Physicochemical properties and sensory evaluation of green and red spinach crackers

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Abstract. Green and red spinach are leafy vegetables prepared in varieties of Malaysian dishes. Utilisation of vegetables or fruits in baked foods such as crackers could increase nutritional values besides creating new flavor of the food. The objectives of this study were to determine the physicochemical properties and sensory acceptability of crackers incorporated with green spinach (*Spinacia oleracea*) and red spinach (*Amaranthus dubius*). The crackers were prepared by substituting 5%, 10% and 15% of green or red spinach with flour in the formulations. The formulated crackers were analysed for proximate compositions according to AOAC Methods, hardness and colour properties were determined using Texture Analyzer and chromameter respectively. Descriptive sensory evaluation was performed using 7-scale hedonic method to determine products preferences. The results showed that flour substitution with green or red spinach powder had decreased the moisture (3.35 to 10.48%) but increased the ash (2.34 to 3.23%), fat (11.2 to 13.93%) and protein (8.61 to 9.79%) content of crackers. Hardness values of both crackers were increased (4500 N to 5461 N) with increasing percentage of spinach powder used. The hardness decreased as longer time of storage applied. Lightness, redness and yellowness of crackers decreased with increased percentage of spinach used. Similarly, the colour intensities were decreased during four weeks of storage. In sensory evaluation, the lowest percentage of spinach in crakers (5%) received higher sensory acceptabilities than control and other formulations. In conclusion, the incorporation of green or red spinach in crakers at all percentages had increased nutritional values. The incorporation of 5% of green or red spinach received higher consumers' acceptability among all formulations. It is recommended that green or red spinach powder could be incorporated in crackers up to 5% level for commercialization.

1. Introduction

Spinach is a leafy green vegetable belongs to Amaranthaceae family. In Malaysia, two species of spinach commonly consumed as vegetable dishes are green spinach (*Spinacia oleracea*) and red spinach (*Amaranthus dubius*). Green spinach provides good amount of antioxidant compound, dietary fibre, minerals, vitamins, and iron compound which is beneficial to prevent anaemia [1]. Meanwhile, red spinach contains vitamin A, vitamin B6, vitamin C, chlorophyll, beta carotene, and riboflavin as well as multiple secondary metabolites such as alkaloid, flavonoid, tannin, glycoside and many more

[2]. It is commonly used as a herbal remedy to cure various problems and act as an important anti-tumor function in various types of cancers, including lung, prostate, breast, colon, and ovarian cancers [3]. The remarkable effects of dietary fibre in preventing and treating various gastrointestinal disorders such as constipation, obesity, coronary heart disease, colorectal cancer and diabetes were well documented [4]. The demand for food that is rich in dietary fibre has increased in the past decade and lead to the development of many fibre rich products and ingredients [5].

Crackers are baked products and served as good source of nutritional and functional components [6]. Crackers are popular snack products and favourable by consumers due to the texture and flavor. Recent reports emphasized the utilization of plant sources exploited in cracker formulations for various purposes [7, 8]. In this study, physical properties, proximate and sensory acceptability of crackers formulated with green and red spinach were determined.

2. Methodology

2.1. Plant materials

Green and red spinach (500 g) were purchased from local market in Jeli, Kelantan. The leaves of vegetables were washed under a running water to remove dirt and soil while the roots of the vegetables were removed. The vegetables were cut into small pieces and dried in an oven at 60°C for 24 hours. The dried spinach was grinded into powder form and kept in a screwed cap bottle at room temperature.

2.2. Development of Green and Red Spinach Crackers

The ingredients used to prepare the crackers were flour (360 g), butter (30 g), sugar (50 g), salt (30 g), and water (225 ml). Green and red spinach powder were added in the dough at 5%, 10% and 15% level of total weight. Formulation without spinach powder served as control. All ingredients were mixed using a blender until soft dough obtained. The dough was sheeted into 0.3 cm thickness and cut into a square shape. The crackers sized 3 cmx3cm were baked in an oven at 180°C for 15 minutes.

2.3. Proximate Analysis

Proximate analysis was conducted to determine moisture, protein, fat, ash and carbohydrate content of green and red spinach cracker according to Association of Official Analytical Chemists (AOAC) method [9]. Moisture content was determined using oven drying method. The protein content was determined using Kjedahl method. Lipid was extracted using petroleum ether and the content was determined using Soxtet System. Ash content was determined using muffle furnace at 600°C until whitish ash obtained. Carbohydrate content was calculated by subtracting percentage of moisture, protein, fat and ash content.

2.4. Hardness and Colour Analysis

Texture analysis was carried out by using Texture Analyzer (Brookfield, CT3, USA) having 5 kg load cell and TA7 probe. The pre and post test speed was 10.00 mm/s. For colour analysis, surface colour of crackers were determined using chromameter (Konica Minolta CR-400, Japan). The results were expressed in terms of lightness (L*), redness (a*) and yellowness (b*). The hardness and colour properties of the spinach crackers were recorded during four weeks of storage at every 7 days interval.

2.5. Sensory Evaluation

Sensory evaluation was carried out using with 7-scale hedonic. Fourty undergraduate students from University Malaysia Kelantan (UMK) Jeli campus performed the sensory evaluation. They rated the crackers on colour, flavour, taste, crispiness, hardness, and overall acceptance attributes based on likeness.

3. Results and Discussion

3.1Proximate composition

The moisture and carbohydrate content of green and red spinach crackers were decreased with increased percentage of spinach powder (Table 1). In contrast, the protein, fat and ash content of both crackers had increased with increased percentage of spinach. The increase in moisture content may be attributed to the presence of hydroxyl groups in fibre which allows more water interaction through hydrogen bonding [10]. Similar decreasing trend was reported in cookies incorporated with sweet potato-maize flour blends [11] and tapioca [12]. Lower moisture content of a product would have better shelf stability [13]. The increased content of protein, fat and ash content in crackers were contributed by the compositions of these macromolecules in spinach vegetables. Spinach has been known for its diversed nutritional composition, phytochemicals, and bioactives that promote health beyond basic nutrition [14].

Table 1. Proximate composition of green and red spinach crackers.

Crackers	Proximate composition (%)				
	Moisture	Protein	Fat	Ash	Carbohydrate
Control	9.04 ± 3.812	8.87 ± 1.05	5.87 ± 3.06	1.00 ± 3.56	75.22
5% Green spinach	10.48 ± 1.555	8.61 ± 1.29	11.2 ± 3.30	2.34 ± 1.23	67.71
10% Green spinach	7.21 ± 0.854	9.08 ± 1.47	12 ± 3.33	2.67 ± 0.56	69.04
15% Green spinach	3.35 ± 0.832	14.01 ± 8.07	13.33 ± 8.57	3.02 ± 0.56	66.31
5% Red spinach	9.76 ± 1.114	7.87 ± 1.86	11.07 ± 2.37	2.33 ± 0.61	69.30
10% Red spinach	8.40 ± 3.175	9.48 ± 1.17	11.27 ± 0.61	2.78 ± 0.56	68.07
15% Red spinach	7.24± 0.367	9.79 ± 0.86	13.93 ± 1.10	3.23 ± 0.45	66.04

3.2 Hardness and colour properties

The hardness values of green and red spinach crackers increased as higher percentage of spinach was incorporated (Figure 1a & 1b). Higher percentage of spinach powder may increase fibre composition resulting in lower binding of carbohydrates thus reduce its breaking strengths [15].

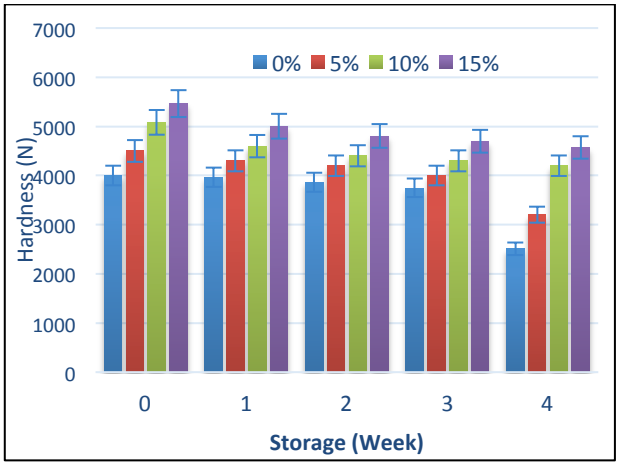

Figure 1a. Hardness values of crackers with green spinach during storage.

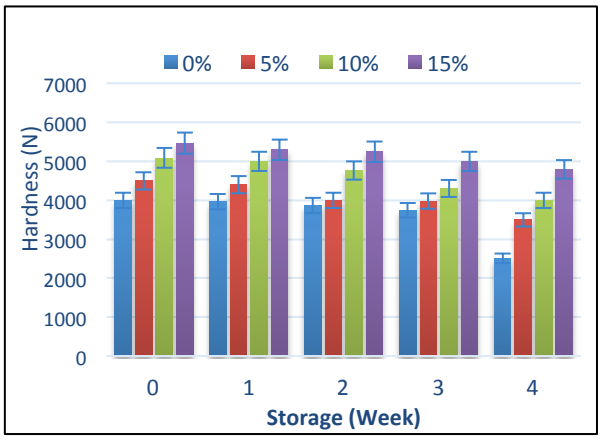

Figure 1b. Hardness values of crackers with red spinach during storage.

A decreasing trend in hardness of the spinach crackers could be due to the increased in moisture content in cracker during storage. A similar trend was reported in cookies with *Murraya koenigii* powder where hardness increased with increased addition of the plant powder [16].

The influence of spinach powder substitution in crackers on colour properties were shown in Figure 2 & 3. Lightness (L^*), redness (a^*) and yellowness (b^*) were decreased as higher percentage of spinach powder were incorporated. A slight decreased in all colour intensities for both green and red spinach crackers were recorded as longer storage time applied. Colour changers in baked items could be due to Maillard reaction which caused browning during baking process [17]. The reaction creates brown pigments in cooked food by rearranging amino acids and certain simple sugars in collections of rings that reflect light in a way to give brown colour [18].

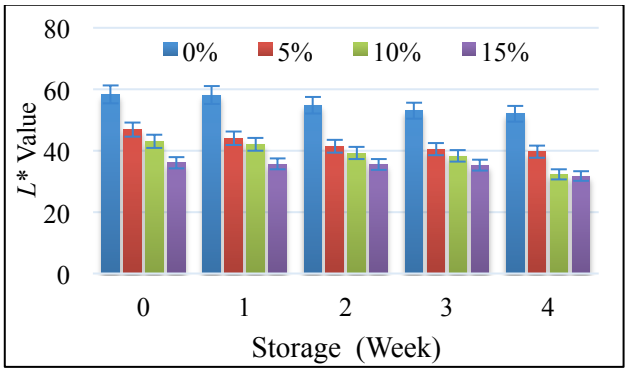

Figure 2a. Lightness (L^*) values of crackers with green spinach during storage.

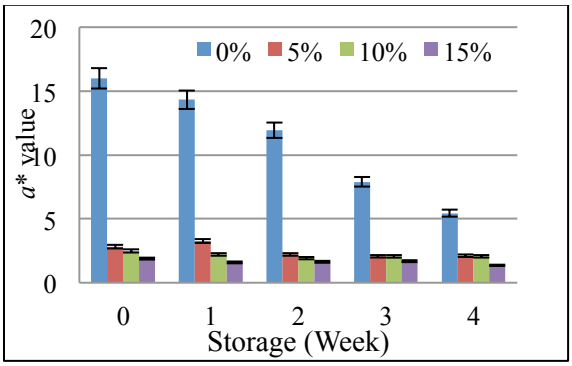

Figure 2b. Redness (a^*) values of crackers with green spinach during storage.

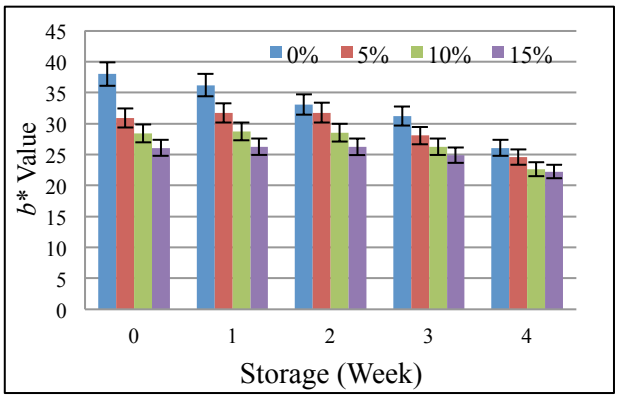

Figure 2c. Yellowness (b*) values of crackers with green spinach during storage.

Higher redness value (a^*) value in red spinach cracker than that of green spinach cracker could be due to the presence of red pigment. Red spinach contains betacyanins which is responsible for the red colour of stems and leaves.

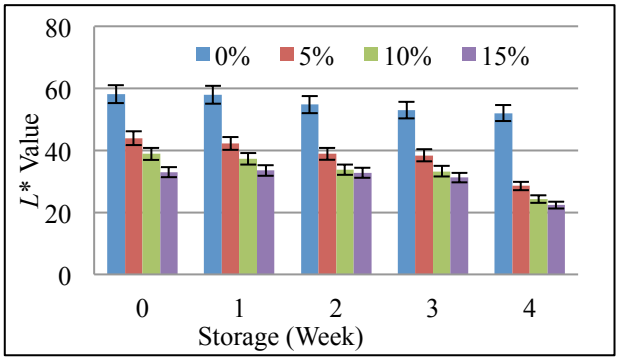

Figure 3a. Lightness (L^*) values of crackers with red spinach during storage.

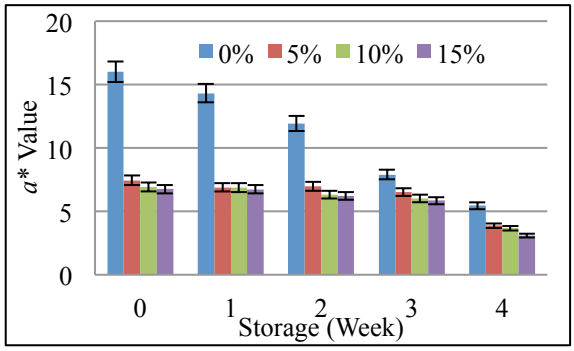

Figure 3b. Redness (a^*) values of crackers with red spinach during storage.

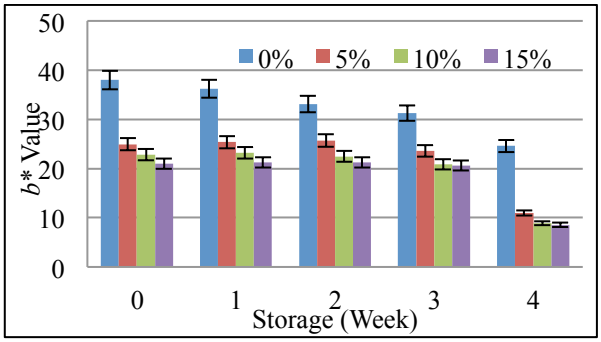

Figure 3c. Yellowness (b^*) values of crackers with red spinach during storage.

3.3 Sensory properties

The flavor, colour, taste, crispiness and hardness may influence overall acceptability of the crackers (Table 2). Incorporation of 5% green or red spinach received higher overall acceptability than higher percentage of spinach. The overall sensory scores of spinach crackers were close to control. Overall, the incorporation of green spinach powder into crackers received slightly higher sensory attributes than that of red spinach crackers. In other study, the incorporation of 5% to 15% of spinach in biscuit were highly acceptable [19].

Table 2. Sensory properties ofcrackers incorporated with green and red spinach.

	Sensory attributes					
Spinach crackers	Flavour	Colour	Taste	Crispiness	Hardness	Overall acceptability
Control	4.28 ± 1.47	4.75 ± 1.53	4.75 ± 1.60	3.60 ± 1.60	3.63 ± 1.69	4.13 ± 1.20
Green spinach cracker						
5%	5.05 ± 1.41	5.13 ± 1.42	5.03 ± 1.37	5.43 ± 1.15	5.03 ± 1.05	5.13 ± 1.18
10%	5.05 ± 1.20	5.00 ± 1.20	5.08 ± 1.00	4.88 ± 1.47	4.73 ± 1.20	5.10 ± 1.06
15%	4.80 ± 1.42	4.65 ± 1.33	4.33 ± 1.51	5.20 ± 1.18	4.95 ± 1.13	4.70 ± 1.45
Red spinach cracker						
5%	5.23 ± 1.56	4.55 ± 1.66	5.35 ± 1.46	5.58 ± 1.32	5.38 ± 1.28	5.33 ± 1.23

10%	4.48 ± 1.43	4.40 ± 1.37	4.55 ± 1.41	3.23 ± 1.69	3.23 ± 1.37	3.85 ± 1.31
15%	4.28 ± 1.58	3.83 ± 1.30	4.15 ± 1.79	5.30 ± 1.21	5.03 ± 1.07	4.55 ± 1.55

4. Conclusion

In conclusion, the incorporation of green and red spinach in crakers has increased the nutritional composition of the bakery product. These vegetables had increased the hardness but decreased lightness, redness and yellowness attributes. Incorporation of 5% green or red spinach received higher consumers' acceptability among all formulations thus, its is recommended that green or red spinach powder be incorporated in crackers formulation up to 5% level for commercialization.

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