count (TPC) and yeast and mould (YM) count [].

2.11 Statistical analysis

Statistical analysis of the collected data was performed using Microsoft Excel 97-2003 of windows 10 software. The standard deviation (SD) and critical difference (CD) at 5% level were provided.

3. RESULT AND DISCUSSION

3.1 Effect of replacement of sodium chloride with magnesium chloride on physical properties of *Papad*

Physical properties of *Papad* formulations made in replacement of sodium chloride by magnesium chloride along with control was represented in Table 2 both in raw and fried form. Insignificant difference in initial moisture content of raw control and magnesium salt used samples was noted, however upon frying the moisture content of all samples was reduced significantly. On frying the moisture content of *Papads* made with using magnesium chloride was recorded to be comparatively higher ($6.11\pm 0.03\%$ to $6.30\pm 0.03\%$) than control formulation *Papads* ($5.71\pm 0.05\%$). This probably due to higher hygroscopicity magnesium chloride. The weight of all raw *Papads* was in range of $3.57\pm 0.03\%$ to $3.63\pm 0.00\%$ which was found to be increased on frying due to oil absorption ($4.14\pm 0.04\%$ to $4.29\pm 0.06\%$). Thickness and diameter of were increased due to the action of carbonate mixture during frying. The expansion percentage of *Papads* made by using magnesium chloride in place of sodium chloride was found to be decreased with increasing in magnesium chloride percentage which might be due to higher amount of moisture retained in the product after frying. Among all magnesium salt used formulations selected formulation according to sensory evaluation (PM_1) had comparatively higher expansion percentage ($15.44\pm 0.08\%$) than control ($14.78\pm 0.09\%$). The oil absorption was recorded lower in case *Papads* made with use of magnesium chloride than control. The high water-holding capacity during frying causes less oil absorption hence *Papads* made with replacing sodium chloride by magnesium chloride had the least amount of oil absorbed than control *Papad*.

Table 2: Effect of NaCl replacement with MgCl₂ on physical parameters of fried black gram *Papads*

Formulations	Raw <i>Papads</i>				Fried <i>Papads</i>				Expansion (%)	Increase weight (%)
	Moisture (%)	Weight (g)	Thickness (mm)	Diameter (cm)	Moisture (%)	Weight (g)	Thickness (mm)	Diameter (cm)		
Control <i>Papad</i>	12.12±0.02	3.61±0.08	0.82±0.01	9.0±0.0	5.71±0.05	4.29±0.02	1.45±0.00	10.33±0.11	14.78±0.09	18.84±0.07
PM ₁	12.11±0.01	3.57±0.03	0.81±0.0	9.0±0.0	6.11±0.03	4.14±0.04	1.41±0.01	10.39±0.08	15.44±0.08	15.96±0.09
PM ₂	12.12±0.02	3.59±0.06	0.82±0.04	9.0±0.0	6.17±0.01	4.20±0.05	1.49±0.01	10.31±0.08	14.56±0.07	16.99±0.07
PM ₃	12.11±0.05	3.63±0.00	0.82±0.03	9.0±0.0	6.22±0.00	4.29±0.06	1.53±0.03	10.26±0.08	14.00±0.03	18.18±0.10
PM ₄	12.12±0.04	3.56±0.05	0.81±0.02	9.0±0.0	6.30±0.03	4.22±0.07	1.67±0.05	10.22±0.011	13.56±0.05	18.53±0.16
SD±	0.006	0.028	0.006	0.0	0.230	0.064	0.100	0.066	0.722	1.200
CD at 5%	0.009	0.046	0.009	0.0	0.366	0.101	0.159	0.104	1.149	1.906

*Formulation details: Control *Papad*- 100% NaCl, PM₁- 25% MgCl₂+75% NaCl, PM₂- 50% MgCl₂+50% NaCl, PM₃- 75% MgCl₂+25%NaCl, PM₄- 100% MgCl₂

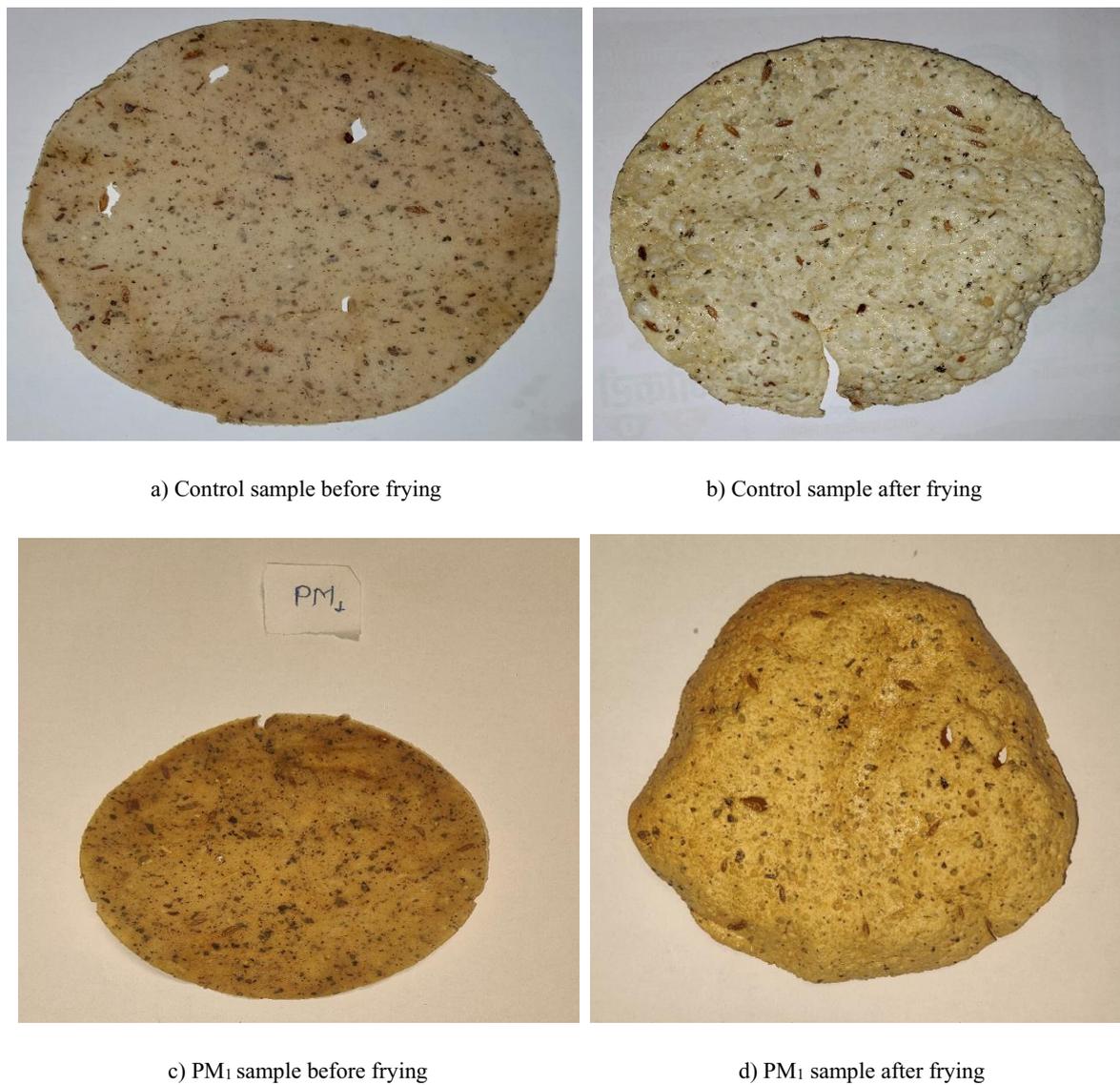


Fig. 1 Photographic images of control and selected NaCl replaced *Papad* formulations before and after frying

3.2 Effect of replacement of sodium chloride with magnesium chloride on sensory properties of fried *Papad*

Table 3 shown the results for sensory properties of fried *Papad* formulations made with using magnesium salt in place of sodium chloride. Among fried different *Papads* made in replacement sodium chloride with magnesium salt the formulation containing magnesium chloride and sodium chloride (25% and 75%) obtained higher overall acceptability score (7.79±0.10) followed by control (8.09±0.10). No significant difference was observed in between colour scores of controls and prepared magnesium salt used formulations. The flavour, taste, texture and overall acceptability were recorded to be declined with increasing level of magnesium

chloride. However as compared with flavour and taste the decline in texture score was lower. This progressive decline in flavour and taste might be due to bitter flavour, metallic, undesirable taste, unsound and astringent sensation of magnesium salt. In relates to this result no difficulties were noted in baking performance of wheat bread which concerned with the textural property on 40% replacement of sodium chloride with magnesium chloride when the flavour and taste get affected adversely. Regarding bread flavour and odour, he found that 10% substitution of sodium chloride with magnesium chloride caused no difference where 20 % substitution resulted in musty, insipid and bland flavour and odour. This supports the obtained result of present work.

Table 3: Effect of sodium chloride replacement by magnesium chloride on sensory quality of fried black gram *Papads*

Formulations	Colour	Flavour	Taste	Texture	Overall acceptability
Control <i>Papad</i>	8.12±0.08	8.09±0.05	7.93±0.17	8.22±0.11	8.09±0.10
PM₁	8.12±0.07	7.51±0.09	7.41±0.13	8.11±0.10	7.79±0.10
PM ₂	8.11±0.06	6.24±0.10	6.18±0.15	7.43±0.09	6.99±0.10
PM ₃	8.12±0.05	5.35±0.10	5.27±0.16	6.38±0.13	6.28±0.12
PM ₄	8.13±0.07	4.16±0.09	3.85±0.06	6.09±0.04	5.56±0.06
SD±	0.007	1.593	1.645	0.977	1.047
CD at 5%	0.011	2.533	2.615	1.553	1.665

*Formulation details: Control *Papad*- 100% NaCl, PM₁-25% MgCl₂+75% NaCl, PM₂- 50% MgCl₂+50% NaCl, PM₃- 75% MgCl₂+25%NaCl, PM₄- 100% MgCl₂

3.3 Effect of replacement of sodium chloride with magnesium chloride on chemical properties of *Papad*

Table 4 showed the results of chemical analysis of control and selected *Papad* formulation prepared in replacement of sodium chloride with MgCl₂. According to results the moisture, crude fat, ash, alkalinity of ash, crude fibre content of all developed *Papads* were in range with IS *Papad*-specifications (1999) without significant differences in values between control and selected PM₁ formulation [7]. The protein content of both samples was also without significant difference. According to reported data *Papad* made with black gram flour had a protein level of 25.71 % and 24.57% [9]. These values are in close agreement with the present results. Similar result was noted in case of carbohydrate percentage. The obtained ash content of both *Papads* was comparable with ash content of black gram *Papad* . The pH of the water extract of all control and selected sodium chloride replaced samples was within the range of IS *Papad*-specifications (1999) and with no significant

difference in between them. Same finding was reported in the dough pH of wheat bread which was not affected significantly upon 40% substitution of sodium chloride with magnesium chloride and potassium chloride separately. There was less work reported on replacement of sodium chloride with any other salts in case of any cereal/legume-based snack food, hence no literature on this aspect is available.

The mineral content reported showed the sodium content of control and PM₁ *Papad* sample was about 258.91±0.12 mg/100g and 198.04±0.10mg/100g respectively. Thus, a significant reduction in the sodium content was achieved through the partial substitution of sodium chloride by the magnesium chloride salt. Accordingly, on the other side the level of corresponding MgCl₂ salt used was found to increase the magnesium content. Thus, formulation PM₁ presented higher level of magnesium (270.31±0.11) than the control one.

Table 4: Chemical composition of raw control and selected *Papad* formulations made by replacing sodium chloride with magnesium chloride

Parameters	Formulations		SD±	CD at 5%
	Control	PM ₁		
Moisture (%)	12.10±0.01	12.11±0.06	0.007	0.011
Crude protein (%)	25.22±0.19	25.17±0.29	0.035	0.056
Crude fat (%)	1.86±0.18	1.85±0.13	0.007	0.011
Ash (%)	3.49±0.08	3.50±0.04	0.007	0.011
Total Carbohydrate (%)	55.90±0.28	55.91±0.19	0.007	0.011
Crude fibre %)	1.43±0.08	1.44±0.05	0.007	0.011
Alkalinity of ash (%)	1.91±0.14	1.90±0.16	0.07	0.011
pH	7.00±0.01	7.01±0.04	0.007	0.011
Minerals (mg/100g)				
Sodium	258.91±0.12	198.04±0.10	43.042	68.436
Magnesium	270.31±0.11	305.12±0.14	24.614	39.137

*Control *Papad*- 100% NaCl, PM₁- 75% MgCl₂ + 25% NaCl, all values are mean ± standard deviation of three determinations

3.4 Effect of replacement of sodium chloride with magnesium chloride on colour properties of *Papad*

The formulation made with using magnesium chloride (PM₁) showed L* value slightly higher than control without significant difference in both raw and fried form. This indicates use of magnesium chloride in place of sodium chloride did not affect lightness colour parameter significantly. In this concern, 50% replacement of sodium chloride with mixture of calcium chloride and magnesium chloride resulted in lighter luncheon meat when compared to the control [10]. In present study slight increase in lightness found at 25% sodium salt replacement with magnesium salt. Comparatively lower a* values of raw and PM₁ fried *Papads* than

control might resulted in slightly higher L* value. The b* values of fried *Papads* was higher than raw samples and those increased b* values indicate more yellowish tinge in the fried *Papads*.

No data recorded previously regarding sodium chloride replacement in *Papad*. However, L*, a* and b* values of 12 different market black gram *Papad* samples after frying in range of 70.82 to 76.38, 2.84 to 6.89 and 30.80 to 33.62 respectively [15]. The obtained L* value of present research was lower (57.34±0.02 to 64.18±0.00), a* was higher (6.82±0.01 to 11.03±0.00) and b* was comparatively lower (31.93±0.00 to 33.56±0.04) which might be due to incorporation of curry leaves powder, cinnamon and tamarind pulp in *Papad*.

Table 5: CIE colour parameters of raw and fried control and selected *Papad* formulations made by replacing NaCl with MgCl₂

Formulations	L* value		a* value		b* value	
	Raw	Fried	Raw	Fried	Raw	Fried
Control	53.36±0.01	61.73±0.01	5.82±0.00	7.73±0.01	23.19±0.01	31.93±0.00
PM ₁	53.39±0.02	61.78±0.01	5.76±0.01	7.69±0.01	23.07±0.01	31.98±0.01
SD±	0.120	0.035	0.042	0.028	0.085	0.035
CD at 5%	0.191	0.056	0.067	0.045	0.135	0.056

*Control *Papad*- 100% NaCl, PM₁- 75% MgCl₂ + 25% NaCl and all values are mean ± standard deviation of three determinations

3.5 Effect of replacement of sodium chloride with magnesium chloride on storage life of raw *Papad* stored in LDPE and HDPE

Table 6 and 7 represents results for storage study of control and selected PM₁ stored in low density polyethylene and high-density polyethylene for the parameters like moisture content, peroxide value, free fatty acid, overall acceptability and texture up to 270 days at interval of 15 days. Among those texture and overall acceptability were checked after frying at particular interval. A non-significant increase in moisture content was found in both formulations during the storage period stored in both low density polyethylene and high-density polyethylene. In low density polyethylene the PM₁ *Papads* showed increase in moisture content from 12.12±0.13% to 15.67±0.08% up to 150 storage days where in high density polyethylene showed increase from 12.11±0.13% to 15.62±0.14% up to 270 storage days. This indicates there was considerably more rise in moisture content among formulations stored in low density polyethylene than high density polyethylene, which might be due the difference between the water permeability of packaging material. The water vapour transmission rate of low-density polyethylene is in the range of 1.0 to 1.3 g/m²/24hr and high-density polyethylene is 0.3 to 0.5 g/m²/24hr. Among the rise in moisture content of formulation PM₁ was shown relatively higher gain than control formulation which might be due to hygroscopic nature of magnesium chloride. The PM₁ and control formulations stored in low density polyethylene recorded higher moisture content after 135 and 150 days of storage. As a result, the PM₁ formulation *Papads* became less crispy and developed noticeable rancid flavour after 135 days and control were after 150 days. Wherever in HDPE pouch the PM₁ and control formulations *Papad* remained crispy and good overall quality up to 255 and 270 days of storage respectively. Similar rise in moisture content during storage in LDPE and HDPE was reported in jowar based *Papad*, black gram and rice bean flour *Papad* (Polyethylene), date chakli (HDPE), wheat pasta (200guage LDPE) and in black gram *Papad* (200guage LDPE & HDPE) [11].

Peroxide value helps to check storage life of the product stored in packaging material. Off smell generated due to rancid taste becomes identifiable when the peroxide values range between 20-40meq/kg. The peroxide values of both control and

PM₁ formulations stored in low density polyethylene and high-density polyethylene was found to be increased throughout the storage period. In low density polyethylene the peroxide value of PM₁ formulation was increased from 6.35±0.12meq/kg to 22.41±0.12meq/kg up to 150 storage days and in control formulation from 6.30±0.19meq/kg to 22.30±0.18meq/kg up to 165 days of storage. Thus, as per safe peroxide value range in low density polyethylene the PM₁ formulation was found good up to 135 days while control formulation up to 150 days storage. On other side in high density polyethylene the peroxide value of PM₁ formulation exceeds the safe peroxide value range after 255 days onwards while the control formulation after 270 days onwards. Thus, selected *Papads* prepared with 25% replacement of sodium chloride with magnesium chloride was stored safely in HDPE for 255 storage days.

Shelf life of food product can also be determined by measuring free fatty acid content. Oxidation of fat produces free fatty acids. In present study the free fatty acid content of both raw control and PM₁ *Papad* formulations was found increased during the storage in both the low- and high-density polyethylene. This increase was slightly more pronounced to the *Papad* stored in the low-density polyethylene than high density polyethylene. The free fatty acid content above 1.5% level leads to identifiable rancidity. In LDPE the free fatty acid content of control formulation was raised from 0.34±0.09% to 1.51±0.13% up to 150 storage days which further reached to 1.73±0.14% on 165 storage days. The PM₁ formulation free fatty acid content was raised from 0.34±0.13% to 1.36±0.10% up to 135 days while up to 150 days it was reached to 2.09±0.11%. Thus, as per permitted free fatty acid content in low density polyethylene the PM₁ and control formulations raw black gram *Papads* were found good up to 135 and 150 days respectively. Among the black gram *Papads* stored in high density polyethylene the control formulation showed increase in free fatty acid content from 0.33±0.09% to 1.49±0.12% up to 270 days which was further reached to 1.79±0.13% on 285 storage days. The PM₁ formulation showed increase from 0.34±0.13% to 1.45±0.14% up to 255 days which was further reached to 1.94±0.15% on 270 storage days. Thus, as per permitted limit for free fatty acid content in high density polyethylene the PM₁ and control formulations raw black gram *Papads* were found good up to 255 and 270 days of storage. Free

fatty acid content was comparatively higher in low density polyethylene than high density polyethylene in millet khakhra during period of 90 days [12]. This difference might be due to highly protecting

properties of high-density polyethylene.

The sensory score in terms of overall acceptability at intervals of control and PM₁ fried samples stored in both low- and high-density polyethylene shown that the overall acceptability scores were decreased during storage. The initial overall acceptability score of PM₁ formulation was 7.79 ± 0.19 which was decreased to 4.19 ± 0.14 up to 150 storage days. Thus it was found within acceptable limit up to 135 days of storage. Wherever according to hedonic scale prediction the control formulation was within acceptable quality up to 150 days. In LDPE the PM₁ formulation *Papads* lose their crispness after 135 days and control after 150 days of storage due to absorption of moisture. Among high density polyethylene stored samples it was cleared that there was comparatively less decline in the overall acceptability score during the storage, hence

samples remained good for longer period of time. The PM₁ formulation overall acceptability score was about 6.21 ± 0.15 up to 255 days where upon 270 days it was lowered to 4.67 ± 0.14 . This indicates the PM₁ formulation was within acceptable overall quality up to 255 days only. However after 255 days onwards the quality was declined, which might be due to texture loss, off and rancid flavour development. The control formulation had acceptable sensory scores 6.19 ± 0.13 up to 270 storage days and declined below neither like nor dislike score after 270 days onwards. Higher storage quality in high density polyethylene was probably because of good barrier properties of high density polyethylene than low density polyethylene.

Table 6: Effects of partial NaCl replacement and packaging material (LDPE) on physicochemical and sensory properties of raw *Papads* during storage

Storage Days	Moisture (%)		PV (meq/kg)		FFA (%)		Overall acceptability		Texture	
	Control	PM ₁	Control	PM ₁	Control	PM ₁	Control	PM ₁	Ctrl	PM ₁
0	12.12±0.05	12.12±0.13	6.30±0.19	6.35±0.12	0.33±0.09	0.34±0.13	8.10 ±0.09	7.79±0.19	Crisp	Crisp
15	12.27±0.07	12.31±0.14	6.39±0.17	6.64±0.11	0.47±0.07	0.47±0.11	8.00±0.10	7.65±0.14	Crisp	Crisp
30	12.49±0.10	12.55±0.11	6.77±0.15	6.91±0.11	0.49±0.06	0.52±0.10	7.92 ±0.07	7.51±0.13	Crisp	Crisp
45	12.62±0.06	12.67±0.13	7.02±0.16	7.23±0.10	0.58±0.09	0.61±0.11	7.71±0.12	7.40±0.15	Crisp	Crisp
60	12.83±0.09	12.88±0.14	7.49±0.17	7.87±0.09	0.64±0.10	0.67±0.13	7.61±0.13	7.28±0.16	Crisp	Crisp
75	13.02±0.07	13.22±0.15	9.12±0.16	8.98±0.08	0.79±0.11	0.86±0.14	7.53±0.15	7.13±0.14	Crisp	Crisp
90	13.37±0.10	13.52±0.14	10.66±0.14	10.89±0.11	0.90±0.08	0.96±0.09	7.44±0.14	7.01±0.13	Crisp	Crisp
105	13.65±0.11	13.82±0.16	11.34±0.13	12.76±0.13	1.02±0.07	1.10±0.11	7.21±0.16	6.86±0.16	Crisp	Crisp
120	13.92±0.09	14.18±0.10	12.80±0.12	15.37±0.14	1.13±0.09	1.27±0.10	6.94±0.15	6.75±0.14	Crisp	Crisp
135	14.19±0.07	14.48±0.09	14.14±0.16	18.76±0.13	1.34±0.11	1.36±0.10	6.60±0.13	6.31±0.16	Crisp	Crisp
150	14.48±0.05	15.67±0.08	16.51±0.17	22.41±0.12	1.51±0.13	2.09±0.11	6.42±0.14	4.19±0.14	Crisp	Less crisp
165	15.46±0.09	-	22.30±0.18	-	1.73±0.14	-	4.88±0.16	-	Less crisp	-

*LDPE- Low density polyethylene, PV- Peroxide value, FFA- Free fatty acids, Control- 100% NaCl, PM₁- 25% MgCl₂+75% NaCl, all values are mean ± standard deviation of three determinations and '-', sample discarded

Table 7: Effects of partial NaCl replacement and packaging material (HDPE) on physicochemical and sensory properties of raw *Papads* during storage

Storage Days	Moisture (%)		PV (meq/kg)		FFA (%)		Overall acceptability		Texture	
	Control	PM ₁	Control	PM ₁	Control	PM ₁	Control	PM ₁	Ctrl	PM ₁
0	12.12±0.05	12.11±0.13	6.30±0.19	6.35±0.12	0.33±0.09	0.34±0.13	8.10±0.09	7.79±0.19	Crisp	Crisp
15	12.12±0.09	12.17±0.12	6.33±0.18	6.58±0.11	0.34±0.08	0.36±0.12	8.10±0.10	7.75±0.20	Crisp	Crisp
30	12.15±0.10	12.22±0.11	6.62±0.17	6.85±0.13	0.37±0.07	0.38±0.15	8.09±0.11	7.70±0.14	Crisp	Crisp
45	12.20±0.11	12.28±0.13	6.81±0.14	7.02±0.11	0.42±0.07	0.47±0.16	8.00±0.13	7.63±0.16	Crisp	Crisp
60	12.27±0.06	12.35±0.14	7.09±0.13	7.36±0.10	0.48±0.06	0.55±0.14	7.94±0.14	7.57±0.17	Crisp	Crisp
75	12.38±0.07	12.46±0.08	7.43±0.15	7.72±0.13	0.54±0.09	0.59±0.13	7.87±0.13	7.51±0.18	Crisp	Crisp
90	12.43±0.10	12.55±0.09	7.92±0.16	8.01±0.14	0.61±0.10	0.65±0.12	7.82±0.14	7.46±0.13	Crisp	Crisp
105	12.50±0.11	12.62±0.10	8.27±0.14	8.33±0.15	0.67±0.11	0.69±0.14	7.75±0.11	7.38±0.14	Crisp	Crisp
120	12.61±0.12	12.69±0.11	8.68±0.13	8.61±0.13	0.75±0.13	0.77±0.13	7.70±0.10	7.29±0.16	Crisp	Crisp
135	12.76±0.14	12.85±0.10	8.92±0.14	9.12±0.11	0.81±0.14	0.84±0.18	7.62±0.09	7.22±0.11	Crisp	Crisp
150	12.89±0.08	12.99±0.09	9.23±0.16	10.01±0.13	0.88±0.11	0.92±0.19	7.55±0.08	7.13±0.12	Crisp	Crisp
165	13.00±0.09	13.11±0.08	9.45±0.13	11.13±0.14	0.94±0.13	0.97±0.15	7.46±0.12	6.99±0.16	Crisp	Crisp
180	13.12±0.08	13.28±0.09	10.00±0.12	12.64±0.13	1.03±0.15	1.08±0.13	7.35±0.11	6.86±0.14	Crisp	Crisp
195	13.23±0.12	13.48±0.10	10.62±0.13	13.75±0.13	1.11±0.08	1.15±0.11	7.21±0.13	6.73±0.13	Crisp	Crisp
210	13.32±0.11	13.67±0.11	11.19±0.16	14.64±0.14	1.19±0.09	1.23±0.10	7.03±0.14	6.57±0.14	Crisp	Crisp
225	13.42±0.12	14.06±0.12	11.70±0.14	15.22±0.16	1.27±0.11	1.30±0.09	6.83±0.15	6.48±0.16	Crisp	Crisp
240	13.53±0.13	14.41±0.13	12.32±0.15	17.36±0.15	1.34±0.10	1.34±0.13	6.59±0.13	6.34±0.17	Crisp	Crisp
255	13.79±0.14	14.76±0.11	13.05±0.13	18.66±0.13	1.40±0.11	1.45±0.14	6.32±0.14	6.21±0.15	Crisp	Crisp
270	13.90±0.15	15.62±0.14	17.09±0.14	22.89±0.13	1.49±0.12	1.94±0.15	6.19±0.13	4.67±0.14	Crisp	Less crisp
285	15.34±0.11	-	20.79±0.16	-	1.79±0.13	-	4.53±0.11	-	Less crisp	-

*HDPE- High density polyethylene, PV- Peroxide value, FFA- Free fatty acids, Control- 100% NaCl, PM₁- 25% MgCl₂+75% NaCl, all values are mean ± standard deviation of three determinations and ‘-’ sample discarded

3.6 Effect of replacement of sodium chloride with magnesium chloride on microbiological quality of raw *Papads* during storage

The change in microbial quality of developed control and PM₁ *Papad* formulations stored in both LDPE and HDPE throughout the storage period are tabulated in Table 8. The results for TPC and YM count were given in terms of log of colony forming unit per gram (log cfu/g) of sample. It was observed that all *Papads* were free from bacterial growth during initial period up to 30 days in LDPE and 60 days in HDPE pouches. However no visible fungal growth was found throughout the storage period in both LDPE and HDPE. After 30 days of storage bacteria started to grow in *Papads* stored in LDPE. The permitted microbial load for fresh samples as per International Commission on Microbiological specifications for foods was 5 log cfu/g [28]. According to this both PM₁ and control formulations were shown the total plate count within the permissible limit even after 135 and

150 days of storage respectively. Though PM₁ formulation was under the safe microbial limit after 135 storage days and control after 150 days the *Papads* had rancid, undesirable musty odour because of rendering them organoleptically unacceptable. In high density polyethylene bacteria started to grow after 60 days of storage. Both PM₁ and control formulations had microbial load within the safe permissible limit after 270 days but because of occurrence of rancid, undesirable, off odour and texture loss PM₁ and control were rejected organoleptically after 255- and 270-days storage. Due to less availability of data on microbial shelf life of salt replaced black gram *Papad* the available research work related to *Papad* are mentioned here. Sorghum *Papads* could be stored safe up to 90 days without noticeable microbial growth [2]. Foxtail millet *Papad* can be stored for 120 days with safe microbial level but they were good for 30 days only in low density polyethylene because of high rancidity of foxtail millet [29].

Table 8: Effects of partial NaCl replacement and packaging material (LDPE and HDPE) on microbial properties of raw *Papads* during storage

Storage Days	LDPE				HDPE			
	Control		PM ₁		Control		PM ₁	
	TPC (log cfu/g)	YM (log cfu/g)						
0	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
30	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
45	3.699	Nil	3.732	Nil	Nil	Nil	Nil	Nil
60	3.924	Nil	3.991	Nil	Nil	Nil	Nil	Nil
75	4.114	Nil	4.230	Nil	2.978	Nil	3.100	Nil
90	4.491	Nil	4.556	Nil	3.134	Nil	3.241	Nil
105	4.643	Nil	4.702	Nil	3.326	Nil	3.412	Nil
120	4.732	Nil	4.820	Nil	3.643	Nil	3.760	Nil
135	4.839	Nil	4.857	Nil	3.929	Nil	3.959	Nil
150	4.914	Nil	4.982	Nil	4.009	Nil	4.041	Nil
165	4.944	-	-	-	4.196	Nil	4.248	Nil
180	-	-	-	-	4.255	Nil	4.314	Nil
195	-	-	-	-	4.303	Nil	4.365	Nil
210	-	-	-	-	4.380	Nil	4.449	Nil
225	-	-	-	-	4.438	Nil	4.486	Nil
240	-	-	-	-	4.480	Nil	4.521	Nil
255	-	-	-	-	4.505	Nil	4.542	Nil
270	-	-	-	-	4.547	Nil	4.582	Nil

*LDPE- Low density polyethylene, HDPE- High density polyethylene, TPC- Total plate count, YM- Yeast and mould count, Control- 100% NaCl, PM₁- 25% MgCl₂+75% NaCl, Nil – absent in sample, all values are mean ± standard deviation of three determinations and ‘-’ sample discarded

4. CONCLUSION

In present study, the effects of magnesium chloride replacement in development of black gram *Papad* was successfully analysed. The sodium chloride was replaced with magnesium chloride by 25% without causing adverse effect on sensory, physical, colour and chemical properties. The sodium content was reduced successfully from 258.91±0.12 mg/100g to 198.04±0.10 mg/100g. The shelf life of developed PM₁ *Papads* was recorded to be about 135 and 255 days in LDPE and HDPE respectively. Thus black gram *Papads* prepared with reduced level of sodium content could positively contributes to minimizing risk of hypertension related issues.

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