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Anthocyanin infused watermelon rind and its stability during storage

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ABSTRACT

Anthocyanins from *Garcinia indica* Choisy was impregnated in watermelon rind (WMR) through osmotic dehydration. The impregnation of anthocyanin was enhanced by application of pretreatments like vacuum and sonication (from 24 to 32 mg/100 g). Application of pretreatment during impregnation changes the tissue architecture of the WMR which helps in retaining the infusate during candy making process. The developed product from WMR was highly acceptable w.r.t. texture, taste and appearance. Moisture sorption study indicated that the WMR product was quite stable at ambient temperature upto 75% RH. Storage of the sample in LDPE (low density polyethylene pouches) and PET/LDPE (Polyethylene terephthalate/low density polyethylene pouches) did not show any significant difference in moisture content, anthocyanin degradation, texture, taste and appearance of the product. The WMR product was stable for 90 days at ambient storage conditions.

Industrial relevance: The knowledge provided by this work may be useful the development of new product (watermelon candy) from watermelon rind impregnated with anthocyanin. The extent and rate of infusion of anthocyanin was enhanced by application of pretreatments like vacuum and sonication. The developed product had highly acceptable texture, taste and appearance. The product was quite stable at ambient temperature upto 75% RH in LDPE (low density polyethylene pouches) and PET/LDPE (Polyethylene therapthalate/low density polyethylene pouches) pouches without significant difference in moisture content, anthocyanin degradation, texture, taste and appearance of the product. The WMR product was stable for 90 days at ambient storage conditions. This technique may be helpful in producing foods with enriched bioactive compounds, besides providing diversified products in terms of taste and nutrition.

1. Introduction

Functional food is a natural or processed food that contains known biologically-active compounds which in defined quantitative and qualitative amounts provides a clinically proven and documented health benefit, and thus, an important source in the prevention, management and treatment of chronic diseases of the modern age (Martirosyan, 2011). Business Communications Company (BCC) research estimated that the global market of functional food industry has reached 176.7 billion in 2013 with a compound annual growth rate (CAGR) of 7.4%. Functional foods are an emerging field in food science due to their increasing popularity with health-conscious consumers and the ability of marketers to create new interest in existing products. Mixing of the functional ingredient in solid system is not as easy as in case of the powder and liquid products. An example of this type of fortification would be the historic addition of iodine to table salt, or Vitamin D to milk. Fermented foods with live cultures are considered functional foods with probiotic benefits. Impregnation of physiologically active compounds such as minerals (Gras et al., 2002, Barrera et al., 2004, Ortiz et al., 2003), phenolic compounds (Rózek, Achaerandio, Almajano, et al., 2007; Rózek, Achaerandio, Güell, et al., 2007; Rózek et al., 2008, 2009; Rózek, Achaerandio, et al., 2010; Rózek, García-Pérez, et al., 2010), curcuminoids (Bellary et al., 2011, Bellary and Rastogi, 2012, 2013, 2015), probiotics (Betoret et al., 2003, Alzamora et al., 2005, Puente et al., 2009), and vitamins (Lin et al. 2006, Hironaka et al. 2011) into solid food tissue by employing osmotic treatment has been demonstrated by many researchers.

A natural colorant can serve as a functional health ingredient as it enhances marketability of the end product. Color in foods drive other sensory attributes of the product, defines the nutritional value of the product and provides emotional attribute for consumer behaviour (Bellary and Rastogi, 2012). Anthocyanins constitute the largest and probably the most important group of water-soluble natural pigments (Takeoka & Dao 2002). To date, there have been more than 635 anthocyanins identified in nature, and such a versatile group is responsible for the vivid blue, purple, and red color of many fruits, vegetables, and flowers (Anderson & Jordheim, 2008). Anthocyanins belong to a large

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group of polyphenolics named flavonoids, which are secondary metabolites synthesized by higher plants. However, only six of them are commonly found in nature, and approximately 95% of all anthocyanins are derived from these six anthocyanidins (aglycones): cyanidin (Cy), peonidin (Pn), pelargonidin (Pg), malvidin (Mv), delphinidin (Dp), and petunidin (Pt) (Eder, 2000; Kong et al., 2003). Anthocyanins are used as food colorants primarily in the beverage industry. As public concern about synthetic food dyes has increased recently, consumers and food manufacturers desire colorants from natural sources. As promising alternatives to the most widely used synthetic food dye FD&C Red #40 (Allura red), anthocyanins are attracting great interest by the food industry and consumers (He and Giusti, 2010).

Garcinia indica Choisy (popularly known as kokum) is an underexploited fruit species, which is a rich source of anthocyanins. It is a rich source of anthocyanins. Anthocyanins are considered as a potential replacement for synthetic colors because of their bright attractive hue and water solubility that allows their incorporation into aqueous food systems; they may also possess several health benefits (Nayak, Chethana, Rastogi & Raghavarao, 2006; Nayak, Rastogi & Raghavarao, 2009). Red color from kokum fruit was first reported by Krishnamurthy and co-workers (Krishnamurthy et al., 1982). They reported that the red color is due to the presence of anthocyanins such as cyanidin 3-glucoside and cyanidin 3-sambubioside. Kokum has been reported for the treatment of dysentery, tumours, heart complaints, stomach acidity and liver disorders (Bhaskaran & Mehta, 2007, Krishnamurthy et al., 1982).

Recently, it the use of fruit and vegetable waste to reduce environmental pollution has taken a boom, taking into account, that these residues are important sources of nutrients. Agricultural and industrial residues are attractive sources of natural antioxidants and dietary fiber. New by-product application should be investigated to have a positive environmental impact or to turn them into useful products. Fruits like watermelon, which have a short shelf life and are sold for only a short season during the summer, can benefit from this process to make it more versatile for use in different products. Only a few studies have dealt with drying of watermelon, mainly osmotic dehydration of the pulp (Falade et al., 2007) and spray-drying of the juice (Quek et al., 2007), but none have dealt with the pomace and enriching it with nutraceuticals. The *Citrulluslanatus* fruit has a smooth exterior rind (green, yellow and sometimes white and a juicy, sweet interior flesh). The rind is used to make preserves and jellies (Dane et al., 2004; Dane and Liu, 2007). In China, they are stir fried, stewed or more often pickled. The de-skinned and de-fruited rind is cooked with olive oil, garlic, chilli-pepper, scallions, sugar and rum (Mandel et al., 2005). In some cases the rind is used to make various dishes like jam (Souad et al., 2012), crystallized fruit (Gontero et al., 2010) and cake (Al-Sayed & Ahmed, 2013). However, most of the times, the rind is thrown as waste after eating the sweet fruit. The rind contains citrulline, a nonessential amino acid that plays an important role in the human body's urea cycle, which removes nitrogen from the blood and helps convert it to urine, that's where citrulline helps create arginine, another amino acid. Interestingly, the largest amount of citulline is concentrated in the shell, the white part that almost nobody uses (Rimando & Perkins-Veazie, 2005).

Watermelon fruit can be categorized as three main components which are the flesh, seed, and rind. Watermelon constitutes approximately 68% flesh, the rind 30%, and the seeds 2% of the total weight. Watermelon rind is one of the major solid waste generated by several restaurants, cottage fruit juice producers and so on. Unfortunately, more than 90% of the rind is discarded indiscriminately into the environment thereby constituting environmental challenges. This waste rind is not presently being utilized for any value added processes due to limited research activities focusing on the possible conversion of the waste to other valuable products thereby making it available for dumping as solid waste (Souad et al., 2012). Watermelon rind has a water content of about 95% making it susceptible to deterioration. Therefore, it is necessary to reduce the moisture content and produce shelf stable products from watermelon rind. Because of the high moisture content of watermelon rind it is very difficult to develop a shelf stable product. Infusion of nutraceutical in solid food matrix is equally difficult.

The objective of the present work is infusion of kokum anthocyanins in watermelon rind through osmotic dehydration treatment to develop a candy like product and to study the shelf life of anthocyanin infused watermelon rind candies.

2. Materials and methods

2.1. Preparation of sample

The watermelon rind (WMR) was subject to the procedure of selection from fruit vendors, washed and rind was separated from the edible part if present. Then, the external green cuticle was eliminated from the rind (around 4 mm).

2.1.1. Blanching of samples

The rind was diced into cubes of approximately 10 mm each side in a manual dicer and blanched in boiling water (95 °C) for 5 min (Gontero et al., 2010). Then the blanched samples were cooled in running water, later the surface moisture was removed by blotting gentally with a tissue paper, and then samples were used for anthocyanin impregnation.

2.1.2. Preparation of anthocyanin extract

Anthocyanin from the kokum was extracted as per Nayak and Rastogi (2010) from dry source. Fifty gram of the dry kokum fruit was taken for extraction. The fruits were washed and mixed with 1:10 ratio of acidified water (0.1% hydrochloric acid). The extract was filtered using a muslin cloth. Anthocyanin concentration and total soluble solids in the extract were found to be 168.63 mg/L and 5–6 Brix, respectively. The extract was stored in a cold room at 4–5 °C and drawn as and when required for the experiment within 7 days.

2.1.3. Osmotic treatment for anthocyanin impregnation

For infusion the experiments were carried out as per Bellary et al., 2011. Anthocyanin extract was directly used for infusion. The blanched WMR dices were immersed in the anthocyanin extract for a period of 4 h. The WMR dices were subjected to vacuum and ultrasonication treatment as reported by Bellary and Rastogi, 2014. During infusion initially the blanched samples were subjected to vacuum of 20 kPa for 30 min further during restoration period the samples were subjected to intermittent ultrasonication treatment (5 min on and 25 min off cycle) upto 4 h of period. Later the WMR dices were removed from the extract and blotted with tissue paper to remove external moisture. These pieces were pre-weighed and subjected to candy making through osmotic treatment in respective vessels containing osmotic solutions of varying concentration (30, 40, 50, 60 and 70° Brix of sugar solution containing anthocyanin extract). Ratio of the volume of the sample to that of osmotic solution during impregnation and candy making was maintained at 1:5, in order to confirm that the surrounding solution concentration did not vary significantly during the experiment. At the end of 24 h of immersion time during candy making, the samples were withdrawn and blotted gently with tissue paper to remove adhering osmotic solution and at that time weighed. The samples with high anthocyanin content were further subjected to a series of sucrose concentration for candy making process from 30 to 70° Brix. All the experiments were done in triplicate, and the average value were reported. The flow chart for preparation of WMR candies/rolls is presented in Fig. 1.

2.2. Estimation of moisture and solute content

The moisture and solute content were expressed in terms of kg of water/kg of initial dry solids and kg of solids/kg of initial dry solids,