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A sustainable approach for value addition in cookies by effective utilization of watermelon and pineapple by products

Sivapriya Balagopal[1], Diya Roy[2], Mary Celine Joe Nidhiry[3], Alphonse Maria Joseph[4], Janaki S[5]
[1] Head of Department, Department of Research, M. E. Meeran Innovation Center, Eastern Condiments Pvt. Ltd, Cochin, Kerala, India
[2] Research Officer, Department of Research, M. E. Meeran Innovation Center, Eastern Condiments Pvt. Ltd, Cochin, Kerala, India
[3, 4] Technical Officer, Department of Research, M. E. Meeran Innovation Center, Eastern Condiments Pvt. Ltd, Cochin, Kerala, India
[5] Senior Officer, Department of Research, M. E. Meeran Innovation Center, Eastern Condiments Pvt. Ltd, Cochin, Kerala, India

Abstract
A major fraction of the fruit and vegetable produce is wasted during the initial processing stages. The solid waste stream constitutes of peels, pomace, seeds and stems that are rich in bioactive components beneficial for our wellbeing. Utilization of such organic waste reduces the stress on our agriculture system and helps to make it more sustainable. Watermelon rind and pineapple core were used in this research to develop cookies rich in dietary fiber and micronutrients. The cookie dough was fortified with different dosages (10%, 15% and 20%) of a powder blend made from these by products. The cookies fortified with 20% of the blend were found to be optimum from both nutritional and organoleptic point of view.

Keywords: sustainable, fortification, pineapple, watermelon, dietary fiber

1. Introduction

Food waste has a detrimental effect on food quality, nutrition security and environment. Sustainability of the existing food supply chain is becoming a necessity to secure food and resources for our future. A sustainable food system can be defined as one which ensures food security and nutrition for consumers, utilizes natural resources optimally, is economically and socially viable and does not damage the ecosystem [1].

The contribution of different regions to the total food waste is depicted in Fig 1. Researchers have recognized a number of factors like infrastructure, climate, consumer behaviour and financial conditions that determine the quantity of food wasted in a region. The amount of food waste generated by developed countries is comparatively higher and it mostly occurs at the consumption stage. On the other hand, waste generated by developing and underdeveloped countries is lower and takes place in the agriculture phase or during initial processing [2]. At present, the total global food production is sufficient to feed the entire population but approximately 1/3rd of it gets wasted every year. The shortage of food is creating a calorie gap leaving 900 million people hungry and undernourished across the globe. It also leads to depletion of natural resources, fertilizers and human labour [3]. Moreover, food waste dumped in landfills degrade air and water quality and have an adverse impact on biodiversity and climate. According to a study conducted by FAO in 2007 about 3.3 giga tonnes of greenhouse gases are emitted from food wastes [4].

FAO has previously reported the percentage of produce of various food commodities that is getting wasted globally. The percentage of waste generated by a few major food sectors is illustrated in Fig 2. The wastage occurring in fruit and vegetable sector is the highest in every region. Fruits and vegetables are excellent sources of micronutrients and fiber but are extremely perishable. Their loss may aggravate incidence of deficiency diseases in future [5]. The waste stream of fruits and vegetable processing is mostly non-hazardous and rich in several bioactive substances of high nutritional and therapeutical value [6]. Only recently, the significance of retrieving substances like organic acids, micronutrients, phenolic compounds, fibers and pigments from waste stream has been realized [7]. The recovery and utilization of these by-products is being considered not only economical but a promising avenue for attaining food sustainability. These constituents are finding application in food, pharmaceutical, chemical and healthcare sectors for development of novel, high-value products [8].

Watermelon (Citrullus lanatus) is a vine like plant belonging to the Cucurbitaceae family [9]. The water melon rind is the greenish white layer between the tender, succulent pulp and outer skin [10]. The rind contains good amounts of polyphenols, amino acids, fiber and minerals [10]. It is also rich in citrulline which has excellent radical scavenging potential [12]. Unfortunately the rind which constitutes 30% of the entire fruit is mostly discarded [13]. It is used as feed or fertilizers generally, only some places like China consume it as a vegetable [14].

Pineapple (Ananus cosmosus) a member of the Bromeliaceae family is a seasonal tropical fruit [15]. Pineapple is the third most consumed fruit juice globally and the canning waste accounts for almost 50% of the fruit weight [16, 17]. The pineapple core is the central hard portion generally discarded in canning and juice processing. Studies on pineapple core reveal it as a good source of bromelain and dietary fiber [18, 19].

In this study watermelon and pineapple were selected because of their significant contribution to the waste generated by canning and juice industry and to understand the nutritional significance of their by-products. While the composition and utility of watermelon rind has been established, further research is needed to understand the

nutritional significance of pineapple core other than being a good source of dietary fiber. Moreover, previous research works have studied certain applications of these individual by products but their contribution in combination on the nutritional value of foods has not been investigated so far.
The primary objective of this work is to develop cookies fortified with watermelon and pineapple by products to enhance their nutritional value. The secondary objective is to utilize the watermelon rinds and pineapple core for value addition and reducing their contribution to the organic waste.

2. Materials and methods

2.1 Preparation of Fruit Waste Powder (FWP)

Fresh pineapples and watermelons were purchased from local super market in Cochin, India. The fruits were thoroughly washed, peeled and cut to retrieve the core and rind respectively. The pineapple core and watermelon rind were sliced into thin pieces and dried in hot air oven at 55 °C to 60 °C for 5 to 6 hours. Once the slices were dried they were ground to a fine powder using a blender. The individual powders of pineapple core and watermelon rind were combined in 1:1 ratio to give Fruit Waste Powder (FWP).

2.2 Preparation of cookies

The four sets of cookies were baked using a standardized recipe. One set was made with 100% wheat flour and it was labeled as standard. The other three sets were prepared by replacing 10%, 15% and 20% of respectively of wheat flour with FWP. Butter, castor sugar and brown sugar were taken in a vessel and beaten thoroughly to get a smooth creamy mixture. Egg and vanilla essence were added to this mixture during the beating process. Wheat flour and baking powder was taken in a separate vessel. The FWP was also added at this stage in different dosages for respective batches. This blend was added in small quantities to the butter-sugar mixture and stirred together. The mixture was whipped until a smooth consistency was obtained. Small portions of the cookie dough was placed on the baking tray and gently pressed to form the cookie shape. The procedure was repeated to fill the tray with uniformly sized cookies placed at a distance from each other. The cookies were baked in oven at 180 °C for 12-15 minutes.

2.3 Nutritional analysis

The proximate composition of all the cookie samples was analysed. The total ash, crude protein, crude fat, sugar and moisture content of the samples were determined following the standard protocol in AOAC, 20th edition (2016). The carbohydrate and energy values are calculated using the equations provided by FAO, 1988. The micronutrient composition of cookies was also analysed, namely potassium, phosphorus, calcium, iron and vitamins A and C using standard AOAC methods. The dietary fiber of the samples fortified with different dosages of fruit waste powder was evaluated using IS 11062 (1984) – Method for estimation of total dietary fiber in food stuffs.

2.4 Sensory evaluation

The consumer acceptability of cookies fortified with FWP 10%, FWP 15% and FWP 20% was compared with the standard cookies. The 5 variants were coded with 3 digit numbers and placed in sensory booths. Organoleptic properties such as texture, appearance, aroma, taste and overall acceptability was evaluated by 20 trained panelists. The panelists had to also rank the samples according to their preference based on a 5 point hedonic scale (1-dislike extremely to 5-like extremely)

2.5 Physical Characteristics

Diameter and thickness of cookies post baking for all the four variants was measured using digital callipers. The ratio of weight of cookies before and after baking was calculated in percentage to get the yield of all 4 variants. The expansion factor of cookies was also estimated by calculating the ratio of their final diameter and thickness [20]. The average of 3 random cookies was considered for all the attributes.

3. Results & Discussion

3.1 Nutritional Composition

The cookies prepared with various dosages of FWP were analysed for their nutritional value. The analysis data showed an improvement in the nutrient profile of cookies with increase in dosage of Fruit Waste powder (FWP). The proximate composition of cookies is illustrated in Fig. 5. The protein content of cookies containing 20% of FWP had increased by 48.97% from the standard cookies. The ash, sugar and energy values for fortified cookies had also increased with increase in dosage percentage. While the carbohydrate and fat content showed a gradual decrease. Addition of watermelon rind may have led to this increase in protein content as indicated by analysis data given in Table 1. Plant proteins are generally associated with other components such as vitamins, minerals and fibers. Consequently consumption of plant protein brings about an overall well-being. It is supposed to reduce cholesterol and blood pressure levels which in turn lower the risk of cardiovascular diseases and certain cancers [21].
The nutritional composition of cookies containing FWP was also compared with cookies made with watermelon rind powder and pineapple core powder individually. The dosage of fortification was fixed at 20%. The results obtained denote cookies containing 20% FWP have a better nutritional value as depicted in Table 2.
Dietary fiber is an important non-nutrient component found abundantly in plant sources. It helps to maintain a healthy digestive system, regulate blood glucose levels and cholesterol levels [22]. The dietary fiber of cookies fortified with 20% FWP increased by 16.12%. The graphical representation of dietary fiber values are given in Fig 6. The increase in fiber content of fortified cookies may be due to the presence of watermelon rind and pineapple core powders. The dietary fiber content of pure pineapple core powder is about 99.8 % as reported by Prakongpan *et al*. [23] Also previous studies have indicated that replacement of wheat flour with watermelon rind powder increased the crude fiber content of products [24].

The proximate composition of fortified cookies denoted an increase in ash content with increase in dosage of FWP (Fig 5). This corresponds to an improved mineral content of the cookies. The enhanced mineral content of fortified cookies is illustrated in Fig 7. In particular, amounts of phosphorus, potassium and calcium increased considerably. Clinical studies have established that potassium, phosphorus and calcium aid in lowering blood pressure levels. Phosphorus and calcium are also required for maintaining the strength of skeletal system and they are essential for several metabolic processes as well. Potassium ions are responsible for energy metabolism and play a major role in transfer of nerve impulses. An improvement in vitamin A content of cookies was observed as well. It ensures proper functioning of our vision and is needed for maintenance of immune system, skin, teeth, tissues and mucos membranes [10]. The increase in quantity of vitamins B, C and minerals like iron, magnesium, manganese was insignificant. Addition of watermelon rind may have resulted in this improvement of mineral content. Earlier studies incorporating watermelon rind powder in baked products show similar improvement in mineral and vitamin quantities [10].

3.2 Physical characteristics

The physical attributes of the fortified cookies are given in Table 3. The diameter of cookies increased with increase in quantity of FWP There was an inverse relation observed between the diameter and thickness of the cookies. Consequently, expansion factor of cookies also increased. This increase in diameter and expansion factor may be due to the reaction of bromelain a protease enzyme found in pineapple core with the peptide bonds of gluten. A gradual decrease in final weight with increase in dosage of FWP was noted as well.

3.3 Sensory characteristics

The sensory score obtained from panel rating of fortified cookies was analysed using single factor ANOVA in MS EXCEL (Microsoft Office, 2010). There was no significant difference (P> 0.05) observed in acceptability of cookies fortified with different dosages of FWP. The statistical analysis data is depicted in Table 4. The sensory evaluation results imply that the cookies supplemented with 20% FWP was preferred among all the fortified samples. In terms of appearance, the cookie samples with 15% and 20% FWP scored better than 10% FWP. The crispiness of cookies increased with fortification dosage, the high fiber content of both pineapple core and watermelon rind may have enhanced the crispiness. There was a gradual increase in sweetness as well which maybe because of natural sugars present in the fruit by products [25]. The proximate analysis data of both pineapple core and watermelon rind powders indicate high sugar contents (Table 1.)

4. Tables and Figures

Table 1: Analysis data for proximate composition of pineapple core and watermelon rind powders

Nutrient/ 100g	Watermelon rind powder	Pineapple rind powder
Moisture (g)	9.28	7.84
Total ash (g)	14.72	1.52
Protein (g)	8.74	2.11
Fat (g)	6.64	3.72
Carbohydrate (g)	52.06	84.81
Sugar (g)	22.24	24.47
Energy (Kcal)	302.96	381.16

Table 2: Nutritional composition of cookies fortified with 20% FWP, 20% Pineapple core powder and 20% watermelon rind powder

Nutrient/ 100g	Cookies fortified with		
	20% Pineapple core	20% Watermelon rind	20% FWP
Moisture (g)	4.97	4.99	3.96
Total ash (g)	1.07	1.60	1.69
Protein (g)	6.28	4.97	6.57
Fat (g)	31.55	29	29.24
Carbohydrate (g)	56.13	59.44	59.84
Sugar (g)	42.65	31.28	43.33
Energy (Kcal)	533.59	518.64	524.80

Table 3: Physical attributes of cookie samples

Nutrient/ 100g	Cookies fortified with FWP			
	0% (Std.)	10%	15%	20%
Diameter (cm)	6.43	6.56	6.84	6.93
Thickness (mm)	14.18	13.85	13.57	13.20
Weight (g)	28.16	27.10	27.01	26.66
Expansion factor	4.53	4.73	5.040	5.25

Table 4: Sensory evaluation of cookie samples

Parameters	FWP 10%	FWP 15%	FWP 20%
Appearance	3.325±0.765	3.475±0.818	3.55±0.944
Aroma	3.25±0.952	3.375±0.809	3.6±0.926
Flavour	3.2±1.043	3.475±0.966	3.575±0.765
Texture	3.177±0.732	3.325±1.016	3.4±1.095
Overall	3.35±0.890	3.35±1.077	3.45±0.944

*The data represent mean values ± SD and P>0.05

Fig 1: Food waste contribution of different regions in kg/year.

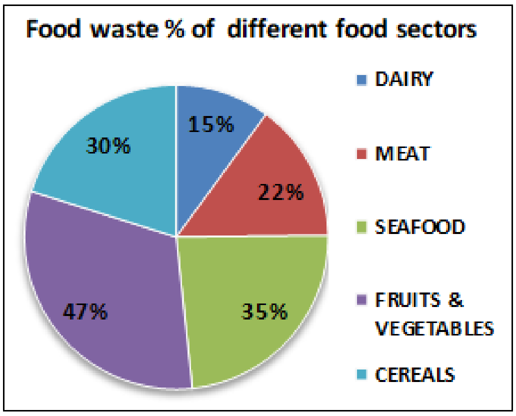

Fig 2: Food waste % from different sectors

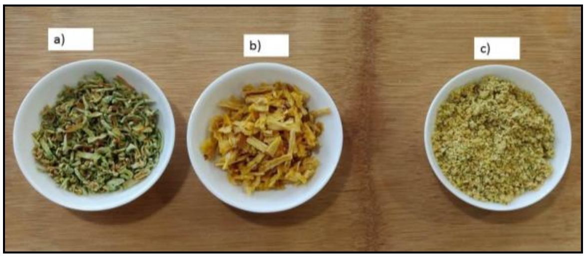

Fig 3: a) Dried watermelon rind slices; b) Dried pineapple core slices; c) Fruit Waste Powder

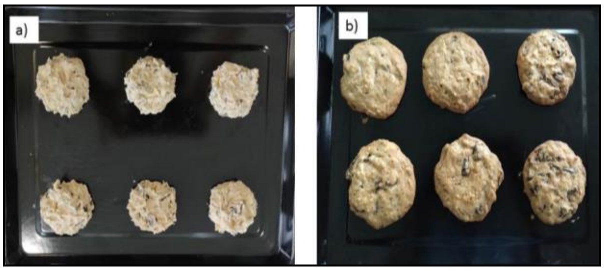

Fig 4: Cookies fortified with 20% FWP a) before baking; b) after baking

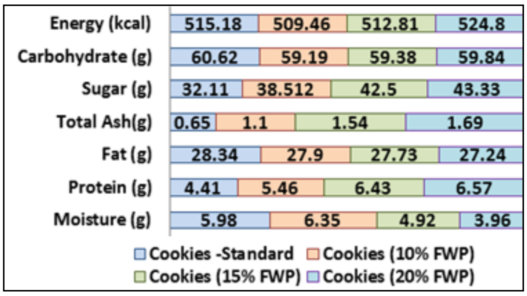

Fig 5: Proximate composition and calories of cookies-standard, cookies (10% FWP), cookies (15%FWP) and cookies (20% FWP)

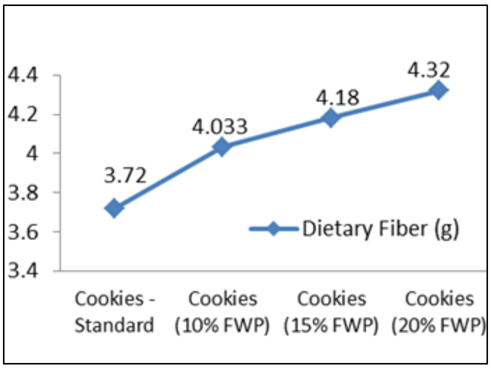

Fig 6: Dietary fiber content of cookies-standard, cookies (10% FWP), cookies (15%FWP) and cookies (20% FWP)

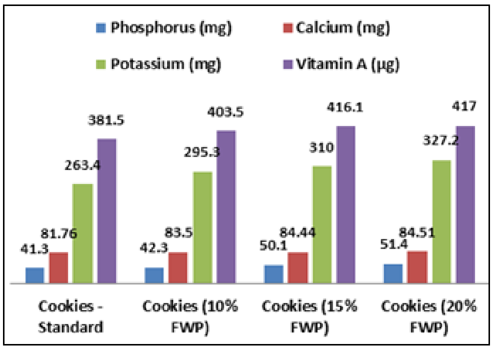

Fig 7: Micronutrient content of cookies-standard, cookies (10% FWP), cookies (15%FWP) and cookies (20% FWP)

5. Conclusions

The above findings bring us to the conclusion that fruit waste generated from pineapple and watermelon processing can be effectively employed for enrichment of bakery products. 20 % of wheat flour can be substituted with blend of pineapple core and watermelon rind powders to produce cookies with improved nutritional value. The fortified cookies are rich in dietary fiber and are good sources of protein, phosphorus, calcium, potassium and vitamin A. They also scored high in organoleptic qualities and can be considered a healthier snacking option suitable for all age groups.

Fruit canning companies and juice manufacturers can employ this approach to make their production units more sustainable. Thus, fruit waste minimization can be considered a favourable pathway to reduce the existing calorie gap and improve the environmental conditions.

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