PHENOLIC CONTENT, ANTIOXIDANT ACTIVITY AND SENSORY ACCEPTABILITY OF WHEAT-FINGER MILLET COMPOSITE COOKIES

M. Siwela[1,2], J. R.N. Taylor[2] and K. G. Duodu[2]

[1]Discipline of Dietetics and Human Nutrition, University of KwaZulu-Natal, Scottsville 3209, Pietermaritzburg, South Africa
siwelam@ukzn.ac.za
[2]Department of Food Science, University of Pretoria, Pretoria 0002, South Africa

INTRODUCTION

Finger millet [*Eleucine coracana* (L.) Gaertn.] is one of the staple foods in the semi-arid tropics of Africa and Asia (Anon., 1996). It is nutritionally superior to most other cereals (Obilana and Manyasa, 2002). Finger millet contains various phenolic compounds including tannins (Dykes and Rooney, 2006). These phenolic compounds contribute to the antioxidant properties of the grain (Sripriya et al., 1996; Siwela et al., 2007). High-tannin finger millet grain types exhibited higher antioxidant activity than non-tannin types (Siwela et al., 2007). Due to their antioxidant activity, phenolic compounds are potentially health-promoting (Scalbert et al., 2005). While soft wheat is the ideal grain for making cookies, it is suited to cooler climates and as such countries in hotter regions import part or all of the wheat they require. Wheat-finger millet composite cookies may have the advantages of being nutritious, economical and health-promoting. As has been reported on various foods (Nicoli et al., 1999), thermal processing may change the phenolic content and antioxidant activity of the cookies. Substituting part of the wheat with finger millet may negatively affect the texture of the cookies as has been the case with cookies containing sorghum and pearl millet (Taylor et al., 2006). Finger millet phenolic compounds, particularly the tannins, may impart a bitter and astringent flavour (Lesschaeve and Noble, 2005) and pigmented finger millet may impart an unusual colour to the cookies. The objectives of the study were to: 1) determine the effect of baking on phenolic content and antioxidant activity of wheat-finger millet composite cookies and 2) determine the effect of finger millet type and substitution level on the sensory acceptability of the cookies.

MATERIALS AND METHODS

The cookies were made as described by Anon. (1991). Composite doughs were made by substituting cake flour with 15%, 35% and 55% (w/w) flour of either a creamy white, non-tannin finger millet or a brown, high-tannin type. A portion of each dough type was stored in the freezer until analysis. The doughs were labeled and baked together.

Cookie doughs and baked cookies were extracted with 1% conc. HCl in methanol for the determination of total phenolics and antioxidant activity, and with 100% methanol for the determination of condensed tannins. Extraction was as described by Siwela et al. (2007). Total phenolics, condensed tannins and antioxidant activity were measured using the Folin-Ciocalteu (Singleton and Rossi, 1965), vanillin-HCl (Price et al., 1978) and Trolox method (Awika et al., 2003), respectively.

The texture of the cookies was measured with a texture analyser. The colour of the cookies was determined in terms of Hunter L values using a chromameter.

Fifty nine untrained panellists evaluated the cookies for taste, texture and appearance and overall acceptability on a 9-point hedonic scale (1= dislike extremely; 9= like extremely).

RESULTS AND DISCUSSION

Table 1. Effect of baking on phenolic content and antioxidant activity of wheat-finger millet composite doughs

Finger millet type	Subst (%)[a]	Dough			Cookie			Decrease in (%):[c]		
		TP [b]	CT [b]	AA [b]	TP [b]	CT [b]	AA [b]	TP	CT	AA
Cake flour, control	0	ND	ND	4.56	ND	ND	3.68	ND	ND	19.3
Creamy white, non- tannin	15	ND	ND	4.65	ND	ND	3.65	ND	ND	21.5
	35	0.13	ND	5.37	0.06	ND	3.80	53.8	ND	29.2
	55	0.18	ND	5.79	0.07	ND	3.65	61.1	ND	37.0
Brown, high-tannin	15	1.30	0.27	56.73	0.90	0.14	41.26	30.8	48.1	27.3
	35	1.71	0.42	61.82	1.19	0.29	42.99	30.4	31.0	30.5
	55	2.13	0.66	68.65	1.26	0.37	55.34	40.8	42.8	19.4

[a] % (w/w) substitution of wheat flour with finger millet flour.TP, total phenolics (g gallic acid equivalents kg^{-1} sample, DB); CT, condensed tannin content (g catechin equivalents kg^{-1} sample, DB); AA, antioxidant activity (mM trolox equivalents kg^{-1} sample, DB). [b]Mean of three replicate analyses. [c]Reduction in levels of assayable total phenolics, condensed tannins and antioxidant activity. ND, not detected

Table 1 shows that methanolic extracts from doughs containing brown finger millet had much higher phenolic contents and antioxidant activities than extracts from the control dough and doughs containing creamy white finger millet. The control dough and doughs containing creamy white finger millet had much lower antioxidant activities than those of doughs containing brown finger millet most likely because they had low phenolic contents and in particular, they had no tannins which have been shown to be powerful antioxidants (Hagerman et al., 1998). Phenolic content and antioxidant activity decreased when the doughs were baked (Table 1). Phenolic content decreased probably due to decomposition (Kikugawa et al., 1990), volatilisation (Hamama and Nawar, 1991) and interaction of the phenolics (particularly the tannins) (Dykes and Rooney, 2006) with other components of the dough. Antioxidant activity decreased seemingly due to a decrease in phenolic content. However, the antioxidant activities of the cookies containing a high-tannin finger millet (41.26-55.34 mM trolox equivalents (TE) kg^{-1}) (Table 1) are either higher than or comparable with those of a variety of plant foods on the market (0.50-66.00 mM TE kg^{-1}) (Miller et al., 2000).

Finger millet type and finger millet substitution level had a highly significant effect on the texture (hardness) and colour (Hunter L) of the cookies ($p<0.001$). All the composite cookies were gritty and grittiness increased with increasing finger millet substitution level. Cookies containing 55% high-tannin finger millet were very brittle (328 gs) (Table 2) and crumbly. Grittiness may be partly attributed to the presence of ungelatinised starch granules and hard, sharp-edged endosperm particles and bran (Taylor et al., 2006). Cookies containing 55% high-tannin finger millet were very brittle and crumbly probably because the tannins bound to gluten proteins resulting in a decrease in the cohesiveness of the dough. Cookies containing brown finger millet were much darker (low HunterL values) than those containing creamy white finger millet (Table 2).

Table 2. Texture and colour of wheat-finger millet composite cookies

Finger millet type	Subst (%)[γ]	Texture (hardness [gs])[λ]	Colour (Hunter L)[λ]
Cake flour, control	0	1701.4 (80.1) a	78.0 (0.5) a
Creamy white, non- tannin	15	3009.0 (72.3) b	70.2 (0.9) b
	35	2175.0 (77.8) a	68.2 (0.3) b
	55	1607.9 (180.2) a	63.0 (0.3) c
Brown, high-tannin	15	2 265.4 (146.4) a	65.0 (0.5) c
	35	1 585.1 (238.5) a	56.8 (0.4) d
	55	328.1 (7.3) c	54.7 (0.3) d

[γ] % (w/w) substitution of wheat flour with finger millet flour. [λ] Mean of three replicate analyses, standard error in parenthesis.
Values within same column with different letters are significantly different at $p<0.05$;
Tukey's Studentized Range (Honestly Significant Difference [HSD]) test used.

Table 3. Effect of finger millet type and finger millet substitution level on sensory acceptability of wheat-finger millet composite cookies

	p value			
Source	**Taste**	**Texture**	**Appearance**	**Overall acceptability**
Finger millet type	0.0631	0.8225	<0.0001***	0.8555
Substitution level	0.0129*	<0.0001***	0.0001***	0.0010**
Type*substitution	0.953	0.917	0.1187	0.4754

*Significant at $p<0.05$; **significant at $p<0.01$; ***significant at $p<0.001$; two-way (ANOVA) used.

Table 4. Sensory acceptability of wheat-finger millet composite cookies

Finger millet type	Subst (%)[γ]	Acceptability[λ]			
		Taste	**Texture**	**Appearance**	**Overall accept.**
Cake flour, Control	0	6.60 a	6.18 abc	6.88 a	6.47 a
Creamy white, non- tannin	15	6.11 ab	6.20 abc	6.45 ab	6.23 ab
	35	6.01 ab	6.24 abc	6.07 ab	6.10 ab
	55	5.61 b	5.48 bc	6.05 b	5.73 b
Brown, high tannin	15	6.48 a	6.20 abc	6.06 ab	6.29 ab
	35	6.30 ab	6.38 a	5.21 c	6.34 a
	55	5.85 b	5.45 bc	4.84 c	5.52 b

[γ]% (w/w) substitution of wheat flour with finger millet flour
[λ] Least square mean of two replicate analyses using 59 panelists. Values within same column with different letters are significantly different at $p<0.05$; Tukey's Studentized Range (Honestly Significant Difference [HSD]) test used.
Overall accept., overall acceptability

Table 3 shows that taste and texture acceptability of the cookies were significantly affected by finger millet substitution level ($p<0.05$ and $p<0.001$, respectively) but not by finger millet type. Table 4 shows that cookies containing either 55% non-tannin finger millet or 55% high-tannin finger millet had the least acceptable taste and texture. It seems that either the tannin levels were too low to be detected or some components of the cookies such as sugar masked the bitterness while polymers such as proteins and starch interfered with the binding of the tannins to the taste receptors and thereby reducing astringency (Lesschaeve and Noble, 2005). Cookies containing either 55% non-tannin finger millet or 55% high-tannin finger millet had the least acceptable texture seemingly due to their grittiness. Cookies containing 35% and 55% high-tannin finger millet, respectively, had the least acceptable appearance (Table 4), which indicates that consumers dislike dark cookies. Table 3 shows that overall acceptability was significantly affected by finger millet substitution level ($p<0.01$) but not by finger millet type. Cookies containing either 55% creamy, non-tannin finger millet or 55% brown, high-tannin finger millet were the least overall acceptable (Table 4). Pearson's correlation analysis indicated that overall acceptability was positively correlated to taste and texture acceptability of the cookies ($p<0.05$ and $p<0.01$, respectively) which suggests that a decrease in overall acceptability as substitution with finger millet is increased is due to a poor taste and texture.

CONCLUSIONS

Baking wheat-finger millet doughs into cookies results in a decrease in phenolic content and antioxidant activity, which is probably due to heat-induced changes in the phenolic compounds. However, cookies containing a brown, high-tannin finger millet have substantial phenolic contents and exhibit antioxidant activities that are either comparable or higher than those of a variety of plant foods on the market. The wheat-finger millet composite cookies are gritty probably due to the presence of ungelatinised starch, hard, sharp-edged endosperm particles and bran. Taste, texture and overall acceptability of the cookies decrease as substitution with finger millet increases irrespective of finger millet type. Overall acceptability is positively correlated to texture and taste acceptability ($p<0.05$ and $p<0.01$, respectively).

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