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Influence of drying temperature on physico-chemical and techno-functional attributes of elephant foot yam (*Amorphophallus paeoniifolius*) var. *Gajendra*

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ABSTRACT

Elephant foot yam is a salubrious but underutilized tuber. Being rich in starch as well as various bio-actives (phenolics), it offers dual-functionality. The study was undertaken to obtain *Amorphophallus* flour that can be utilized in various food applications. Pre-cooked *Amorphophallus* paste was dried in convective air dryer at varying temperatures (50, 60 and 70 °C) and milled into a powder. The powders were then analyzed for physico-chemical and techno-functional aspects. Drying temperature markedly affected the color, techno-functional attributes including pasting properties, phenolic content and anti-oxidative capacity of *Amorphophallus* powder; the oxalate content remained unaffected by drying temperature. Decrease in whiteness index and increase in browning index were noticed with rising drying temperature. All gelatinization-viscosity parameters (peak, trough, breakdown, final and setback viscosity) showed a decline with rising drying temperature while an increasing trend was observed for pasting temperature. Significant differences were also observed in flavor and mouth-feel ($p < 0.05$) scores of *Amorphophallus*-milk dispersion and were maximum for powder obtained upon drying at 60 °C. The nutritional and thickening potential of yam could very well be utilized in hybrid-dairy foods.

1. Introduction

Elephant foot yam (EFY) (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), a high potential tuber, is referred to as 'King of Tuber Crops' because of its high yield potential, culinary properties and medicinal utility (Sengupta, Chowdhary, Singh, & Ray, 2008). The dry matter content in the tuber ranges from 17.5% to 24.0%, starch from 13.9% to 21.5%, sugar from 0.55% to 1.77%, protein from 0.84% to 2.60% and fat from 0.07% to 0.37% (Chattopadhyay, Saha, Pal, Bhattacharya, & Sen, 2010). Therapeutic uses of EFY include *arsa* (hemorrhoids), *pliha* (splenic disorders), *gulma* (tumor conditions), *svasa* (breathing disorders), *kasa* (cough) and *asthila* (prostate disorder). Its role against cytotoxic and apoptic potential against human colon carcinoma cell line HCT-15 has been proven (Ansil, Wills, Varun, & Latha, 2014). Various health and recuperative benefits of EFY have been well described by Dey, Ota, Srikanth, Jamal, and Wanjari (2012). Due to its nutritional advantages, the EFY can be consumed regularly (Sangeeta & Hathan, 2016).

Apart from aforementioned functional benefits, EFY is a rich source of starch and therefore a potential thickening agent. Starch imparts body and mouth-feel to the product (Verbeken, Baela, Thasb, & Dewettincka, 2006). It has the ability to gelatinize upon heating in the presence of water leading to increase in the viscosity. This phenomenon eventually influences the texture and stability of various foods such as sauces, cream soups, pie fillings, salad dressing, cake toppings, gum confections etc.

Since EFY has a high moisture content, drying could facilitate its easy preservation by removal of free moisture. Drying, one of the oldest and efficient preservation techniques, causes microbial spoilage to subside as water is removed (Xiao, Gao, Lin, & Yang, 2010). Additionally, drying causes a reduction in weight and volume of product, thus accounting for savings during packaging, transportation and storage. Conventionally, sun drying is preferred to obtain EFY powder, but the process is slow and uncontrolled because it is affected by weather changes. Hot air drying (tray drying) is much quicker, controlled and economically feasible drying technique that can be employed in developing nations for a better and uniform product. Hot air drying produces several physical and chemical modifications in the product i.e. color, phenolic

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level, anti-oxidative potential, pasting properties, sensory behavior, which are largely temperature dependent and affect the product quality. The quality of the product obtained after drying is important because minimal damage to its dual-functionality i.e. bioactive constituents (phenols), anti-oxidative potential (Vashisth, Singh, & Pegg, 2011) and pasting properties, could possibly govern the usage of EFY powder in value-added foods as well as in foods where thickening/ stabilizing potential of EFY powder is desirable. Use of EFY as an ingredient in dairy foods would be greatly facilitated if it is converted into powdered form. Convective drying of EFY has not been studied so far. Hence, the objective of the study was to assess the impact of various drying temperatures (50, 60 and 70 °C) during hot air drying on EFY powder in terms of color parameters, phenolic content, anti-oxidative potential and techno-functional properties.

2. Materials and methods

2.1. Raw Material

Fully mature globose corms of elephant foot yam (var. *Gajendra*) harvested in the month of March were purchased from Navsari Agriculture University, Navsari, Gujarat, India. The EFY was washed, peeled and diced into $2 \times 2 \times 2$ cm cubes. The cubes were immediately dipped in 0.1% potassium metabisulphite (Himedia Laboratories, Mumbai, India) solution (5 min) to prevent browning. The cubes were then blanched in boiling water (cubes:water–1:6) for 10 min, cooled, packed in nylon pouches (Hitkari Industries Ltd., Parwanoo, India) and stored in the freezer (-20 ± 2 °C) until further analysis.

2.2. Powder preparation

To obtain yam powder, EFY cubes, boil-cooked for 10 min, were converted to homogeneous paste in a mixer (Maxie food processor, Inalsa Appliances, Noida, India), and the paste (~510 g) was evenly spread on stainless steel trays (55×30 sq. cm.) of a tray dryer (Accolab Instruments and Equipments, Ambala Cantonment, India). The dryer was run for 60 min to obtain steady conditions before placing the product in the dryer. The paste in trays was then subjected to hot air current at the desired temperatures (50, 60 and 70 °C). Drying was continued until the yam paste acquired a brittle consistency (Njintang & Mbofung, 2006). The dried paste was allowed to cool and then scraped off from the trays, coarse-ground in a mixer and then fine-ground in a colloid mill (1093 Cyclotec, Foss Tecator, Hoganas, Sweden). The powder thus obtained was packaged in poly-pouches and stored.

2.3. Physical properties

The color profile of a product measured as Hunter coordinates L*, a* and b* represents a quantitative analysis of the color components, L* quantifying degree of gray on a scale ranging from 'absolute white' (100) to 'absolute black' (0), a* quantifying the red component (positive values) or green component (negative values), and b* measuring the yellow (positive values) or blue (negative values) component. Hunter color values (L*, a* and b*) of EFY powder were measured employing spectro-colorimeter, (Colorflex-45/0, Hunter Lab, Reston, VA, USA) and converted to whiteness index (WI) from formula as shown;

$$W\,I = 100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}}$$

Browning Index of the powder samples was determined as per Krishnan, Padmaja, Moorthy, Suja, and Sajeev (2010). Powder (4 g) was extracted with 80% ethanol (20 ml) (Himedia Laboratories) at 30 ± 1 °C for 30 min (stirring at 5 min intervals), under darkness. The clear supernatant was obtained through centrifugation at 2253 g (~4000 rpm) for 20 min (2–16 PK, SIGMA Laborzentrifugen, Osterode am Harz, Germany). The absorbance was immediately measured at 420 nm using spectrophotometer (Genesys 10 UV, Thermospectronic, Madison, WI, USA).

The volume displacement method described by Hsu, Chen, Weng, and Tseng (2003) was used to determine true density (PD), bulk density (BD), and porosity of EFY powder.

2.4. Techno-functional properties

Distilled water (5 ml) was added to the sample (0.2 g) and Vortexed (Spinix-vortex shaker, Tarsons Products, Kolkata, India) for two minute and then centrifuged at 700 g for 20 min. Water absorption index (WAI) and water solubility index (WSI) were then determined as per Anderson, Conway, and Peplinski (1970).

Oil absorption index (OAI) was determined according to the method of Liadakis, Floridis, Tzia, and Oreopoulou (1993). Refined corn oil (Sigma-Aldrich, St. Louis, MO, USA) (2 g) was mixed with sample. The mix was left undisturbed for 30 min and then centrifuged at 700 g for 20 min. The free oil was weighed to calculate OAI.

Pasting properties of EFY powders were measured on a Rapid-Visco-Analyser (RVA-4 Newport Scientific Pvt. Ltd., Warriewood, Australia), a viscoamylograph, which is a rotational, continuously recording viscometer with variable heating, cooling and shear capabilities. The General Pasting Method given by the instrument supplier was used for determining the pasting behavior. About 2.5 g of powder was transferred into a canister and approximately 25 ml distilled water was added (corrected to compensate for 5% moisture basis). The slurry was heated to 50 °C and stirred at 960 rpm for 10 s for thorough dispersion, followed by constant stirring at 160 rpm. The slurry was held at 50 °C for up to 1 min, and then heated to 95 °C in 3 min 42 s and held at 95 °C for 2 min 30 s, and cooled to 50 °C in 3 min 48 s and holding at 50 °C for 2 min. Each analysis took 13 min to complete. Viscosity values and pasting temperature were obtained directly from the pasting curve using Thermocline 2.2 software supplied by the manufacturer.

2.5. Chemical properties

For oxalate estimation, oxalate was extracted from powder and determined, as per the procedure described by Okombo and Liebman (2010), with minor modifications. About 1–2 g sample was weighed into a 250 ml Erlenmeyer flask with 50 ml of 2 M HCl (Qualigens Fine Chemicals, Mumbai, India). The flask was covered with aluminum foil and placed into water bath (Laboratory Glassware Co., Ambala Cantonment, India) at 75 °C for 30 min with intermittent swirling (5 min). The flask was then allowed to cool and 50 ml of deionised water was added and swirled. The mixture was centrifuged for 10 min at 1267 g (~3000 rpm). The supernatant was then filtered into plastic vials and refrigerated prior to oxalate analysis. For soluble oxalate extraction, distilled water was utilized. The extracted samples were then analyzed for oxalate using the oxalate kit (Trinity Biotech Co., Wicklow, Ireland).

The total phenolic content, DPPH and ABTS activity of EFY powder were determined for aqueous and methanolic extracts of powder. One gram of sample was weighed and dispersed in 25 methanol/water. The mix was shaken for 3 h. The solution was then centrifuged at 4000 rpm (~2253 g) for 30 min. The supernatant was collected and stored at −20 °C until analysis. The total phenolic content was determined as per Kahkonen, Hopia, and Vuorela (1999). Standard curve was prepared using gallic acid