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Betanins Rich Purple Potato Chips: An Innovative Fusion Product with Enhanced Functionality

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Abstract—*Enriching potato chips with bioactive betanins pigments is an innovative and non-transgenic approach of enhancing antioxidant activity of processed potato products. Betanin glycosides (BG) known for their remarkable pH stability and GRAS status can successfully replace synthetic pigments in foods. Having high α-glucosidase inhibitory activity (GIA), the BG not only imparts an attractive purple color to potato chips but also help in managing type-2 diabetes. The present study was designed to explore the potential of infusing BG into potato matrix to transform hitherto unhealthy image of potato chips into a low fat functional product by developing an innovative fusion product using microwave processing. Potato chips were made by a commercial processing variety Kufri Chipsona-2. Effect of blanching; betanins concentration and infusion time on the betanins content in raw and microwave processed potato chips was determined using Response Surface Methodology (RSM). Beet root juice (cv. Crimson Globe) extracted after various pre-treatments was used for infusion of betanins in potato matrix under atmospheric pressure. Blanching duration, infusion time and concentration of betanins in infusing medium ($p< 0.05$) was found to be the major factors influencing the infusion process. Prior blanching (72°C at 1 min), significantly reduced the infusion time by 1.5 to 2 folds. Results suggest that it is feasible to infuse betanin pigments ranging from 200- 500 mg/kg in the potato matrix, depending upon the functionality required in the end product. Colour attributes in terms of RGB (174, 56, 114) further confirms, strong purple colour of the developed product. Infusion of betanins and phenolics increased the antioxidant activity in potato chips and imparted α- glucosidase inhibitory activity. This methodology is an innovative way of transforming, starchy, low antioxidant image of potato chips into a low fat functionally enriched healthy product.*

1. INTRODUCTION

Enriching potato chips with bioactive betanins pigments is an innovative and non-transgenic approach of enhancing antioxidant activity of processed potato products. Betanins glycosides (BG) known for their remarkable heat stability and GRAS (Generally Recognized as Safe) status can successfully replace synthetic pigments in foods. Betanins are water-soluble vacuolar pigments which show remarkable stability in various pH range of food matrix. Betanins are well known for their pharmacological properties and when included in the human diet, they exhibit a wide range of antioxidant protection and therapeutic benefits [1] and [2]. Having high α-glucosidase inhibitory activity (GIA), the BG will not only impart an attractive purple color to potato chips but also help in managing Type-2 diabetes.

India, with 48.60 million ton production (2016-17), is the second largest producer of potatoes in the world after China (State Departments of Horticulture & Agriculture, 2018). Potato chips and French fries are widely consumed processed products from potato among all age groups. The present processing percentage of potatoes is 7.61 which is predicted to be enhanced by 20.57% by the year 2050 as per the VISION-2050 of ICAR-CPRI. Therefore, **processing is required in more versatile and innovative dimensions to suit consumers' expectations**. Functional foods, Reduced-fat and Reduced-energy foods for weight control are the requisites for health conscious populace today. Since potato based snacks having high in fats and carbohydrates, low in fibre are known to be a significant source of fat and energy intake, therefore suffered from **high dietary restraint category** and generally pronounced as **'JUNK FOODS'** by the consumers. A protocol for developing low fat potato chips using microwave processing was standardized and further studies for enhancing

its functionality are being explored through beet root pigments [3].

Potato flesh in its original form is poor source of phenolics. However, potato's porous nature provides great opportunity in the form of ideal matrix to impregnate bioactive/functional/essential components like betanins through osmosis. Betanins used to substitute synthetic pigments for their attractive colour and physiological functionality [4]. Use of natural food colorants in impregnation is expected to have dual value by providing exotic colour and enhancing nutritional status of foods, besides being more appealing and rewarding [5]. **Thus, the present study was designed to explore the potential of infusing betanins glycosides (BG) into potato matrix to transform hitherto unhealthy image of potato chips into a low fat functional product by developing an innovative fusion product.**

Target to be achieved: Maximum Permitted Levels (MPLs) of betanins (E 162) have been defined in commission regulation (EU) No. 1129/2011 as food additive. Currently, betanins (E 162) prepared by physical means from fruits and vegetables are authorized food coloring substances in the EU with a MPLs of 200 mg/Kg of food in fruit flavoured breakfast cereal alone or in combination with E 120 and E 163. **The targeted level of betanins in present study was 286 mg/Kg of raw potato flesh (50% of MPLs)** keeping thermal degradation of betanins during microwaving into consideration.

2. MATERIAL AND METHODS

2.1. Material

Potato chips were made by a commercial processing variety K. Chipsona-2 (Fig 1a) using microwave heating. The cultivar was grown at CPRIC, Modipuram, India during winters (*Rabi* season) in 2017-18 using standard package of practices [6]. Potato tubers after skin curing were stored at elevated temperature (10-12^{0}C) storage chambers using sprout suppressant CIPC or Chloropropham treatment till utilized [7]. Beet root (cv. Crimson Globe) was procured from Vegetable Science division of ICAR-IARI, Delhi cultivated under standard pacakage of practices. Standard environmental condition was maintained for prelcooling and curing treatment of beetroots (Fig 1b).

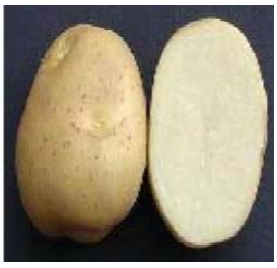

Fig. 1a: Potato (cv. K. Chipsona-2)

Fig. 1b: Beet roots (cv. C. Globe)

2.2. Methods:

2.2.1. Betanins quantification: Total betanins were calculated as total miligram equivalent of betacyanins and betaxanthins per Kg of matrix by spectrophotometer method using 80% methanol as solvent after solvent optimization.

Betacyanins and betaxanthins content were determined according to methods given by Castellar et al. [8] and Stintzing et al. [9]. Betacyanins were detected at 535 nm and betaxanthins at 484 nm, according to the equation (1):

Betacyanins or betaxanthins content [mg/L] = [(A × DF × MW × 1000/ ε × L)]------(1)

where: A = absorbance at 535 or 480 nm, DF = dilution factor, MW = molecular weight, ε = extinction coefficient, L = width of the spectrophotometer cell (1 cm), For betacyanin the extinction coefficient is 60,000 L/(mol cm) and MW = 550 g/mol. For betaxanthins the extinction coefficient is 48,000 L/(mol cm) and MW = 308 g/mol.

2.2.2. Microwaved Potato chips development: Microwave processing of potato chips was done to make low fat potato chips (Joshi et al. 2016).

2.2.3. α- glucosidase inhibitory activity: For α-GIA, standardization was done using ELISA plate reader as per the methodology suggested by McCue et al.[10] with slight modification explored by Raigond et al. [11]

2.2.3. Betanins extact preparation: Betanins extract obtained after various pre-treatments (Enzyme assistant, freshly crushed and vacuum dried) from Beet root (cv. Crimson Globe) juice and used for infusion of potato chips at atmospheric pressure.

2.2.4. Process Parameters Optimization: The effect of degree of blanching; betanins concentration and infusion period on the betanins content in raw and microwave processed potato chips was determined using a three-level three-factor Box–Behnken design.

3. RESULTS

3.1. Betanins qualntification and extraction

In the first phase of study, methodology for betanins quantification was standardized. Water, 80% methanol and

Ethanol-HCl (80:20 ratio) as solvent system were tried for this purpose. Since **80% methanol was found the best for betanins quantification** and hence was used during whole investigation. Enzyme assisted betanins glycosides (BG) concentrate had the highest betanins content (1434mg/100g) followed by freshly crushed (436mg/100g) and then vacuum dried (251mg/100g). However, microwaved blanching was required to inhibit Polyphenol Oxidase (PPO) activity of BG substrate followed by immediate and direct cooling.

3.2. Microwave Processing

Lower drying rate from 3.12 x 10^{-4} to 1.95 x 10^{-3}Kg H_2O/Kg db at 180 and 300W under microwaving was found to impart boiling effect however higher drying rate ranging from 1.54 x 10^{-2} to 2.30 x 10^{-2} Kg H_2O/Kg db at 450 and 600 W was associated with development of crispness. Therefore, it became possible to make potato chips without addition of oil/fat with acceptable structure, texture and color attributes through microwaving (Fig 2a). **The chips thus developed had approximately 90% lesser fat than their conventional counterparts.**

In second phase of investigation, betanins infusion study was conducted in low fat microwaved chips rather than fried potato chips **as literature suggested that from a low fat product more efficient delivery of functionality can be expected**.

3.3. Infusion of Betanins

Blanching time, length of infusion time and concentration of betanins in infusing medium ($p< 0.05$) was found to be the major factors influencing the infusion process. Prior blanching (72°C at 1min), significantly reduced the infusion time by 1.8 to 2 folds. Results suggest that it is feasible to infuse betanins content ranging from 200- 500 mg/Kg, depending upon the functionality required in the end product. Colour attributes in terms of (RGB) 174, 56, 114 further confirms, strong purple colour (Fig 2b) of the developed product. Fig 2c & 2d is showing effect of microwave heating on color stability of potato chips. Lower absorbance of the developed chips compare to control showed that betanins infusion imparted **α-GIA** to the potato chips.

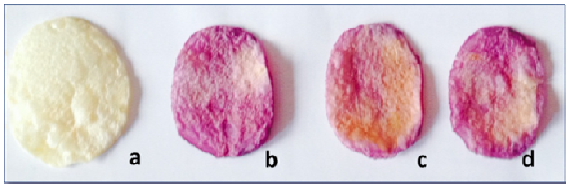

Fig. 2: (i) Microwaved (b) Betanins infused chips (c,d) Thermal degradation of betanins under microwaving

4. CONCLUSION

Infusion of betanins and phenolics, increased antioxidant activity in potato chips and imparted α- glucosidase inhibitory activity seems an innovative way of transforming, high starchy, low antioxidant image of potato into a health product. Except colour, all other sensory scores were at par with the microwaved controlled chips. The developed product has the potential to change the perception of consumers for potato based snacks from the category of **'JUNK FOODS TO HEALTH FOODS'---A THIRD GENERATION POTATO SNACKS---**

The developed technology is a **successful initiative** to provide functionality without transgenic approaches to potato based snacks which can easily be adopted by the small and large scale industry with very nominal capital investment. However, scale up studies and consumer trials on large scale are still required to carry out the study further and a long way.

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