Plant Archives Vol. 18 No. 1, 2018 pp. 230-234 ***ISSN 0972-5210***

COMPARATIVE ASSESSMENT ON TEXTURAL PARAMETERS OF COMMERCIALLY AVAILABLE AND FORTIFIED POTATO CHIPS

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Abstract

Diseases like high cholesterol content and lactose intolerance, among some individual, has led to change in preferences towards foods other than milk to combat the deficiency of calcium. The discrepancy between calcium consumption and requirement has switched the interest of the consumers to calcium fortified products. Processed potato products such as potato chips are widely consumed among vulnerable (children and teenager), therefore can be used as an ideal carrier for targeted nutrient's delivery *i.e.* calcium. During potato crisp production, the raw material changes in both texture and color. These changes depend on both potato cultivar and process parameters. The present study was carried out to fortify potato chips with calcium and in turn observed the effect of mineral fortification on texture of chips in comparison with commercial available ones. Fortification of potato chips was done at 15 mm Hg vacuum pressure with GRAS fortificant of calcium (Calcium chloride, E509) using Box-Behnken design of Response Surface Methodology through vacuum impregnation technique. Results showed that optimized process conditions can fortify potato chips at 700mg/100g of calcium level having 460N hardness with acceptable sensory attributes. Textural parameters were found to be similar for both fortified and commercial chips in terms of less number of peaks before fracture and more no of peaks after fracture, reflecting good overall acceptability. Even, calcium fortified potato chips were found to be more acceptable, in terms of higher sensory scores (8.1 on 9-point Hedonic scale versus 8.0 of control preparation), to the consumers in organoleptic evaluation. Thus, mineral fortification for a widely acceptable potato based snacks can be helpful in changing the perception of consumers for potato based snacks from the category of 'Junk food to Healthy food'.

Key words: Vacuum Impregnation (VI), Fortification, Potato Chips, Calcium, Texture

Introduction

Potato (*Solanum tuberosum* L.) is the world's single most important non cereal crop with a vital role in the global food system (Burgos *et al.*, 2009). It is popularly known as the "Vegetable King" in terms of quantities produced and consumed worldwide. It is the world's most productive vegetable and provides a major source of nutrition and income to many population and communities, and its content in dry matter, edible energy and edible protein makes it of good nutritional quality (Singh and Raigond, 2014). Besides being used as a daily food item in various vegetable preparations, potato today increasingly consumed in the form of chips or wafers as snacks food. Potato chips and fries are popular processed food items that give considerable value addition to potatoes. Potato chips, also known as 'potato crisps', are popular salty snacks which is estimated to constitute nearly 85% of India's total market of salty snack food market of about − 2500 crore (Riangond *et al.*, 2015). Adolescents, because of their imprecise eating behaviour like consuming energy-rich, nutrient poor diets comprised of fast food, and processed foods are considered to be a nutritionally vulnerable segment of the population for mineral deficiency (Forthing 1991; Perry-Hunnicuft and Newman, 1993). Globally, in particular, an inadequate consumption of calcium over an extended period of time has been found to induce calcium deficiency risk among 3.5 billion people (Kumssa *et al.* 2014).

Dietary calcium, due to the number of processes it is involved in, the high amount present in the body, and the continuous research highlighting the benefits of an adequate intake, raises concern for consumers and health specialists. In recent years, the interest in calcium has been intensified because low calcium intake has been

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reported to be associated with osteoporosis, hypertension and many more disorders (Life extension update 2010). Most of the people manage their calcium demand from dairy products. However, concerns like comparative higher cost lactose intolerance, dietary fat, cholesterol and other related allergies, among some individuals, have led to switch their preferences from dairy to nondairy products.

Food fortification is considered a sustainable public health strategy because it can reach wider at-risk populations through existing food delivery systems without requiring major changes in existing consumption patterns (Das *et al.*, 2013). Compared to other interventions, food fortification is likely to be more cost-effective, and–if fortified foods are regularly consumed–it has the advantage of maintaining steady body stores (WHO/FAO 2006). Thus, calcium fortified non-dairy products will be one of the effective alternative to overcome the challenges arise due to difference in recommended and actual calcium dose (Konar *et al.* 2015). Among the technologies used in the development of Food fortification, Vacuum Impregnation (VI) have been reported as fast as well as low energy costs processes and an ideal non-thermal method for food fortification (Tiwari & Thakur, 2016). VI have been identified as a new innovative technique to enrich food not only with nutritional and functional components but also with the aim to obtain food with innovative sensorial properties as well as able to inhibit the most important bio-chemical degradation and the microbial growth (Deroosi *et al.*, 2010). Potato chips and fries, because of their porous matrix, affordable price, easy availability and wide acceptability among adolescents (10-19 yrs) can make it an ideal carrier for calcium fortification using VI technique.

Texture and flavor are of the most important attributes of fried foods and are also one of the major concerns while manufacturing of fried food products. Texture, apart from color, odour and flavor, is one of the most important quality attributes of finished products (fortified potato chips) which is the result of changes in the original structure of potato tissue during frying and VI (Sezin and Palazoðlu. 2017). Potato chips texture is often explained in terms of crispness, hardness and crunchiness. Crispness of potato chips are often determined by raw potato properties (low reducing sugar), manufacturing conditions (use of blanching before frying) (Salvador *et al.* 2009) and pre-drying after blanching (Pedreschi *et al.*, 2007). It has been also reported that use of calcium salts has been associated with increased firmness and extended shelf life.

Therefore, the current study has been designed to fortify calcium in potato chips using VI technology. The study was focused mainly on the effect of calcium fortification on textural properties of fortified chips in comparison with control and commercially available non-fortified potato chips. Organoleptic evaluation has also been performed by conducting consumer perception survey in order to observe the effect of fortification on the overall acceptability of the developed product.

Materials and Methods

Fresh harvest of potatoes (*Solanum tuberosum* L.) Cv. Kufri Chipsona-1 has been selected and procured from CPRI campus Modipurum, Uttar Pradesh for fortification purpose. Using standard package of practices (Kumar *et al.*, 2007) this cultivar was grown at CPRIC, Modipuram, India during winters of 2014–15 (*Rabi* season). The peels (upper 1.5mm layer) have been removed manually using a ceramic knife. Chips have been made using a commercial chips cutter (Make: Felix wafer maker Slim, Om Appliances, Rajkot, India) with an average thickness of 1.5±0.061mm as measured by Vernier Caliper.

Fortificants and carrier

Qualities like high bioavailability (≥ 90%), water solubility and neutral effect on taste and colour made calcium chloride (food grade & GRAS substances) the best among all the available fortificants for the calcium. Calcium chloride solution of different concentrations has been used for impregnation and the potato chips have been used as a carrier. Research work has been planned in such a manner that by consuming 30g of potato chips serving, the target level (21% RDI) of Ca can be achieved in accordance with Recommended Amount Customarily Consumed (RACC). The standard RDI value of calcium was calculated on the basis of 2000 calorie intake for young individual living sedentary lifestyle (www.lenntech.com/recommended-daily-intake.htm 2015). Keeping the respective RDI values of calcium in view for young individual (10-19 yrs) living sedentary lifestyle, the goal for calcium fortification were set at 700mg/100g with 456N hardness.

Statistical analysis

The statistical evaluation has been performed by running analysis of variance (ANOVA) and regression calculation using SAS (version 11). Each factor had three levels which were coded as -1, 0 and 1. The central points (coded as 0) for each factor were 3% calcium chloride, 1 min blanching time, 10 min vacuum time and 15 min rest time.

Texture Analysis

Joshi *et al.*, (2016) reported that average fracturability (hardness) of commercial available chips (Lay's classic salted) was 456.03 N. In order to meet the desired firmness of the commercial potato chips, developed fortified potato chips were also evaluated for the textural parameters like F_{max}, total number of peaks before and after breaking texture Analyzer (Stable Micro System, UK). On a hollow planar base, a chip was placed for analysis. The force was applied to the sample by using a cylindrical probe of 0.25mm diameter at a constant speed of 1mm/s until the sample was cracked. To determine the texture characteristics of the chips, force deformation data were recorded. The maximum force of break was indicated as the hardness of chips (Anguilera *et al.* 2004). The pre-test speed, test speed, post-test speed, distance, trigger type, data acquisition rate and load cell were set at 1.0 mm/s, 1.0 mm/s, 10 m/s, 3 mm, Auto-10 g, 500pps and 5 Kg, respectively.

SEM Evaluation

To further confirm the textural differences, structural changes in potato cells in chips before and after fortification were observed through SEM (Scanning Electron microscopy - EVO 18, Zeiss model). After time completion of 180 seconds, to evaluate the structural difference in fortified chips compared to Control chips SEM observation had been taken.

Organoleptic Evaluation

The developed products were organoleptically evaluated by a semi-trained panel of 20 judges from Amity Institute of Food Technology, Amity University, Noida, U.P., India. The judges were served each preparation with one control and two test samples of calcium fortified, and commercial potato chips. Control sample was prepared from ingredients used in the standard recipes and test samples were prepared by fortifying calcium chloride at 1 to 5% levels. The samples (through VI technique) were coded to avoid any bias. Each product was tested thrice and mean scores were calculated. Judges were asked to score the samples for color, appearance, flavor, texture, taste and overall acceptability using a score card of 9 point Hedonic Rating Scale.

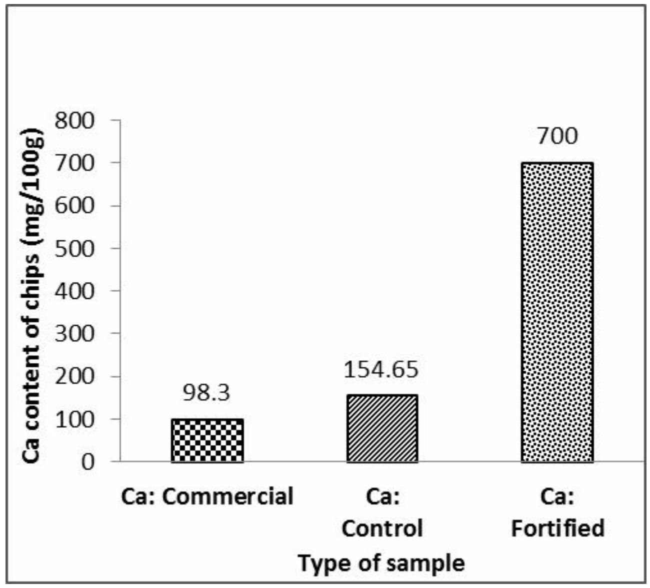


Fig. 1: Comparative chart for Mineral content in various types of chips.

Result and Discussion

The profound study showed that by using VI technique, it was possible to increase the concentration of calcium in the potato chips 154.65mg to 700 mg/100g (fortified) when compared to control fried potato chips preparations (fig. 1). The results of various experiments run showed that the range of calcium impregnation varied from 66.42 to 2449.94mg/100g, while hardness values varied from 321 to 591 N.

Texture of fortified and non-fortified potato chips

Table 1 showed the textural parameters of fortified and non-fortified potato chips. Typical force-deformation curve of fortified and non-fortified has been shown in

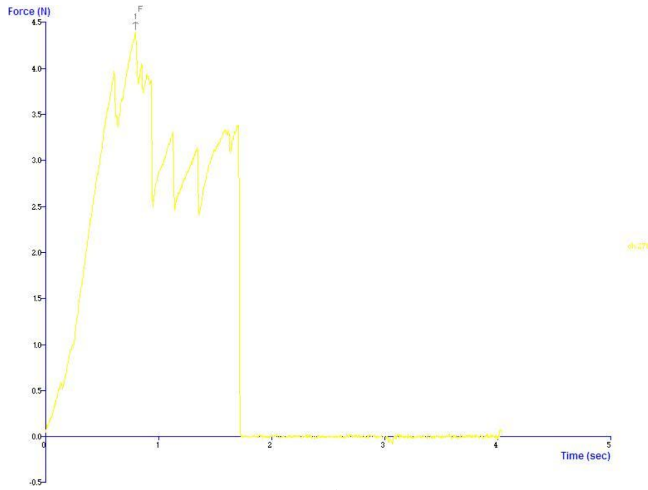
Table 1: Texture parameters of fortified and non-fortified potato chips.

Chips Sample	No. of force peaks before breaking	No. of force peaks after breaking	No. of total force peaks	Maximum Force (F_{max})(N)
Commercial Chips	1	7	8	456
Control Chips	1	9	10	410
Calcium fortified Chips	0	8	8	460

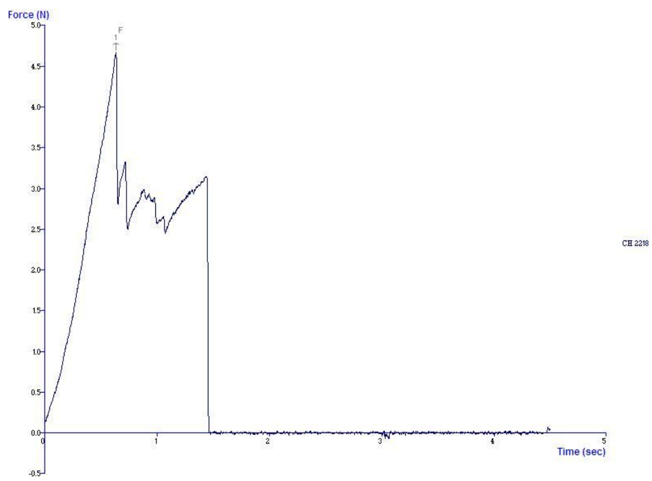
Table 2: Effect of calcium fortification on sensory evaluation of the potato chips

Potato Chips	Taste	Flavour	Colour	Texture	Overall acceptability
Commercial chips	8.30 ± 1.14^{a}	8.50 ± 1.10^{a}	8.36 ± 1.05^{ab}	8.39 ± 1.07^{a}	8.54 ± 0.93^{ab}
Control Chips	7.96 ± 1.09^{a}	8.07 ± 1.11^{a}	7.95 ± 1.31^{a}	8.20 ± 1.17^{a}	8.04 ± 1.01^{a}
Calcium Fortified Chips	8.14 ± 1.33^{a}	7.32 ± 1.12^{a}	8.36 ± 1.06^{ab}	8.68 ± 1.29^{a}	8.10 ± 1.07^{ab}

$^{a\text{-}l}$Values with the different letters within the same column are significantly different at $p < 0.1$. Mean ± SD (n=56). 1-9 scale: 1= dislike extremely. 9 = like extremely.



(a)



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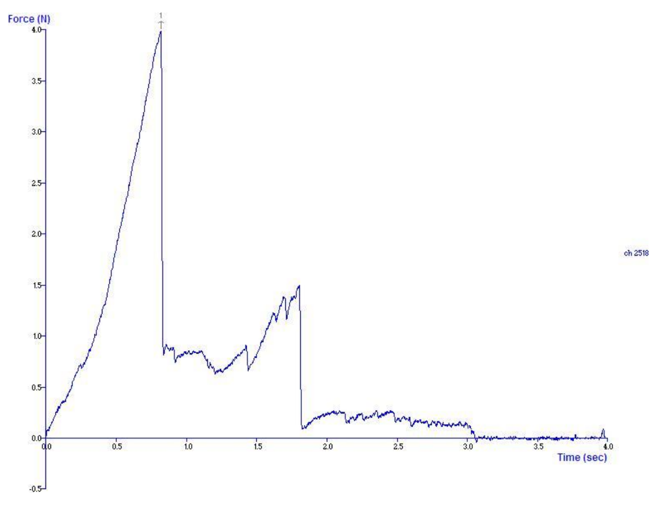

(c)

Fig. 2: Typical force-deformation curves of commercial (a) calcium fortified, (b) control, (c) potato chips

fig. 1. Maximum force value of calcium fortified and commercial (Lay's classic salted) were found to be similar *i.e.* 456 and 460 N. F_{max} was found to be 400N for control. This observation was in agreement with the results obtained by Saftner *et al.* (2003) that calcium salts has firming effect on textural characteristics. Results showed that calcium fortified chips were comparatively firm in texture and hence had better acceptability than control counter parts.

In general, the higher number of total force peaks was associated with higher number of total sound peaks and to $SPLmax_{10}$. As expected, in all the potato chips the number of force and acoustic peaks was lower in the first region (before breaking) than in the second region (after breaking), which confirms the fact that the main structural breakdown occurs in the second region. Calcium fortified chips showed the higher number of peaks, sound peaks and $SPLmax_{10}$. Chen *et al.*, 2005 reported that high number of force and sound peaks have been associated with high sensory crispiness. It was observed that in comparison with commercial chips, in calcium fortified chips this positive relation among number of peaks and sensory crispiness was found.

Structural effect of Calcium and Iron impregnation

The 100x magnification, in comparison to control there has been no significant difference in cell structure of calcium fortified potato chips. The structural changes are more evident by observing the SEM images at 500x. Under magnified view, it has been observed that granular structure did not differ but there have been deposition of calcium and iron in the periphery of cells in fortified chips. This has been the reason for unchanged mouth-feel of fortified chips.

Overall acceptability Evaluation

Values of sensory attributes evaluated are shown in table 2. Scores showed that overall acceptability of calcium fortified chips were similar to control and commercial potato chips. Calcium fortified chips was the sample with higher sensory crispiness and brighter color.

Conclusion

The present study showed that using vacuum impregnation technique, it was possible to increase the concentration of calcium in the potato chips from 154.65mg (control) to 700 mg/100g (fortified) under predefined process variables of the study. Total number of peaks and Maximum force for fortified as well as non-fortified chips were almost similar to each other reflecting good acceptance in terms of textural properties.

Acknowledgement

The authors gratefully acknowledge the support provided by Dr. Brajesh Singh, Head Division of Food

Science and Postharvest Technology (FS & PHT) ICAR-IARI, Shimla, Himachal Pradesh, India and Titen Biotech Limited, Delhi, India for providing fortificant.

References

Aguilera, J.M., L. Castro and L. Cadoche (2004). Structure property relationships in starch amorphous model. In: Proceedings of the 14th international drying symposium, Sao Paulo, Brazil, 1468–1472.

Burgos, G., S. Auqui, W. Amoros, E. Salas, and M. Bonierbale (2009). Ascorbic acid concentration of native Andean potato varieties as affected by environment, cooking and storage. *J Food Compos Analy*, **22**: 533-538.

Chen, J., C. Karlsson, and M. Povey (2005). Acoustic envelope detector for crispness assessment of biscuits. *Journal of Text Studies*, **36**: 139–156.

Das, J.K., R.A. Salam, R. Kumar and Z.A. Bhutta (2013). Micronutrient fortification of food and its impact on woman and child health: a systematic review. *Syst. Rev.*, **2**:67

Derossi, A., D.T. Pilli and C. Severini (2010). Reduction in pH of vegetables by vacuum impregnation: a study on pepper. *J Food Eng*, **99**: 9-15.

Forthing, M.C (1991). Current eating patterns of adolescents in the United States. *Nutr Today*, **26**:39.

Joshi, A., S.G. Rudra, V.R. Sagar, P. Raigond, S. Dutt, B. Singh and B.P. Singh (2016). Singh Development of low fat potato chips through microwave processing. *J Food Sci Technol*, doi:10.1007/s13197-016-2304-y.

Konar, N., E.S. Poyrazoglu and N. Artik (2015). Influence of calcium fortification on physical and rheological properties of sucrosefree prebiotic milk chocolates containing inulin and maltitol. *J. Food Sci.Technol*, **52(4)**: 2033–2042.

Kumssa, D.B., J. Edward, M. Joy, E. Louise Ander, J. Michael, D.Watts Scott, S.W. Young and R.B. Martin (2015). Dietary calcium and zinc deficiency risks are decreasing but remain prevalent. Scientific Reports 5, Article number: 10974, doi:10.1038/srep10974.

Kumar, P., S.K. Pandey, S.V. Singh and D. Kumar (2007). Irrigation requirements of chipping potato cultivars under West Central Indian plains. *Potato J.*, **34**:193–198.

Life extension update (2010). Insufficient calcium may link hypertension, osteoporosis doi:http://www.lifeextension.com/Newsletter/2010/6/Insufficient-Calcium-May-Link-Hypertension-Osteoporosis/Page-01.

Pedreschi, F., P. Moyano, N. Santis and R. Pedreschi (2007). Physical properties of pre-treated potato chips. *J. Food Engineering*, **79**: 1471–1482.

Perry-Hunnicuft, G. and I.M. Newman (1993). Adolescent dieting practices and nutrition knowledge. *Health Values*, **17**: 35-40.

Raigond, P., B. Singh, A. Dhulia, S. Chopra and S. Dutt (2015). Flavoring compounds in Indian potato snacks. *Food Sci. Techn.*, **52**: 8308–8314.

Saftner, R.A., J. Bai, J.A. Abbott and Y.S. Lee (2003). Sanitary dips with calcium propionate, calcium chloride, or calcium amino acid chelates maintain quality and shelf stability of fresh- cut honeydew chunks. *Postharvest Bio and Techn.*, **29**: 257- 269.

Salvador, P., T. Varela and S.M. Sanz Fiszman (2009). Understanding potato chips crispy texture by simultaneous fracture and acoustic measurements, and sensory analysis *LWT - Food Science and Technology*, 763–767.

Singh, D. and P. Raigond (2014). Potatoes: a complete food. Agropedia. Retrieved from: www.agropedia.iitk.ac.in/node/56899.

Sezin Tuta, T. and Koray Palazoðlu (2017). Effect of baking and frying methods on quality characteristics of potato chips, *Gida,* **42 (1)**: 43-49.

Tiwari. P. and M. Thakur (2016). Vacuum impregnation: A novel non-thermal technique to improve food quality. *Int. J. Curr. Res. Bioscci. Plant Biol.*, **3(7)**:117-126.

WHO/FAO (2006). Guidelines on Food Fortification with Micronutrients. Geneva: World Health Organization/Food and Agriculture Organization of the United Nations.

www.lenntech.com/recommended-daily-intake.html (2015). Recommended daily intake of vitamins and minerals. Accessed 04 March 2015.