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FULL PAPER

Utilization of psyllium husk and lemon peels to produce high fibre crackers

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Abstract

The exploitation of food waste for functional food production provides an alternative approach for food quality enhancement and environmental protection. Psyllium husk and lemon peels are good sources of dietary fibre. Soluble fibre has been claimed to control blood cholesterol and sugar levels while insoluble fibre could reduce risks of colon cancer. Thus, this study aims to develop crackers using psyllium husk and oven-dried lemon peel powder as functional ingredients. The control was prepared without psyllium husk and lemon peel powder. Proximate composition, sensory quality, and physicochemical properties of crackers were determined. The psyllium crackers contained 63.01% carbohydrate, 20.62% fat, 5.75% crude fibre, 4.30% ash, 3.61% protein, and 1.71% moisture content. Sensory attributes (appearance, aroma, taste, crunchiness, hardness, bitterness, and overall acceptance) of sample and control were evaluated by 50 panellists using a 9-point hedonic scale. The acceptance Index of psyllium crackers and control were 83% and 77%, respectively. A total of 68% of the panellists preferred the psyllium sample while 32% preferred the control. The addition of psyllium husk and lemon peel powder significantly increased the dietary fibre content of the sample (15.10%) as compared to the control (5.95%). Psyllium husk could be used as a potential substitute for oat in crackers for cost-effectiveness and the product provides a good source of dietary fibre. The utilization of agricultural waste such as psyllium husk and lemon peels in functional food production warrants further exploration.

1. Introduction

Functional foods are foods that provide health benefits beyond basic nutrition. The global functional food market size was valued at USD 173.26 billion in 2019 and is expected to reach USD 309.00 billion by 2027 with a compound annual growth rate of 7.5% during the forecast period of 2020 to 2027 (Precedence Research, 2020). The consumer demand for functional foods is growing steadily worldwide due to the increased health consciousness among consumers. For the past few decades, there was a paradigm shift in consumers' perception of health care, switching from disease treatment to disease prevention. Many consumers are willing to pay a higher price for healthy products including food supplements and functional foods to protect themselves from various diseases. However, food supplements such as nutraceuticals in the form of capsules and pills are not appetizing nor aesthetically pleasing. Thus, the concept of functional foods is widely accepted as consumers can take in health-promoting ingredients or bioactive compounds through delicious foods.

The Ministry of Health Malaysia has introduced The Healthier Choice Logo initiative in 2017 to facilitate the consumers to make a smarter choices for healthier products. The initiative also aims to encourage the local food industry to manufacture products with better health benefits through reformulation or new product development, and to provide an environment that supports healthy nutritional practices. One of the ultimate objectives of these efforts is to reduce the number of non-communicable chronic diseases such as cardiovascular diseases, cancers, diabetes, osteoporosis, and obesity among the population.

Cultivation activities and agro-industrial manufacturing have generated a vast amount of food loss and waste every year. According to FAO (2012), approximately 1.3 billion tons of food are lost or wasted globally along the food supply chain, representing one-third of the edible portion of the total volume of food that is produced for human consumption. Plant-derived

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food wastes constitute 63% of the total food wastes (Pfaltzgraff *et al*., 2013). Extensive research have been conducted to recover valuable bioactive compounds such as phenolic, flavonoids, phytosterols, citrulline, vitamins, essential amino acids, and dietary fibre, from plant food wastes by using various bioprocesses. These bioactives are widely utilized for pharmaceutical and cosmetic products. Since plant food wastes are excellent and renewable sources of health-promoting bioactive compounds, exploitation of plant-derived food wastes such as fruit peels, seeds, and pomace for functional food production provides an economical approach for food quality enhancement, improvement of population health, and environmental protection.

Psyllium husk is produced by milling off the dry outer coat of the *Plantago ovata* seeds. The psyllium husk was reported to contain 77.24% total dietary fibre and high mineral content including 805 mg potassium, 104 mg calcium, 62.3 mg sodium, and 19.7 mg magnesium per 100 g (Chong *et al*., 2019). The uses and functions of the psyllium husk were reviewed and summarized by Belorio and Gomez. (2020). Psyllium husk has been used as a food ingredient for rheological modification, dietary fibre enrichment, gluten replacement, staling prevention, fat replacement, and gelling agent. It has also been used as a health supplement for cholesterol reduction, hunger control, lipid absorption control, and blood glucose control (Belorio and Gomez, 2020; Soukoulis *et al*., 2018; Phan and Burton, 2018)

The lemon (*Citrus limon*) peel, seeds, and residue pulp are by-products of lemon juice processing and constitute about 50% of the whole fruit with high potential use. Lemon peel has high dietary fibre (63.9%) (Garcia Beltran *et al*., 2019) and the total amount of monoterpene in the peels of sour lemon is reported to range from 91.72 to 97.91% (Resketi *et al*., 2021). Numerous studies have been performed on the chemical composition, antimicrobial, antifungal, antiviral, antitoxic, anticancer, antioxidant, and radical scavenging abilities of the essential oil of lemon peel of various cultivars of lemon (Espina *et al*., 2011). Bacteriostatic effects resulting from monoterpene compounds, mainly limonene, have been reported in citrus peels. Research has shown that citrus essential oils show both antimicrobial (Moreira *et al*., 2005; Sharma and Tripathi, 2006) and antifungal properties (Chee *et al*., 2009; Dambolena *et al*., 2008). Lemon peels are rich in minerals (calcium, potassium, and magnesium) and antioxidants such as D-limonene and vitamin C, flavonoids that boost our immune system and reduce the risk of various diseases. It may even have several anticancer properties (Rao, 2016). Pectin in lemon peels may promote heart health by lowering blood cholesterol levels and other risk factors for heart disease. Lemon peels have been reported as a good source of pectin-derived oligosaccharides with promising prebiotic properties (Gómez, *et al*., 2014).

This study aimed to develop high fibre crackers using psyllium husk and lemon peels as functional ingredients as these food wastes are good sources of dietary fibre. Soluble fibre has been claimed to control blood cholesterol and sugar levels while insoluble fibre could promote bowel health and possibly reduce risks of colon cancer. Crackers are popular snack foods in the human diet and are generally well accepted by consumers due to their sensory attributes, long shelf-life, convenience, and affordability. Therefore, crackers are chosen as the vehicle to deliver health-promoting and bioactive ingredients to consumers.

2. Materials and methods

2.1 Sample preparation

All ingredients were purchased from local stores. Psyllium husk powder (Supplier: Love Earth) was purchased from Alpro Pharmacy. The lemon peels were dewaxed using the boiling water method. The lemon peels were placed in boiled water for 1 min, then rinsed with tap water and scrubbed to remove the wax residue. The lemon peels were oven-dried at 55°C for 5 hrs, then ground and sieved (pore size of 150μm). The dry ingredients (wheat flour, psyllium husk powder, tapioca starch, lemon peels powder, sesame seeds, and salts) were mixed by using a stand mixer at medium speed (Table 1). Then, water and melted unsalted butter were added, mixed, and kneaded. The control was prepared without psyllium husk and lemon peel powder. The dough was rolled out, cut into desired shapes, pricked with a fork, and baked in a preheated oven at 150°C for 20 mins. The crackers were cooled and stored in a dry container for further analysis.

Table 1. Formulation of control and sample crackers

Ingredients	Amount used (%)	
	Control	Sample
Wheat flour	29.0	20.0
Tapioca starch	26.0	26.0
Psyllium Husk Powder	-	6.0
Lemon Peels powder	-	3.0
Unsalted Butter	15.5	15.5
Water	21.0	21.0
Salt	1.50	1.50
Sesame	4.0	4.0
Sugar	3.0	3.0

2.2 Sensory evaluation

A sensory questionnaire was designed to obtain demographic information and the responses of panellists

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on 7 sensory attributes (appearance, aroma, taste, crunchiness, hardness, bitterness, and overall acceptance) of crackers. The control and sample were evaluated by 50 panellists (age 16-29; male 26% and female 74%) using a 9-point hedonic scale (1: dislike extremely to 9: like extremely). All samples were labelled with 3-digit random digits based on a random permutation table. A preference test was also conducted on the sample and control. The acceptance Index of crackers was calculated using the formula below.

Acceptance Index = (Mean overall acceptability score/9) × 100

2.3 Physicochemical analysis

Proximate analysis on crackers was done in triplicate for moisture (Hot air oven method), protein (Kjeldahl method), ash, total dietary fibre (Fibretec method), and fat contents (Soxhlet method) according to AOAC Standard methods.

The colour profile of the control and sample was measured by using the Lovibond spectrocolorimeter and recorded as L*, a* and b* values. The L* value (0-100) indicates the degree of lightness, a* value indicates the chromaticity on green (negative) to red (positive), and b* value indicates the chromaticity on blue (negative) to yellow (positive). Triplicate readings for each sample were measured to obtain the average value.

The hardness of control and sample was determined using a texture profile analyser (Model TA-XT2, Stable Micro Systems, UK) with a blade probe. Calibration was done before the test started by following the instruction of the software. The hardness of the cracker was measured by the peak force that occurred during the first compression. The texture analyser was set with test speed 2.0 mm/s, probe distance 5 mm, and trigger force 25 g for hardness measurement of crackers.

2.4 Data analysis

Data collected were analysed using IBM statistical software SPSS version 25.0. Independent t-test and One-way Analysis of variance (ANOVA) using the Tukey test were used to compare mean values between sample and control at a 95% level of confidence.

3. Results and discussion

The mean sensory scores of the control and sample crackers were displayed in Table 2. The scores for crunchiness and overall acceptance of the sample (psyllium husk crackers with lemon peels powder) were significantly higher than that of the control. No significant difference in sensory scores was observed in other attributes. Overall, the sample had a higher acceptance index (83%) than the control (77%) (Figure 1). A total of 68% of the 50 panellists preferred the psyllium husk sample while only 32% preferred the control. The bitterness of the sample was reduced by the addition of 3% sugar and it was acceptable to the panellists. Although bitterness by itself is often undesirable, it can create well-rounded and desirable palates in combination with other tastes. The bitterness was mainly caused by limonin from the limonoid terpene group and naringin from the flavonoid phenolic group in the fruit peels of citrus fruits such as lemons and limes (Hasegawa *et al*., 1996). Citrus limonoids have been shown to display numerous pharmacological activities including anticancer, antimicrobial, antioxidant, and antidiabetic among others (Gualdani, *et al*., 2016).

Table 2. Comparison on the mean sensory scores of the control and sample

Sensory attributes	Control	Sample
Appearance	6.68±1.2^a	6.98±1.2^a
Aroma	6.86±1.0^a	7.12±1.1^a
Taste	6.88±1.2^a	7.12±1.3^a
Crunchiness	6.76±1.2^a	7.52±1.2^b
Hardness	6.70±1.2^a	7.16±1.3^a
Bitterness	6.28±1.6^a	6.52±1.6^a
Overall Acceptance	6.96±1.1^a	7.50±1.3^b
Acceptance Index	77%	83%

Values are expressed in mean±standard deviation. Values with different superscript within the same row are significantly different ($p<0.05$).

The proximate composition of the control and sample are shown in Table 3. The dietary fibre (DF) content of the sample (15.10 g DF/100 g) was more than 2 folds higher than that of the control (5.95 g DF/100 g) due to the addition of psyllium husk and lemon peel powder. Based on the conditions for nutrient contents for use of nutrition claims of Food Regulations 1985 Malaysia (Regulation 18c - Fifth A Schedule Table II, updated in Jan 2014), psyllium cracker met the nutritional claim of "high in fibre" as it contains more than 6 g dietary fibre per 100 g (Ministry of Health, 2014). The sample also contained a significantly higher amount of ashes than the control. The increase in ashes is attributed to the presence of high mineral content in psyllium husk (Chong *et al*., 2019).

The incorporation of psyllium husk into crackers caused the crumb to become darker (lower L-value), more reddish (higher a-value), and less yellowish (lower b-value) as shown in Table 4. The addition of psyllium husk in the crackers was considered a promising factor that affects the tonality of baked products and it was acceptable by the panellists. The natural pigments present in psyllium husk caused the darkening of colour

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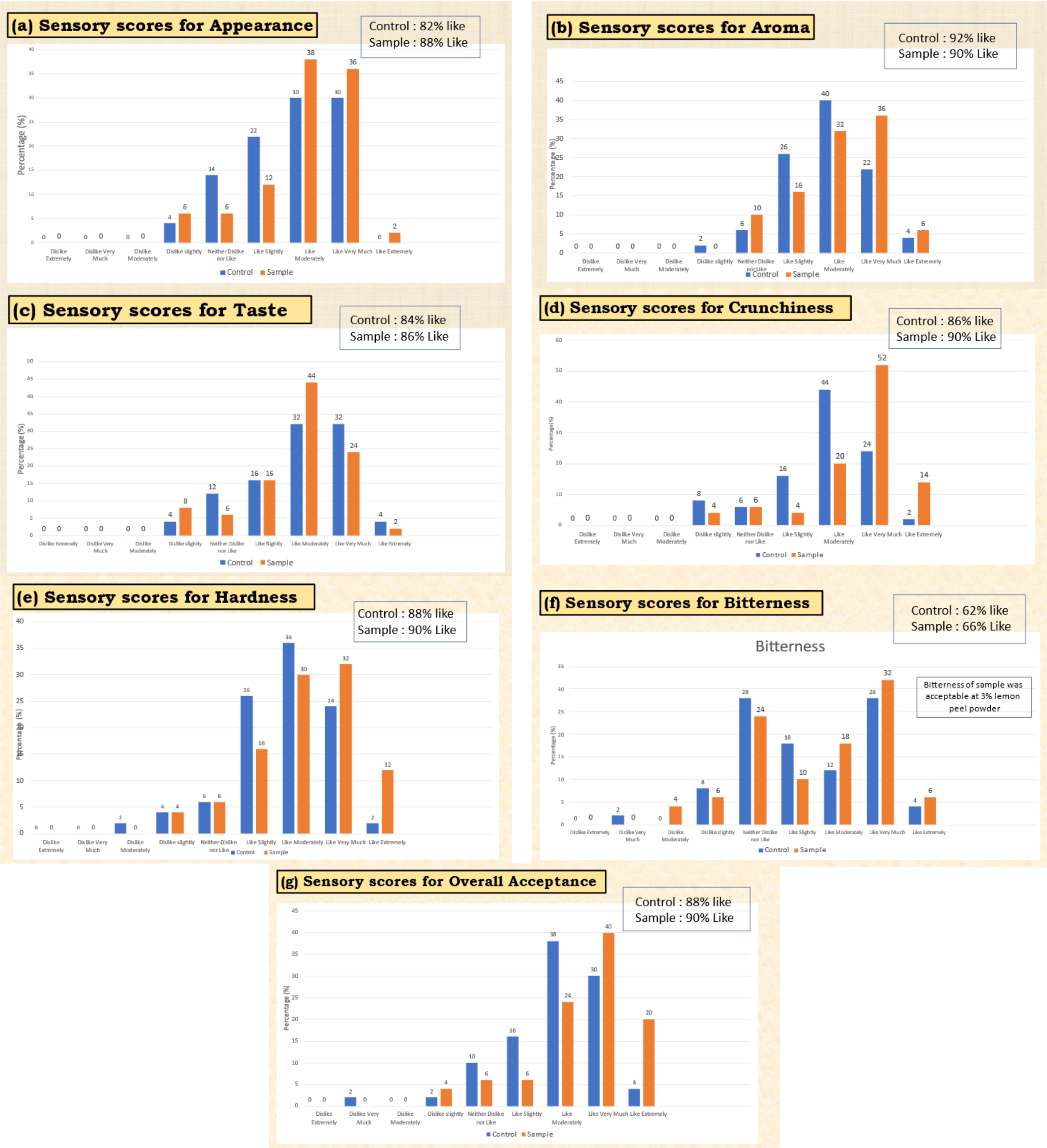

Figure 1. Sensory scores for various attributes of the crackers

Table 3. Proximate composition (%) of control and sample

	Control	Sample
Moisture Content	6.28±0.07[a]	1.71±0.19[b]
Ash	2.95±0.04[a]	4.30±0.01[b]
Protein	6.27±0.13[a]	3.61±0.39[b]
Fat	20.72±0.85[a]	20.62±0.80[a]
Carbohydrates	61.85±0.08[a]	63.01±0.07[b]
Crude Fibre	1.93±0.71[a]	5.75±0.25[b]
Dietary Fibre	5.95±0.15[a]	15.10±0.20[b]

Values are expressed in mean±standard deviation. Values with different superscript within the same row are significantly different ($p<0.05$).

in the sample (Sudha *et al.*, 2007).

Table 4 shows the hardness of control and sample. Hardness is defined as the maximum peak force during the first compression cycle. The peak force during the cutting test was recorded as the apparent hardness (N) of the crackers. Sample cracker is significantly harder and less crumbly than the control due to the addition of psyllium husk with high dietary fibre content. Sharma and Gujral (2014) and Korus *et al*. (2017) found that the strongly hydrophilic components in dietary fibre absorb a lot of water, which at its constant content in the cracker

Table 4. Colour and hardness measurement for control and sample

Formulation	Colour			Hardness (N)
	L*- value	a*- value	b*- value	
Control Crackers	72.80±5.89[a]	5.43±3.20[a]	21.17±0.45[a]	2.26±0.20[a]
Sample Crackers	43.80±2.71[b]	8.53±1.02[a]	18.93±1.00[b]	3.19±0.21[b]

Values are expressed in mean±standard deviation. Values with different superscript within the same row are significantly different ($p<0.05$).

recipe leads to a harder dough. The consequence of hard dough may be a reduction in the volume of crackers and an increase in their hardness.

4. Conclusion

The psyllium husk cracker enhanced with lemon peel powder was developed and it has achieved an acceptance index of 83% (scored 7.5 out of 9.0). A total of 68% of the panellists preferred the sample while 32% preferred the control. The addition of psyllium husk and lemon peel powder significantly increased the dietary fibre content of the sample (15.10%) as compared to the control (5.95%). Psyllium husk could be used as a potential substitute for oat in crackers for cost-effectiveness and the product provides a good source of dietary fibre. Food waste reduction should be seen as a means toward achieving other global goals, including improving food security and nutrition, reducing greenhouse gas emissions, lowering pressure on water, energy, and land resources, and increasing economic growth.

Conflict of interest

The authors declare no conflict of interest.

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