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Effects of white cabbage powder on cookie quality

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Abstract

It is well known that vegetables are good sources of natural antioxidants and dietary fiber. Vegetables in cabbage group have long been used in human nutrition due to their rich nutritional value, and also they are grown in relatively cold areas where other vegetables cannot be produced. The nutritional value of white cabbage stands out among other vegetables, due to its high levels of antioxidants, phenolic compounds, dietary fiber, minerals and low calorie content. The most important reason for increasing interest in cabbage and cabbage products in the recent years is due to their protective effects against cancer. The aim of this study was to evaluate the effects of dehydrated white cabbage powder (DWCP) supplement on chemical, physical, nutritional and sensorial characteristics as well as the consumers' acceptance and purchase intent of the cookies. The studies indicated that dried white cabbage contained 20.65% of total dietary fiber and 846.53 mg GAE/g of polyphenols. Cookie samples were prepared with blends containing 0, 2.5, 5.0 and 7.5% of DWCP substituted for wheat flour. Total dietary fiber and mineral (calcium, potassium) contents of the cookies were improved with increased levels of DWCP. The total level of phenolic compounds, antioxidant activity, width, thickness, spread ratio, and surface cracking did not differ significantly among the cookies. Cookies with a 2.5% substitution level of DWCP showed the highest scores for sensory attributes, consumers' acceptance and purchase intent. Thus, white cabbage, particularly its outer leaves, which are a by-product of the cabbage processing industry, could be utilized for the preperation of cookies and other food products with improved functional and nutraceutical properties.

Key words: Cookie, white cabbage, polyphenols, dietary fiber, functional foods.

Introduction

Demand for health-oriented products, which have high fibre and natural antioxidant and low calorie contents and are sugar-free, is increasing because of their beneficial effects to overcome health problems such as some types of cancer, cardiovascular diseases, hypertension, diabetes, gastrointestinal disorders and weight gain[1, 2]. Weight gain is inversely associated with high fiber intake of whole-grain foods but positively related to the intake of refined grain foods which indicated the importance of distinguishing whole-grain products from refined grain products to aid in weight control.

Changing nutritional habits in favor of the consumption of more fresh fruits, vegetables, whole grains and nuts would be an effective and practical approach to prevent chronicle diseases [3]. Bravi *et al.* [4] reported that an inverse relationship between stomach cancer risk and various types of fiber derived, in particular, from vegetables and fruit.

Vegetables are good sources of natural antioxidants and dietary fiber. Among vegetables white cabbage has been used for years in human nutrition due to its high antioxidant, polyphenol, dietary fiber and mineral and low calorie content. The main constituents of white cabbage are carbohydrates, and around 1/3 of these carbohydrates composed of dietary fiber and 2/3 low-molecular-weight carbohydrates [5]. Nilnakara *et al.* [6] produced antioxidant dietary fibre powder from white cabbage outer leaves and reported that the main component, apart from moisture was carbohydrate, approximately 50% for fresh and dried samples, and 25% and 29% for blanched and samples, which were dried after blanching, respectively. Cabbages are low calorie products, because their crude fat content is extremely low, approximately 1% in outer leaves of white cabbage [6]. However, the most important reason for increasing interest in cabbage and cabbage products in the recent years is due to their protective effects against cancer. Their cancer preventive effects are attributed to their relatively high content of glucosinolates [7]. Certain hydrolysis products of glucosinolates, namely indoles and isothiocyanates have shown anticarcinogenic properties [8, 9]. Phytochemicals like indole, isothiocyanate and sulforaphan trigger the enzymes that suppress or block the cellular DNA damages and reduce the tumor size and the efficiency of estrogen-like hormones. Cancer-preventive effects of isothiocyanates have been established by epidemiological studies and model animal experiments [7].

All cabbage vegetables contain sulforaphan, which is a sulphurous and an effective anticarcinogenic matter [10]. Cooking vegetables does not inactivate the effect of glucosinolates, they are also hydrolyzed by microflora in the human intestinal tract and are thus still bioavailable in cooked vegetables [11-13].

Health promoting Brassicaceae vegetables are major antioxidants due to their high vitamin C and phenolic matter contents. In addition, fat-soluble antioxidants like carotenoids and vitamin E are also responsible for 20 or more of total antioxidant activities in Brassicaceae vegetables [14].

In the studies investigating the antioxidant activities and chemical composition of outer and inner leaves [15] of Tronchuda cabbages researchers reported that this cabbage species could take place in daily diet as a good source of antioxidant, and thus prevent the diseases caused by free radicals.

In the industrial process of cabbage, outer leaves are generally discarded and these wastes are used as either animal feed or fertilizer. Cabbage wastes are potential sources of dietary fibers. Jongaroontaprangsee *et al.* [16] determined total content of dietary fiber in outer leaves of cabbages dried at different temperatures as 42% and reported that different drying temperatures have no significant effect on dietary fiber content.

Due to their useful effects on health, the present study aimed to investigate the utility of cabbage vegetables in cookie production, their effects on technological and sensorial parameters of cookie quality and the acceptable higher limits of cabbage flour in cookie production. For this purpose, dried and ground cabbage samples were added to cookie flour in four different proportions (0, 2.5, 5 and 7.5%) and then certain chemical, physical, technological and nutritional characteristics and also consumers acceptance and purchase intent of cookies were investigated.

Materials and Methods

White cabbages (Landini F1) harvested in autumn were purchased from local producer in Afyon province of Turkey.

Commercial wheat flour having 13.95 % moisture, 0.64% ash, 8.5% protein, 1.03% fat, 24.1% wet gluten, 8.0% dry gluten, 65% gluten index (AACC Method 38-12), sedimentation (AACC Method 56-60) 21 ml and falling number (AACC Method 56-81B) 362 s was supplied from Sosyete Milling Factory (Karaman, Turkey). Its farinogram values, water absorption 52.7%, development time 3.4 min, stability 3.7 min and degree of softening 109 Brabender Units, were determined by using AACC Method 54-21[17].

Sodium bicarbonate from Şişecam Chemicals Group Soda Industry (Mersin, Turkey), corn syrup (HFCS 42%) from Sunar Corn Integrated Plant Inc. (Adana, Turkey), powdered sugar, hydrogenated vegetable oil, skimmed milk powder and other materials used in cookie production were kindly supplied from Saray Biscuits and Food Industry Inc. (Karaman, Turkey). All the reagents used were of analytical grade.

Preperation of white cabbage powders: After harvesting of white cabbages they were transported to laboratory in the same day. They were washed and cut in to slices (dimensions of 20 mm x 20 mm) as soon as they reached to laboratory. Cabbages were dried by convectional method at 60°C until moisture content decreased to 8-9%. Dried cabbage samples were ground with a size <200 μm by means of IKA grinder A11. Samples were packaged in airtight polyethylene bags and stored in a freezer at -18°C for further analysis.

Preparation of cookies: Cookies were prepared using the AACC method 10–54 [17] with slight modifications. Wire-cut cookie formulation is given in Table 1. The study was carried out by adding dried and ground white cabbage powder (DWCP) into cookie flour at four different rates (0, 2.5, 5 and 7.5%) by replacement with wheat flour.

Table 1. Cookie formula.

Ingredients, at 23.90℃	Weight (g)
Sucrose "fine granulating"	12.8
"Brownulated granulated" sucrose	4.0
Nonfat dry milk	0.4
NaCl	0.5
Sodium bicarbonate ($NaHCO_3$)	0.4
All-purpose shortening	16.0
High-fructose corn syrup (HFCS) (%42)	0.6
Flour (14% moisture basis)	40.0
Water[+]	28-30%

[+] : Determined with farinograph.

Electric mixer with timer control and appropriate flat beaters (planet mixer) have been used to prepare cookie doughs. After mixing for 10 min cookie dough was sheeted to 5 mm by rolling pin and cut into circular shapes with a circular scone cutter of 60 mm inner diameter. The cut-out pieces of dough were baked on greased pans at 205℃ for 10 min in a conventional oven. The cookies were cooled at room temperature and packed in high density polyethylene bags with hermetic cover until further analysis.

Chemical analysis: The raw materials used and cookies were analysed for moisture (AACC Method 44-01 [17]), ash (AACC Method 08-01 [17]), total lipid (AACC Method 30-25 [17]), protein-N x 6.25- (AACC Method 46-12 [17]) and total dietary fibre [18] content using standard methods. Mineral matter contents of cookies (calcium, phosphorus, potassium, magnesium and iron) were determined with ICP-OES (Perkin-Elmer, Optima 5300).

Estimation of phenolics: Total phenolic contents (TPC) of fresh and dried white cabbages and cookies were determined using Folin-Ciocalteu reagent [19, 20]. Extraction of total pehenolics from fresh and dehydrated cabbage samples were made according to Sing *et al.* [20].

Antiradical activity of cookies: Antiradical activity of cookies was determined based on free radical catching principles by using picrylhydrazyl (DPPH) according to Dorman *et al.* [21].

Physical characteristics of cookies: In order to determine the physical properties of cookies produced with the addition of different proportions of white cabbage powder, width (W) and thickness (T) of cookies from each batch were measured by calliper, and the spread ratio was calculated by the proportion of width to thickness (W/T). Six cookie samples were taken in each experiment. Colors of fresh and dried cabbage samples and cookies were determined with Minolta CR 400.

Sensory test and purchase intent of cookies: The sensory test was carried out 4 hours after the cookies were made. Twenty trained judges evaluated cookies for appearance characteristics (brightness-darkness, surface color surface smoothness), cross section properties (cross section structure, distribution of pores, crust thickness, color difference between crust and crumb, internal color), texture, taste, flavor and overall quality.

A five-point hedonic scale ranging from 'like extremely' to 'dislike extremely', corresponding to the highest and lowest scores of 5 and 1, respectively, was used. The purchase intent was also evaluated on a five-point scale, 'definitely would buy' to 'definitely would not buy' corresponding to the highest and the lowest scores of 5 and 1, respectively[22]. This test was carried out by 30 volunteers who were habitual cookie consumers (men and women of age between 17 and 62 years).

Statistical analysis: All experiments were carried out in triplicate. Analysis of variance (ANOVA) was conducted by using the SPSS 16.0 procedures. The calculated mean values were compared using Duncan's multiple range test with significance defined at $P < 0.05$.

Table 3. Chemical composition of cookie samples with added DWCP.

	DWCP addition level (%)			
	0 (Control)	2.5	5	7.5
Moisture (%)	8.70[a]	9.59[a]	8.54[a]	9.54[a]
Ash (%)	1.06[b]	1.50[a]	1.33[a]	1.31[a]
Lipid (%)	19.68[a]	20.30[a]	20.25[a]	19.91[a]
TDF (g/100g)	2.26[a]	2.68[b]	3.14[c]	3.65[d]
Protein (%)	4.93[a]	4.53[ab]	4.47[ab]	4.35 [ab]
Calcium (mg/kg)	0.23 ± 0.002	0.24 ± 0.002	0.28 ± 0.002	0.30 ± 0.003
Phosphorus (mg/kg)	0.36 ± 0.009	0.34 ± 0.004	0.35 ± 0.003	0.35 ± 0.005
Potassium (mg/kg)	0.91 ± 0.03	0.97 ± 0.008	1.13 ± 0.01	1.29 ± 0.012
Magnesium (mg/kg)	0.17 ± 0.003	0.16 ± 0.001	0.17 ± 0.002	0.18 ± 0.004
Iron (mg/kg)	0.021 ± 0.001	0.020 ± 0.001	0.016 ± 0.001	0.018 ± 0.001

Results and Discussion

Chemical and physical analysis of fresh and dehydrated cabbage: Moisture, ash, total lipid, phenolic content and color (L, a, b) of fresh and dehydrated cabbage samples used in the experiments are given in Table 2. Total phenolic compounds and total dietary fiber content of cabbages become more concentrated by dehydration process. Anderson and Bridges [23] reported an average TDF of 23.24% for raw cabbage. In this study fresh vegetables and fruits were homogenized, lyophilized, and ground to give a homogeneous sample. Total dietary fibre (dry basis) content of outer leaves of cabbage have been reported approximately 41–43% from Jongaroontaprangsee *et al.* [16].

We found the proximate TDF content as 20.65% for dried cabbage, thus our results are very similar to the earlier reported results (Table 2). This little difference may be arisen from the difference at cabbage variety and drying method.

Chun *et al.* [24] studied antioxidant properties of raw and processed cabbages and reported the total phenolics (mg GAE/100 g) of green cabbage 97.8±0.8, Napa cabbage 75.1±2.2, red cabbage 393.1±10.8 and Savoy cabbage 178.7±3.2. Proteggente *et al.* [25] studied several cabbages cultivated in England and found total phenolic of red cabbages 158±4 and green cabbages 58±1 mg/100 g. Vinson *et al.*[26] reported that the average total phenol content of cabbages cultivated in Pennsylvania was 52.8 mg CE/100 g.

Chemical properties of cookies: The effect of DWCP addition on the chemical composition of cookies are given in Table 3. No spesific trend is seen at the moisture, lipid and protein content of cookies upon addition of DWCP while ash and dietary fiber content of cookies increased with the addition of DWCP. The results indicated that there is a significant increase in the total dietary fiber content in cookies incorporated with DWCP. Also supplementation of cookies with DWCP significantly increased the level of potassium. On the other hand DWCP addition did not affect the total phenolic content and antiradical activity of cookies.

Physical properties of cookies: Physical characteristics such as diameter, thickness and spread ratio of cookies is given in Table 4.

Table 4. Physical characteristics of cookie samples with added DWCP+.

DWCP (%)	Diameter (W, mm)	Thickness (T, mm)	Spread ratio (W/T)
0 (Control)	69.53[b]	12.18[a]	5.72[a]
2.5	71.48[a]	11.78[a]	6.08[a]
5	70.41[ab]	11.84[a]	5.97[a]
7.5	69.05[b]	11.94[a]	5.78[a]

+: Mean followed by different letters in the same column differs significantlly ($p<0.05$).

Cookies with 2.5% of DWCP addition had the highest diameter, followed by 5% supplement rate, control and 7.5% supplement rate groups. The results in Table 4 demonstrated that DWCP addition affected diameter to some degree, but not thickness and spread ratio of cookies. This result may be arisen from the low addition level of DWCP. Increase of DWCP addition level futher to 7.5% may affect physical properties inversely because of the dilution of gluten. However, in this research it was not possible to increase DWCP addition level because their pungent odor and biting taste which are attributed to high content of glucosinolates in Brassica vegetables in amounts of 500-2000 µg/g and particularly high in brussels sprouts, cabbage and broccoli [8, 27]. Recently, Ajila *et al.* [28] reported no significant difference of diameter and thickness of cookies up to 10% level of incorporation of mango peel powder (MPP). They observed decrease in diameter and thickness of cookies with the addition of 15 and 20% MPP may be due to dilution of gluten. Decrease at spread ratio of cookies was reported when increasing the amount of mixtures of wheat, fonio and cowpea flours [29], fluted pumpkin seed flour [30] and apple, lemon and wheat fibre [31].

Color of cookies: Color is an important factor for the quality evaluation of dehydrated vegetables and cookies produced with them. The color of cookie samples was measured by the Minolta CR 400 system using *L*, *a* and *b* values. Color measurements were made on 5 different points on surface of cookies, and subsequently, color of horizontal section of cookies was measured to determine color difference between inner and surface of cookies. The value of *L* represents the trend of brightness (light-dark), while the value of *a* represents the trend of red-green and the

Table 2. Chemical and nutritional properties of fresh and dehydrated cabbage samples used in cookie production+.

White cabbage samples	Mois ture (%)	Ash (%)	Lipid (%)	TDF (%)	Total polyphenols (mg/g GAE)	Surface Color*		
						L	a	b
Fresh	91.12	6.07	1.24	1.52	95.96	82.92	-3.59	18.07
Dehydrated	8.95	6.87	1.24	20.65	846.53	78.25	1.12	18.31

+: Means are based on three replications. *: Values from Minolta color difference meter, in which L = lightness, a = redness, and b = yellowness.

value of *b* represents the trend of yellow-blue. The smaller *L* value, the darker the color of the sample. As shown in Table 5 control sample had the lightest skin color, while sample with 5% supplementation had the darkest skin color, and no statistically significant difference was detected between the group with 2.5% and 7.5% supplementations. At increasing level of DWCP addition *a* values of cookies slightly increased while *b* values decreased. Inner color of cookies was found darker than surface colour. Inner *a* values of cookies significantly increased with parallel to increasing level of WCP. Due to the enzymatic browning, with drying DWCP turned to brownish color, thus addition of this brownish powder to wheat flour also decreased the brightness of the cookies.

Table 5. Surface and inner colors of cookie samples with added DWCP+.

DWCP (%)	Surface color			Inner color		
	L	a	b	L	a	b
Control	63.77[a]	5.08[b]	18.96[a]	67.01[a]	0.21[c]	17.80[a]
2.5	60.09[ab]	7.03[ab]	18.01[ab]	67.09[a]	1.35[b]	18.27[a]
5	56.30[b]	8.35[a]	17.18[b]	64.75[b]	2.22[a]	18.00[a]
7.5	60.29[ab]	7.01[ab]	17.64[b]	65.37[b]	2.40[a]	18.17[a]

+: Mean followed by different letters in the same column differs significantlly ($p<0.05$).

Sensory evaluation of cookies: Table 6 demonstrates that there is no significant difference between cookies in terms of surface color, cross section structure, crust thickness, internal color, color difference between crust and crumb, firmness, chewiness, disintegration in the mouth and resolution in the mounth. However, brightness, surface smoothness, pore distribution, brittleness and taste/flavor of control samples were higher than that of DWCP added cookies.

Affordability test was made by 5-point Likert scale (1: I will definitely buy, 2: I will buy, 3: I am indecisive, 4: I won't buy, 5: I definitely won't buy). Scores of cookies given by consumers of 16 different education and income levels are presented in Table 6. As can be seen from this table, control group was generally given the score 1 (I will definitely buy). It was followed by cookies containing 2.5% of DWCP with score 2 (I will buy). No statistically significant difference was observed between the cookies containing 5 and 7.5% of DWCP in terms of purchasing intent and both groups were given the scores of 3 and 4 (I am indecisive and I won't buy). Generally cookies with 2.5% DWCP supplementation level were found more accaptable than others in terms of general properties and especially for flavor.

Table 6. Sensory evaluation scores for DWCP added cookie samples.

Sensoriel properties	DWCP (%)			
	0 (Control)	2.5	5	7.5
Brightness-darkness	4.38[a]	3.69[b]	3.31[b]	3.63[b]
Surface color	4.06[a]	4.00[a]	4.19[a]	4.06[a]
Surface smoothness	4.38[a]	3.81[ab]	3.56[b]	3.44[b]
Cross section structure	4.13[a]	3.94[a]	3.94[a]	3.56[a]
Distrubition of pores	4.25[a]	3.88[ab]	3.81[ab]	3.44[b]
Crust thickness	4.25[a]	4.13[a]	4.13[a]	3.94[a]
Internal color	4.25[a]	4.13[a]	3.94[a]	3.44[a]
Color difference between crust and crumb	4.00[a]	4.06[a]	3.88[a]	4.00[a]
Firmness	4.13[a]	3.81[a]	4.00[a]	3.63[a]
Brittleness	3.94[a]	3.50[ab]	3.19[b]	3.25[b]
Chewiness	4.38[a]	4.00[a]	3.81[a]	3.81[a]
Disintegration in the mouth	4.13[a]	4.13[a]	3.88[a]	3.81[a]
Resolution in the mounth	4.19[a]	4.19[a]	4.13[a]	4.06[a]
Taste/flavor	4.75[a]	3.69[b]	2.75[c]	2.81[c]
Purchasing intent	1.44[c]	2.38[b]	3.38[a]	3.56[a]

Mean followed by different letters in the same line differs significantlly ($p<0.05$).

Conclusions

DWCP addition increased the total dietary fiber and mineral matter content but did not affect the total phenolic content and antiradical activity of cookies. This situation may be arisen from the lower additional level of DWCP. If its usage can be increased upon the 10% level TDF, phenolic content and antiradical activity of cookies can be increased too, but unwanted odor of dehydrated cabbage powder district us to usage of further concentrations. If unwanted odor of dehydrated cabbage powder could be supressed by using some aroma compounds it can be used higher levels with acceptable overall quality. Thus, white cabbage, especially its outer leaves, by-product of cabbage processing industry, could be utilized for the preperation of cookies and other food products with improved functional and nutraceutical properties.

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