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Optimization of microwave power and curing time of turmeric rhizome (*Curcuma Longa* L.) based on textural degradation

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ABSTRACT

Microwave based curing operation for turmeric rhizome (Curcuma Longa L.) was planned in this study. Parameters were optimized based on textural degradation (hardness) of rhizome due to starch modification. Conventional and improved conventional microwave assisted curing (MCC & MICC) of turmeric rhizome was investigated at two power levels (900 and 600 W) at different time (2, 4, 3 and 5 min) and compared to conventional (CC) and improved conventional curing (ICC) process (boiling in water or alkali for 45min). ANOVA showed time had more significant effect based on hierarchy of F value at $p < 0.0004$ as compared to power on textural degradation. High retention of curcumin was observed in MCC and MICC but with lower hardness when compared to CC and ICC. Optimized conditions based on hardness for MCC and MICC was found to be 900 W for 4min. Evaluation of starch modification in terms of WHC, RVA, XRD and SEM for optimized conditions showed desirable changes in MCC and MICC cured turmeric as comparable to that of CC and ICC. Thus, microwave technology can be used as an alternative method for curing of rhizome to produce turmeric powder with minimum loss of quality, lower process time and energy.

1. Introduction

Turmeric is a popular Indian spice derived from the rhizomes of *Curcuma longa* which is a member of the ginger family. The bright yellow color of turmeric comes mainly from fat-soluble, polyphenolic pigments known as curcuminoids comprising of curcumin (C_1), demethoxy curcumin (C_2) and bis-demethoxy curcumin (C_3) which are reported to have medicinal and therapeutic properties. Turmeric is also reported to have potential in treatment of cancers, cardiovascular diseases, inflammation and Alzheimer's disease (Asghari, Mostajeran, & Shebli, 2009). India is by far the largest producer and exporter of turmeric in the world and also consumes almost 80% in the form of condiment, dye, flavour and cosmetics due to its essential oils. Another use of turmeric powder which is worth mentioning is its use in curry powder for preparation of various dishes word wide. Processing of turmeric rhizome involves washing, cutting, curing, drying, grinding and packing. Conventional curing is performed by boiling of rhizome in water for 45 min to one hour at 100 °C until froth appears at the surface and the typical turmeric aroma is released (FAO., 2004). This prolonged heating leads to modification (gelatinization) of the starch to obtain uniform drying, softer texture, remove the fresh earthy odour and produced good-quality turmeric with respect to curcuminoid content and uniform pigment distribution (Prathapan, Lukhman, Arumughan, Sundaresan, & Raghu, 2009). Overcooking of rhizome leads to color deterioration and undercooking makes it brittle. Therefore optimum cooking is attained when the rhizome yields to finger pressure and can be perforated by a blunt piece of wood (FAO., 2004). Another improved method is boiling rhizome in alkaline solution of 0.05%–1% sodium carbonate, or lime named Improved Conventional Curing (ICC) which mainly helps in the improvement of color. However both these methods (CC and ICC) has certain disadvantages such as leaching of curcumin and oleoresins, energy and labour intensive, handling losses and overcooking of rhizomes due to prolonged cooking.

Recently some quick heating technologies are applied in food application viz. microwave heating, ohmic heating etc which may be employed to overcome the shortfall of CC and ICC method to bring about the desirable changes in texture, color and flavour comparable to that of CC and ICC. Microwave heating is gaining much popularity in food processing applications namely

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pretreatment, drying, tempering, cooking, pasteurization, sterilization, baking and extraction (Puligundla et al., 2013; Canumir et al, 2002). Microwave heating basically works on the principle of volumetric heating which means the material can absorb microwave directly and internally and convert it into heat due to dipole moment and ionic interactions leading to quick heating rates with desirable effects on the texture and minimum loss of nutritional properties (Chandrasekaran, Ramanathan, & Basak, 2013; Matsui, Gut, Pedro Vitoriano de Oliveira, & Tadini, 2008). Vadivambal & Jayas, 2007 reported microwave heating as an efficient blanching process to inactivate enzymes in fruits and vegetables as it allows efficient heat transfer with little or no water and thereby reducing the nutrient loss through leaching when compared to conventional hot water blanching. It is also reported that dielectric heating affects the cellular matrix of food due to vaporization of volatile compounds and eventually leading to swelling and rupturing of the cells (Dandekar & Gaikar, 2002). This phenomenon leads to textural modification. Benlloch-Tinoco et al., 2013 reported inactivation of enzymes by microwave technology to obtain stable kiwifruit puree with an improved antioxidant capacity. However effect of microwave pretreatment on texture of fruits and vegetables is still limited and requires further investigations. Therefore, the present study was planned to investigate the feasibility of microwave based curing comparable to CC and ICC. The process parameters were optimized based on textural degradation of rhizome due to starch modification. Further textural change in terms of starch modification was evaluated using RVA, SEM, XRD and WHC.

2. Materials and methods

2.1. Raw materials and preparation of samples

Turmeric rhizome was procured from the local village farm near Tezpur University Campus, Assam. The turmeric rhizomes were cleaned, washed, packed and stored under refrigerated condition at 4 °C for further experimentation. The initial moisture content of the purchased rhizome was measured using a hot air oven method and was found to be 80–85%.

2.2. Curing or treatment methods

2.2.1. Conventional curing method (CC)

Turmeric rhizome (100 g) were peeled and cut into uniform sizes (10 mm cube) manually using a sharp knife and thereafter dipped in water in a steel container added at a rate of 250 ml/100 g of sample. The sample was cooked in boiling water for 45min according to the method as per FAO., 2004. The water was then drained and the surface moisture was wiped off with tissue paper. It was then dried in hot air drying oven at 60 °C for 6 h to bring the moisture content up to safe level of 10%. The dried samples were grinded in laboratory grain mill using 200 μm sieve and then stored in plastic packets in desiccator for analysis.

2.2.2. Improved conventional curing method (ICC)

Improved conventional method was performed according to the method given by Lokhande, Kale, Sahoo, & Ranveer, 2013. Uniformly cut 100 g samples (10 mm cube) were dipped in alkaline solution of 0.1% sodium bicarbonate ($NaHCO_3$) added at a rate of 250 ml/100 g of sample. The sample was cooked in boiling alkaline solution for 45min (as per FAO., 2004) and thereafter water was drained and the surface moisture wiped off with tissue paper. The later steps were performed similar to the conventional curing method.

2.2.3. Microwave assisted curing

The uniformly cut rhizomes (10 mm cube) were dipped in a glass container containing water for microwave conventional curing (MCC) and 0.1% $NaHCO_3$ solution for microwave improved conventional curing (MICC) at the rate of 250 ml/100 g of sample. Microwave treatment was applied in a microwave oven (Samsung, Model no: CE 104VD, Malaysia) at two selected power i. e, 900 W and 600 W for different time viz. 2, 3, 4 and 5min (Srivastava, Hmar & Kalita, 2016). The water was thereafter drained and wiped with tissue paper followed by drying as per the procedure followed for conventional curing. The detailed experimental conditions with their respective code is presented Table 1.

2.3. Textural degradation by compression test

The compression test for estimation of textural degradation in terms of hardness of fresh and cured turmeric rhizome was performed using Texture Analyzer (TA.HD Plus) of Stable Micro System and supporting software Exponent Lite. A half inch cylindrical probe was used (P/0.5, 12 mm diameter) with a load cell of 100 kg to check the hardness of the cured samples for 20% strain. The experiment was carried out in triplicate to reduce the error.

2.4. Curcumin content

The curcumin content was estimated as per the method described by FSSAI, 2012. Fresh and cured turmeric powder were extracted with 95% ethanol. Standard curcumin solution was prepared similarly in ethanol (0.0025 g/litre). The Intensity of yellow color of both extract and standard was measured at 425 nm in a spectrophotometer (Shimazu, Japan) and curcumin content was calculated from the following equation

$$Absorptivity\ of\ Curcumin, A = \frac{a_1}{L\ x\ c}$$

$$\text{Curcumin content}\ \left(\frac{g}{100g}\right) = \frac{a_2\ x\ 125\ x\ 100}{L\ x\ A\ x\ m}$$

where,

a_1 = absorbance of standard solution at 425 nm
a_2 = absorbance of extract at 425 nm
L = cell length in cm
c = concentration in gm/litre
m = mass of gm in sample

2.5. Visual color inspection

The change in color of fresh and cured turmeric rhizome was determined visually from images taken with a 21.2 Megapixel camera (Canon PC-1474) after the curing process. For homogeneous light conditions during image acquisitioning, a wooden black walled chamber was used. A hole of 5 cm on top of the box was made for holding the camera in position and the samples were illuminated using two fluorescents tubes, TL-D deluxe, Natural daylight, 18 W (Philips, USA) with a color temperature of 6500 K (*D65*, standard light source commonly used in food research).

2.6. Optimization of curing process

Hardness was measured for all fresh and cured turmeric rhizome in triplicate using texture analyzer. The optimization of process parameters for MCC and MICC were carried out on the basis of the desirability function for hardness after curing using