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Pearl millet incorporated sweet potato choco-filled cookies

K. Athira[1,2], C. Pradeepika[2*], T. Krishnakumar[2], M.S. Sajeev[2], K. Hanume Gowda[3]

[1]School of Biosciences, Mar Athanasios College for Advanced Studies, Tiruvalla 689101, Kerala, India
[2]Section of Crop Utilization, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram-695017, Kerala, India
[3]Regional Station, ICAR-Central Tuber Crop Research Institute, Bhubaneswar-751001, Odisha, India

Abstract

Sweet potato and pearl millet are good sources of dietary fiber and health protective antioxidants with potential protection against chronic oxidative stress commonly associated with pathogenesis of non-communicable chronic diseases (NCDs). Therefore, targeting sweet potato and pearl millet in ethnic or functional food design address chronic oxidative stress-linked NCD challenges such as early stages of type 2 diabetes and its associated complications has significant merit. Thus, the aim of this study was to standardize the formulation for the development of pearl millet incorporated sweet potato choco-filled cookies. Among the eight different formulations based on completely randomized design, treatment five (T5) showed significantly higher nutritional and sensory characteristics. The protein content ranged between 2.61 to 4.75 mg 100 g^{-1} dry weight (dw), starch 39.59 to 45.58 mg 100 g^{-1} dw, fiber 0.21 to 0.51 mg 100 g^{-1} dw, ash 3.52 to 6.48 mg 100 g^{-1} dw. In addition, micronutrient analysis revealed the presence of good amounts of micronutrients such as calcium (0.99 to 3.40 ppm), iron (1.05 to 1.67 ppm), magnesium (0.27 to 0.34 ppm), zinc (0.16 to 0.27 ppm), and copper (0.04 to 0.09 ppm). Results of this study indicated that the compsotion containing 40% of sweet potato, 40% of pearl millet, and 20% of wheat flour showed higher nutritional and sensory attributes compared to other formulations.

Keywords: Sweet potato flour, Pearl millet flour, Composite flour, Choco-filled cookies

Introduction

Snacks are increasingly considered as ‘mini-meals’ packed with essential minerals and vitamins that satisfy sweet, spicy, savory, or salty cravings in between regular meals. Health-conscious customers are becoming more interested in snack foods that are high in nutritional components including dietary fiber and micronutrients. Designing snack foods with greater functionality requires the development of a variety of nutritive snack products from tropical tuber crops, such as cassava, sweet potato, elephant foot yam, yams, arrowroot, etc., by carefully optimizing cooking parameters to stabilize the health-promoting components. As a result, nutritious snack foods made from tropical tuber crops have become more essential in diets across Africa, India, Indonesia, the Philippines, and other countries in order to combat risk factors for the development of non-communicable diseases and avoid vitamin A deficiency. Snacking is preferred all around the clock in today’s world, no matter when or where hunger hits. Additionally, customers are constantly searching for more convenient, natural, and healthful snack options.

The need for nutritious snacks was sparked by the COVID-19 epidemic, which put a strong emphasis on health and wellness, as well as by changing tastes and lifestyles. Global consumption of snack products surges during the COVID-19 epidemic. Increased comfort, a happier attitude, and a more relaxed sensation

* Corresponding author
E-mail: pradeepika.chintha@icar.gov.in; Ph: +91 9701801805

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are some of the causes of this development (Statista Research Department, 2023). The snack food industry's international trade group, SNAC International, which represents over 400 companies globally, has revealed the top trends in the market, including natural flavors and colors, reduced sugar content, sustainable goods, and additive-free options.

Global snack food revenue was estimated to be US$539.30 billion in 2023, and it is predicted to increase by 6.34% yearly (CAGR 2023 to 2028). According to studies, the snack food market in India is projected to generate US$66.9 billion in sales in 2023 and is predicted to increase at a rate of 9.01% per year (CAGR 2023 to 2028). According to IIFPT (2023), there are three categories of ready-to-eat snacks: first-generation snacks, which are made entirely of natural ingredients and include products like potato chips, nuts, and popped popcorn; second-generation snacks, which are made with just one ingredient and include tortilla and corn chips; and third-generation snacks, which are made with multiple ingredients.

A lot of food firms are creating new snack products to expand their market share and enhance the flavor profile. Due to their greater diversity in flesh color (white, off-white, cream, orange, and purple) and high content of nutritional components sweet potatoes can offer various human health benefits like antioxidant, antidiabetic, and antihypertensive properties, sweet potatoes are becoming more and more recognized as a super food among various tropical tuber crops (Chintha et al., 2023). Furthermore, pearl millet ranks as the sixth most significant cereal crop, followed by sorghum, rice, wheat, maize, and barley. Additionally, pearl millet has an excellent nutritional profile, is high in micronutrients like iron and zinc, and can help prevent malnutrition and covert hunger (Satyavathi et al., 2021). Thus, two super food ingredients, *viz*., sweet potato and pearl millet, were used in this study to create chocolate-filled cookies and the nutritional qualities, pasting properties and physical attributes of different formulations were examined.

Materials and Methods

Materials

Sweet potato (var. Sree Arun) tubers grown in the experimental farm of ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) were collected. After harvesting, tubers were graded, sorted and diseased and damaged tubers were discarded. Then, the tubers were washed in clean water to remove the adhering dirt. Peeled tubers were cut into small circular chips of 5 mm thickness. Later, chopped sweet potato chips were dried in sunlight for 36 h to reduce the moisture content to $<10\%$. After drying, chips were powdered into a fine flour and stored in airtight container for further use. Pearl millet flour, wheat flour, butter, sugar, eggs were purchased from the local market.

Preparation of choco-filled sweet potato-pearl millet cookies

Eight formulations of choco-filled cookies were made by using sweet potato, pearl millet and wheat flours. The formulations comprised of sweet potato flour (SPF), pearl millet flour (PMF), and wheat flour (WF) in different proportions as shown in Table 1, and treatment T8 was the control made from 100% wheat flour. Cookies were prepared by creaming method for making the dough. The ingredients used were SPF-PMF-WF blends-100 g, powdered sugar-30 g, unsalted butter-50 g, baking powder-1 g, gelatinized starch-15 g, and egg-10 g. The dough was prepared in a dough mixer and sheeted to a thickness of about 5 mm, and cut into circle shape of 30 mm diameter. Then, 2 g dark chocolate ball was inserted inside the individual cookies and again made sheets for individual cookies before transferring to a baking tray. Cookies were baked at 180°C for 15 min. Later, the cookies were cooled to ambient temperature and packed in airtight containers.

Table 1. Formulations of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treatment	Sweet potato flour (%)	Roasted pearl millet flour (%)	Wheat flour (%)
T1	50	50	0
T2	45	45	10
T3	67.50	22.50	10
T4	22.50	67.50	10
T5	40	40	20
T6	60	20	20
T7	20	60	20
T8	0	0	100

Determination of proximate composition

The moisture, starch, crude protein, fat, ash and crude fiber contents of different samples of choco-filled cookies were determined as per standard methods (AOAC 2000).

Determination of water activity

The water activity (a_w) of choco-filled cookies was measured in triplicate at room temperature using an AQUA LAB 4TE water activity meter (Decagon Devices, Inc.).

Micronutrient analysis

Micronutrient analysis (Ca, Mg, Fe, Mn, Zn and Cu) of choco-filled cookies was carried out using an Atomic Absorption Spectrometer (Perkin Elmer PinAAcle 900H model) (Piper, 2019). The results are expressed in ppm.

Determination of functional properties of composite flours

The water and oil absorption capacities of sweet potato and pearl millet composite flour (SPP-CF) were measured according to a protocol described by Mirmoghtadaie et al., (2009). Briefly, 1 g samples of the composite flours (CF) were taken in a pre-weighed 50 ml centrifuge tubes into which 10 mL of ionized water and sunflower oil were added respectively to measure water and oil absorption capacities. After 30 min of standing time, centrifugation at 3000 rpm was done for 10 min. The supernatant was discarded, and the weight of the tube was noted after the complete removal of excess water and oil. The water absorption and oil absorption capacities were calculated by dividing the weight of water/oil absorbed by the weight of the sample and expressed in grams of water/oil retained per gram of CF. The bulk density of CF treatments was determined as per the method of Goula and Adamopoulos (2004). Two grams of SPP-CF was added to the 10 ml measuring cylinder. Five hand taps were given to the cylinder containing CF and bulk density was calculated by dividing the weight of the flour by the volume and expressed in g cm^{-3}. The swelling capacity of SPP-CF was measured by the method recommended by Okaka and Potter (1977). Each SPP-CF sample was taken into a 100 ml measuring cylinder and made up to the volume with distilled water. Later, the contents were mixed by inverting the cylinder by tightly covering the top of the cylinder. After 2 min, the cylinder was brought back to its original position and left undisturbed for 8 min and the volume occupied by the sample suspension was noted. The foam capacity and stability of SPP-CF were determined by the method described by Seena and Sridhar (2005) with slight modifications. The PDM samples were homogenized for two minutes. The volume of CF solution was noted after and before the shear. Foam stability was measured by keeping the CF contents at a standstill for 1h at ambient temperature.

Pasting properties

The pasting properties of SPP-CF were measured using a Rapid Visco Analyzer (RVA) (Perten, RVA-TECMASTER). Reported mean values are the average of 3 samples per treatment.

Physical dimensions of choco-filled cookies

The physical dimensions like diameter (cm) and thickness (cm) of choco-filled cookies prepared from various treatments of SPP-CF were measured with a graduated scale and the spread ratio was calculated using the equation reported in AACC, 1967.

Experimental design and statistical analysis

Results were expressed as mean of triplicate analyses. Statistical analysis of data was carried out using Data Expert software (version 15). Significant statistical differences between treatment effect and interaction effect of sweet potato and pearl millet flour for all experimental runs were determined using Tukey's least square means separation at the 0.05 probability level.

Results and Discussion

Proximate composition of choco-filled cookies

The proximate analysis estimates the macronutrients such as protein, fat, carbohydrate, ash, and moisture content present in the food samples. These values are proclaimed as nutritional facts displayed on the nutrient labels of the product. Among several proximate components, moisture content and water activity are the key components for determining the keeping quality of food products. Lower levels of moisture content (<12%) and water activity (<0.45 a_w) are desirable for the prolonged storage life of the developed food products (Van Hal, 2000). Moisture content of choco-filled cookies was found in the range of 2.14% (T7) to 4.73% (T3) as shown in Table 2. In the present study, water activity was found lower (<0.57 a_w, 0.51 to 0.56 a_w) for choco-filled cookies (Table 2). The starch content of the cookies ranged from 43.36 to 50.45% dw (Table 2) and the starch values for cookies were found similar to the starch content reported by Nor et al., (2021). Furthermore, results showed a highly significant ($p < 0.05$) effect of SPF and pearl millet flour (PMF) on the starch content of the cookies. The total sugar content ranged between 8.78% (T1) to 10.56% (T5) (dw; Table 2). The results of ANOVA showed a significant ($p<0.001$) effect of the interaction of SPF and PMF on the total sugar content in the present study. The protein content is one of the key parameters determining the nutritional aspects of developed food products and it varies between dry food mixes and food products prepared due to its thermo-sensitive nature. The protein content was in the range of 2.62% (T2 & T3) to 4.76% (T8) dw (Table 2) among the choco-filled cookies treatments in this study. Similarly, protein results were reported by Nor et al., (2021) in cookies prepared by different substitution levels of sweet potato flour.

Ash content constitutes minerals (inorganic residue) present in the samples after ignition and absolute oxidation of organic matter (Monti et al., 2008). The ash content of choco-filled cookies was analyzed to understand if the developed product could provide micronutrients, and it ranged from 3.53% (T2) to 6.50% (T4) (dw; Table 2). In this study, a significant ($p<0.05$) effect of SPF and PMF on ash content was observed. The crude fiber content ranged between 0.21% (T8) to 1.44% (T1) (dw, Table 2) and the fat content from 27.48% (T3) to 31.50% (T1). The range was found similar to the results of sweet potato and wheat flour based cookies as reported by Nor et al., (2021).

Table 2. Proximate composition and water activity of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treat-ment	Moisture (%)	Starch (%)	Total Sugar (%)	Protein (%)	Ash (%)	Fiber (%)	Fat (%)	Water activity (a_w)
T1	4.13±0.05[d]	47.35±0.02[e]	8.78±0.00[g]	3.04±0.11[f]	3.75±0.02[f]	1.45±0.01[a]	31.50±0.00[a]	0.55±0.05[b]
T2	4.65±0.10[b]	46.87±0.00[f]	9.57±0.01[f]	2.62±0.14[g]	3.53±0.00[g]	1.44±0.02[b]	31.32±0.04[b]	0.55±0.01[b]
T3	4.73±0.00[a]	50.45±0.13[a]	10.45±0.10[b]	2.62±0.19[g]	3.75±0.10[f]	0.52±0.01[d]	27.48±0.05[h]	0.55±0.00[b]
T4	3.21±0.45[g]	47.86±1.02[c]	9.74±0.00[e]	3.05±0.00[e]	6.50±0.09[b]	0.34±0.11[f]	29.3±0.07[e]	0.54±0.02[c]
T5	4.10±0.10[e]	45.99±0.02[g]	10.56±0.11[a]	3.5±0.01[b]	6.54±0.01[a]	0.72±0.10[c]	28.59±0.11[g]	0.54±0.00[c]
T6	3.51±0.05[f]	48.78±0.00[b]	9.78±0.00[d]	3.07±0.00[d]	5.55±0.00[d]	0.44±0.00[e]	28.87±0.00[f]	0.54±0.02[c]
T7	2.14±0.07[h]	47.65±0.19[d]	10.45±0.09[b]	3.48±0.01[c]	5.18±0.04[e]	0.33±0.02[g]	30.77±0.13[c]	0.51±0.05[d]
T8	4.44±0.11[c]	43.86±0.05[h]	10.11±1.00[c]	4.76±0.02[a]	6.49±0.00[c]	0.21±0.00[h]	30.13±0.00[d]	0.56±0.00[a]

*Values presented are the mean ± standard deviation. Different letters in column represent significant interaction effect of sweet potato and finger millet flour at $p<0.05$

Micronutrient analysis of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Micronutrients are essential to the body for maintaining the health and well-being of an individual. In this study, Ca, Mg, Fe, Mn, Zn, and Cu contents were studied for different treatments of choco-filled cookies. Among different micro mineral nutrients, Ca, Fe and Mg were found in higher amounts than other minerals (Table 3). The Ca, Mg and Fe contents of the cookies were in the range of 0.90 ppm (T1) to 2.81 ppm (T2), 0.26 to 0.34 ppm and 0.99 ppm (T5) to 3.97 ppm (T2), respectively. In addition, Zn and Cu levels were analyzed for different treatments of choco-filled cookies and Zn ranged between 0.15 ppm (T5 & T6) to 0.23 ppm (T8). Lowest micro nutrient observed was the Cu it ranged between 0.03 to 0.08 ppm.

Functional characteristics of choco-filled cookies

The functional properties of sweet potato-pearl millet-wheat composite flour based choco-filled cookies are presented in Table 4. The determination of functional properties of CF is important before the formulation of any food products to understand their behavior in CF-based food matrices (Awuchi et al., 2019). Hence, in this study, the interaction effect of SPF and PMF is explored by studying functional properties like bulk density (ranged from 0.50 to 0.54 g ml^{-1}), water absorption capacity (1.09 to 2.23 g g^{-1}), oil absorption capacity

Table 3. Micronutrient composition of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treatment	Calcium	Magnesium	Iron	Zinc	Copper
	(ppm)				
T1	0.90±0.00[h]	0.34±0.04[a]	1.89±0.12[b]	0.17±0.00[f]	0.03±0.09[e]
T2	2.81±0.02[a]	0.26±0.00[g]	3.97±0.00[a]	0.21±0.12[b]	0.03±0.00[e]
T3	1.21±0.10[e]	0.26±0.01[e]	1.59±0.01[d]	0.17±0.00[e]	0.05±0.02[c]
T4	1.20±0.00[f]	0.26±0.05[d]	1.15±0.00[g]	0.18±0.01[c]	0.06±0.00[b]
T5	1.42±0.01[b]	0.23±0.00[h]	0.99±0.00[h]	0.15±0.00[h]	0.03±0.10[e]
T6	1.34±0.00[d]	0.27±0.09[c]	1.38±0.02[f]	0.15±0.00[g]	0.04±0.02[d]
T7	1.36±0.05[c]	0.29±0.04[b]	1.65±0.01[c]	0.17±0.11[d]	0.07±0.00[b]
T8	0.98±0.00[g]	0.26±0.10[f]	1.57±0.00[e]	0.23±0.02[a]	0.08±0.00[a]

*Values are mean ± standard deviation, Different letters in column represent significant interaction effect of sweet potato and finger millet flour at $p<0.05$.

(0.83 to 1.09 g g^{-1}), swelling capacity (12.32 to 23.21 g ml^{-1}), foaming capacity (1.96 to 5.19%), and foam stability (10.56 to 19.22%). Bulk density represents the porosity, flowability and relative packaging volume of the material which is a key factor in storage, food processing, and transportation (Igbabul et al., 2014). In this study, a significant ($p<0.05$) effect of SPF and PMF, and their interaction on bulk density was observed. The highest bulk density was observed in the treatment, T6 (0.54 g ml^{-1}) (Table 4), whereas the lowest was observed for T3 (0.50 g ml^{-1}).

Water absorption capacity (WAC) is an important functional property used to understand the flour's ability to absorb water and it indicates the quantity of water required during the dough preparation step (Ngoma et al., 2019). Moreover, WAC is influenced by many factors such as the presence of proteins, carbohydrates, polar or charged side chains, etc. in the flour used for food product development (Awuchi et al., 2019). The WAC was studied for sweet potato and pearl millet based CF treatments to understand the interaction between SPF and PMF for the development of choco-filled cookies. The WAC ranged between 1.09 g g^{-1} (T3) to 2.23 g g^{-1} (T2) and the results of ANOVA showed a significant ($p<0.05$) effect of SPF and PMF and their interaction on the WAC (Table 4). Furthermore, the higher WAC of SPF and PMF based CFs suggests suitability of SPF and PMF for the preparation of various baked products and infant formulations (Awuchi et al., 2019).

Oil absorption capacity (OAC) is a key component of functional properties for determining mouth feel, retention of flavor, and improvement of palatability of food products (Iwe et al., 2016). Hence, flours with suitable OAC are created as functional food ingredients for the preparation of food products such as sponge cakes, sausages, whipped toppings, etc. The OAC was determined in this study to determine the suitability of SPF and PMF based CF for the preparation of choco-filled cookies. The OAC of choco-filled cookies were in the range of 0.83 g g^{-1} (T7) to 1.09 g g^{-1} (T8). There was a significant ($p<0.001$) effect of SPF and PMF, and their interaction on the OAC in the present study. The swelling capacity of the cookies was in the range of 12.32 g ml^{-1} (T4) to 23.21 g ml^{-1} (T6) with significant ($p<0.001$) effect of SPF and PMF. These results agree with higher swelling capacities of CFs containing higher proportions of potato flour, green gram, and rice flour (Chandra et al., 2015).

Pasting properties of sweet potato-pearl millet-wheat composite flours

The pasting properties of sweet potato-pearl millet-wheat composite flours are presented in Table 5. Pasting temperature indicates the requirement of minimum temperature for gelatinization of the starch sample (Kaur and Singh, 2005). A significant ($p<0.05$) effect of PMF, and an interaction of SPF and PMF ($p<0.05$) on pasting properties was observed. The pasting temperature of different CF treatments ranged from 89.65°C (T7) to 76.27°C (T3) (Table 5), the control (WF) showed pasting temperature of 87.22°C. This lower gelatinization temperature of SPF indicates the greater availability of starch granules to amylolytic enzymes during food processing as reported by Julianti et al. (2017). Peak viscosity reveals the swelling power and disruption capacity of starch granules at elevated temperatures of 95°C by depicting the characteristic peak in the RVA graph (Corke et al., 1997). In this study, a significant ($p<0.05$) effect of SPF, PMF, and their interaction effect was found on the peak viscosity. Among CF, the highest peak viscosity was observed for wheat flour based choco-

Table 4. Functional characteristics of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treatment	Bulk density (g ml^{-1})	Water absorption capacity (g g^{-1})	Oil absorption capacity (g g^{-1})	Swelling capacity (g ml^{-1})	Foaming capacity (%)	Foaming stability (%)
T1	0.51 ± 0.08^{cd}	1.36 ± 0.01^{d}	1.01 ± 0.00^{b}	18.45 ± 0.10^{c}	3.55 ± 0.00^{b}	19.72 ± 0.01^{a}
T2	0.52 ± 0.01^{abc}	2.23 ± 0.00^{a}	1.03 ± 0.15^{ab}	16.01 ± 0.02^{e}	4.69 ± 0.02^{a}	15.40 ± 0.10^{b}
T3	0.50 ± 0.04^{d}	1.09 ± 0.11^{f}	1.03 ± 0.11^{ab}	19.20 ± 0.11^{bc}	3.75 ± 0.12^{b}	19.22 ± 0.11^{a}
T4	0.53 ± 0.06^{a}	1.36 ± 0.15^{d}	0.92 ± 0.00^{c}	12.32 ± 0.15^{f}	5.19 ± 0.00^{a}	10.56 ± 0.14^{c}
T5	0.52 ± 0.00^{ab}	1.84 ± 0.01^{b}	0.86 ± 0.01^{cd}	17.05 ± 0.09^{d}	3.79 ± 0.01^{b}	19.72 ± 0.00^{a}
T6	0.54 ± 0.09^{a}	1.33 ± 0.00^{d}	0.90 ± 0.17^{c}	23.21 ± 0.01^{a}	2.20 ± 0.02^{c}	10.72 ± 0.18^{c}
T7	0.51 ± 0.02^{bcd}	1.19 ± 0.00^{e}	0.83 ± 0.21^{d}	12.34 ± 0.00^{f}	3.57 ± 0.00^{b}	14.60 ± 0.00^{b}
T8	0.53 ± 0.00^{a}	1.52 ± 0.02^{c}	1.09 ± 0.00^{a}	20.00 ± 0.07^{b}	1.96 ± 0.00^{c}	19.07 ± 0.12^{a}

*Values are mean ± standard deviation, Different letters in column represent mean values that statistically significant $p<0.05$.

Table 5. Pasting properties of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treat-ment	Peak temperature (°C)	Peak viscosity (RVU)	Trough viscosity (RVU)	Final viscosity (RVU)	Breakdown viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)
T1	77.95±0.01[e]	453.0±0.01[d]	334.5±0.01[d]	668.0±0.05[e]	118.5±0.00[e]	333.5±0.02[ef]	5.43±0.00[bc]
T2	79.97±0.02[c]	436.5±0.03[d]	294.5±0.00[d]	648.5±0.00[ef]	142.0±0.01[cde]	354.0±0.01[e]	5.33±0.02[cd]
T3	76.27±0.00[f]	422.5±0.00[d]	292.5±0.02[d]	581.5±0.02[f]	130.0±0.00[de]	289.0±0.00[f]	5.13±0.05[e]
T4	89.63±0.00[a]	604.00± 0.00[b]	458.0±0.02[b]	1091.5±0.01[b]	146.0±0.02[cd]	633.5±0.02[b]	5.50±0.01[bc]
T5	89.22±0.04[ab]	582.5±0.01[b]	396.0±0.00[c]	979.0±0.00[c]	186.5±0.01[b]	583.0±0.00[c]	5.40±0.01[cd]
T6	78.27±0.02[d]	522.0±0.00[c]	393.5±0.00[c]	829.0±0.01[d]	128.5±0.00[de]	435.5±0.00[d]	5.23±0.00[de]
T7	89.65±0.00[a]	588.0±0.01[b]	428.5±0.00[bc]	1040.0±0.00[bc]	159.5±0.01[c]	611.5±0.00[bc]	5.56±0.00[ab]
T8	87.22±0.01[b]	987.5±0.00[a]	664.0±0.01[a]	1372.0±0.05[a]	323.5±0.00[a]	708.0±0.03[a]	5.63±0.02[a]

*Values are mean ± standard deviation, RVA parameters values are the average of two determinations, RVU-Rapid Visco Unit, Different letters in column represent mean values that statistically significant at $p<0.05$.

filled cookie formulation (987.50 RVU) followed by T7 (588 RVU) and T5 (582 RVU) (Table 5). Julianti et al., (2017) reported a similar trend of lower peak viscosity for SPF based composite flours compared to wheat flour. Lower peak viscosities among SPF and PMF based composite flours compared to wheat flour suggest that CFs are well suited for the preparation of food products which require lesser gel strength and elasticity (Imoisi et al., 2020).

Trough/hold viscosity represents the lowest viscosity attained while heating at 95°C and it indicates disruption of swollen starch granules upon heating and under shear force (Shafie et al., 2016). The trough viscosity of CF and wheat flour based choco-filled cookies varied from 292.50 RVU (T3) to 664.00 RVU (T8). This lower range of trough/hold viscosity of the composite flours represents the susceptibility of starch granules to heating and shear as well as the presence of lower levels of amylose content in the CFs (Kaur et al., 2007). Moreover, final viscosity was observed in the range between 581 RVU (T3) to 1372 RVU (T8) (Table 5). ANOVA results showed a significant ($p<0.001$) effect of SPF, and PMF proportions as well as their interaction ($p<0.05$) on final peak viscosity. In the current study, breakdown viscosity was reported between 118.50 RVU (T1) to 323.50 (T8). Setback viscosity was observed between 289 RVU (T3) to 708 RVU (T8). Peak time values among composites ranged between 5.13 to 5.63 min. These higher peak time value observed in the wheat flour based composite flour represent the gradual swelling of starch granules without any significant mechanical damage.

Physical characteristics of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Physical characteristics such as diameter, thickness, and spread ratio of the sweet potato-pearl millet-wheat composite flours-based choco-filled cookies were studied. The diameter of the choco-filled cookies ranged from 5.13 cm (T1) to 5.93 cm (T8) (Table 6). Moreover, the diameter of the choco-filled cookies was found to be significantly ($p<0.05$) different from among the treatments in this study. The thickness of the choco-filled cookies was in the range of 1.01 to 1.03 cm. Furthermore, a significant ($p<0.05$) effect of SPF, PMF, and their interaction was observed for the spread ratio of choco-filled cookies which ranged from 5.02 (T1) to 5.81 (T8) (Table 6). Furthermore, the increase in the spread ratio of choco-filled cookies was directly affected by the higher diameter in the present study which was found similar to the spread factor previously reported of sweet potato based gluten free cookies (Giri et al., 2016).

Table 6. Physical characteristics of sweet potato-pearl millet-wheat composite flours-based choco-filled cookies

Treat-ment	Diameter (cm)	Thickness (cm)	Spread Ratio
T1	5.13±0.12[f]	1.02±0.00[b]	5.02±0.27[f]
T2	5.40±0.10[e]	1.02±0.01[b]	5.29±0.18[e]
T3	5.46±0.11[c]	1.03±0.01[a]	5.30±0.15[d]
T4	5.53±0.12[b]	1.03±0.00[a]	5.36±0.14[c]
T5	5.93±0.14[a]	1.02±0.01[b]	5.81±0.10[a]
T6	5.53±0.03[b]	1.03±0.01[a]	5.36±0.11[c]
T7	5.53±0.00[b]	1.03±0.02[a]	5.36±0.08[c]
T8	5.43±0.03[d]	1.01±0.00[c]	5.37±0.16[b]

*Values are mean ± standard deviation, Different letters in column represent mean values that statistically significant at ($p<0.05$).

Conclusion

Nutritional and physico-mechanical evaluation of choco-filled cookies showed that sweet potato flour could be successfully utilized along with millet flours such as pearl millet, finger millet, sorghum, etc., for the development of baked food products. Good amounts of protein and fiber contents coupled with high contents of minerals such as calcium, magnesium and iron could be an added advantage of the sweet potato and millet flour based cookies. Based on nutritional attributes, it could be concluded that sweet potato and pearl millet flour based blends containing 40% sweet potato flour, 40% pearl millet flour and 10% wheat flour was the best combination. Therefore, targeting sweet potato and pearl millet in ethnic or functional food design can address the chronic oxidative stress-linked NCD challenges such as early stages of type 2 diabetes and its associated complications.

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