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Development of fortified bakery products based on *kokoro*, a traditional Nigerian snack

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Abstract. Variants of kokoro snack samples were produced by fortification of maize flour-Fibersol 2-whey protein blends at 1% each with functional ingredients (ginger, fenugreek, turmeric, spirulina, red paprika) and a final blend containing all the functional ingredients at 1% level each. The resultant kokoro snack samples produced were evaluated for proximate composition and sensory qualities. The results of proximate analysis showed a significant ($P < 0.05$) difference in moisture, protein, ash content, crude fat, crude fibre, carbohydrate content, and energy values in all the blends of the kokoro snack sample and ranged from 51.20% to 36.80%, from 4.46% to 3.85%, from 1.15% to 0.98%, from 0.13% to 0.00%, from 4.93% to 3.94%, from 53.57% to 39.2, and from

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232.30 kcal/100 g to 172.99 kcal/100 g respectively. There was also a significant ($P < 0.05$) difference in the sensory attributes of all kokoro samples in terms of appearance, aroma, taste, texture, and overall acceptability. The kokoro snack blend R 97:1:1:1 (Maize: Fibersol 2: Whey protein: Red paprika) was most preferred by the panellists, having the highest mean sensory score of 8.97. The results of the evaluation of the kokoro snack samples showed that an acceptable fortified bakery product based on kokoro can be produced by the addition of maize flour-Fibersol 2-whey protein blends to red paprika and ginger at 1% level of fortification. This will further encourage the cultivation and utilization of these spices in food formulation and hence provide health-promoting benefits to target consumers.

1 Introduction

The major risk factors which have been implicated in the prevalence of cardiovascular disease and other non-communicable diseases are poor diet and morbid lifestyle. In Africa, statistics showed that one in four people are hungry and numbers have increased from 175 to 220 million in the past few years. According to *FAO* (2012), about 16 million undernourished people live in developed countries. Paradoxically, obesity and overweight are associated with more deaths than underweight worldwide. There seems to be a global shift in diet from food of plant origin rich in fibre towards a diet dominated by higher intakes of animal and partially hydrogenated fats (*Popkin*, 2002). The consumption of these calorie-rich foods is attributed to the increasing prevalence of obesity, a major risk factor for several non-communicable diseases (*Popkin*, 2006).

According to *Hoffmeister et al.* (2005), *Labadarios et al.* (2005), and *Mostert et al.* (2005), carbohydrate foods constitute a range of staples in sub-Saharan Africa. In Tanzania, Ugali, a stiff porridge of maize is the most common carbohydrate as opposed to South Africa, where maize and bread constitute the major carbohydrate sources. However, roots and tubers constitute a major source of carbohydrate in Nigeria (*Oguntona et al.*, 1998; *Oguntona-Akinyele*, 2002; *Afolabi et a*l., 2004).

In the last decades, there has been a shift regarding consumers' demand in food production. Consumers are more informed about their health in relation to their diet (*Mollet-Rowland*, 2002; *Young*, 2000). Nowadays, foods are consumed for their health-promoting effects beyond basic nutrition and hunger satisfaction (*Menrad*, 2003; *Roberfroid*, 2000b). Conventional foods are developed to meet consumer requirements of sensory attributes and convenience.

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The new trend is the development of functional foods as a nutritional therapeutic approach in combating metabolic syndrome (*Guthman*, 2003; *Grunert*, 2002; *Stephen*, 1998). It has been documented that bioactive compounds from our dietary intake can help provide additional protective mechanisms against the excessive generation of reactive oxygen species due to the deficiency in the human body's internal protection mechanisms (*Huang et al.*, 2005; *Pietta*, 2000).

In Nigeria, garlic, hot red paprika, and ginger constitute an important part of Nigerian cuisine (*Oloyede et al.*, 2013). These spices added to food at the various stages of food preparations help in disease prevention and have several proven functional and medicinal properties, which include but are not limited to anti-cancer, anti-diabetes, anti-inflammatory, and anti-tuberculosis effects and are due to the presence of bioactive compounds in them (*Otunola*, 2010, 2014). Several biological activities of these spices, such as antioxidants, anti-diabetes, anti-hyperlipidemic, or anti-hypertension, have been reported and validated (*Banerjee et al.*, 2002; *Al-Amin et al.*, 2006; *Mahmoodhi et al.*, 2006; *Nazam Ansari et al.*, 2006; *Benavides et al.*, 2007; *Ghayur et al.*, 2007; *Otunola et al.*, 2010, 2014).

Health-conscious consumers are eating snacks for health-promoting reasons rather than for refreshment. Hence their demand for snacks, which not only meet their organoleptic requirements but have health-promoting characteristics (*Norazmir et al.*, 2014). There has been a considerable increase in the number of consumers who are conscious of the relationship between their health, well-being, and dietary intake (*Nazzaro et al.*, 2014; *Norazmir et al.*, 2014; *Manzoni et al.*, 2012; *Taverna et al.*, 2012). Since grazing is a new trend for food consumers, snacking is an integral part of such phenomenon (*Costa et al.*, 2010; *Datamonitor*, 2007), thus constituting an essential potential market for snacks that fulfil the requirements of health-conscious snackers.

Maize-based snacks, such as *kokoro*, are principally carbohydrates and are popular amongst inhabitants of south-western Nigeria. According to *FAO* (2015), maize and other cereal crops, such as rice and wheat, constitute an integral part of the human dietary intake. With more than 1,000 million tons of maize harvested in 2014, it is the most popular cereal crop globally (*FAO*, 2015). Hence, fortifying maize-based snack with functional ingredients, such as spices and prebiotics with proven health-promoting properties, will enhance its application in combating disease conditions such as obesity, cardiovascular diseases (CVD), hyperlipidaemia, etc. The aims of the research were to develop a novel fortified bakery product based on a traditional Nigerian snack (kokoro) and to determine the proximate composition and sensory attributes

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of the product for overall acceptability and potential application as a complementary solution in the treatment of metabolic syndrome.

2 Materials and methods

2.1 Sample collection and processing

The maize flour (yellow variety) was obtained from the Institute of Food Technology Food Processing Factory of the University of Debrecen, Hungary. Similarly, the supplementary ingredients, such as Fibersol 2, whey protein powder, spices, and spirulina, were also obtained from the food processing factory.

2.2 Formulation and production of kokoro samples

Table 1: Percentage of blend formulation

Blends	Maize Flour (%)	Whey Protein (%)	Fibersol 2 (%)	Ginger (%)	Spirulina (%)	Fenugreek (%)	Red paprika (%)	Turmeric (%)
Control	98	1	1	-	-	-	-	-
G	97	1	1	1		-	-	-
S	97	1	1	-	1	-	-	-
F	97	1	1	-	-	1	-	-
R	97	1	1	-	-	-	1	-
T	97	1	1	-	-	-	-	1
A	93	1	1	1	1	1	1	1

A blend of maize flour containing Fibersol 2 and whey protein powder was produced and marked as the control sample (98% maize flour: 1% Fibersol 2: 1% whey protein powder). Various blends were thereafter produced by fortification of maize flour-Fibersol 2-whey protein blend with 1% each of the functional ingredients (ginger, fenugreek, turmeric, spirulina, red paprika) and a final blend containing all the functional ingredients at 1% level each.

Kokoro was produced by modifying the method adopted by *Uzo-Peters et al.* (2008). 196 g of maize flour was added to 2 g each of Fibersol 2 and whey protein powder respectively. 2.5 g of table salt was added and then mixed thoroughly using a hand-held mixer (model: CNHR2, Robert Bosch Housgerate GmbH, Munich, Germany) at low speed. The resultant mixture was then added to 450 ml of boiling water, cooked and stirred continuously until a homogenous dough was formed. This was cooled down to a temperature of about

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40 °C and kneaded manually by hand for about 4 mins. The kneaded dough was formed into uniform shapes on a chopping board, baked in a preheated hot air oven (model: RXB-610-SMART 3.5, Valladolid, Spain) at 180 °C for 17 mins, cooled and packed in Ziploc bags, and stored at refrigerated temperature for subsequent analysis.

Maize flour (yellow variety)
↓
Mixing (Fibersol 2, whey protein and each of the spices)
↓
Boiling (continuous stirring)
↓
Cooling (40 °C)
↓
Kneading (4 minutes)
↓
Rolling/shaping
↓
Baking (180 °C, 17 minutes)
↓
Cool and pack
↓
Kokoro

Figure 1: Flowchart of kokoro production

2.3 Proximate analysis of kokoro from maize-fibre-whey protein-spices blends

The moisture, ash, fat, protein, and fibre contents were analysed using the methods described by the official Hungarian National Standards MSZ 6943-1:1979, MSZ 6943-2:1980, MSZ EN ISO 11085:2015, MSZ EN ISO 20483:2013, and MSZ EN ISO 16472:2006 respectively.

Carbohydrate was calculated by difference (100- [sum of moisture, ash, fat, protein, and fibre contents]). Energy values were estimated using the Atwater factors (4×% carbohydrate + 4×% protein + 9×% fat) in kcal/100 g.

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2.4 Organoleptic/sensory assessment of kokoro from maize flour-fibre-whey protein-spices blends

The acceptability of kokoro samples was carried out using a 9-point hedonic preference scale and multiple comparison tests. This was achieved by evaluating the samples with 30 panellists, comprising 12 males and 18 females, who were staff members, students, and members of the Faculty of Agriculture, Food Sciences and Environmental Management, University of Debrecen, Hungary.

Following the approval of the panellists to participate and screening for their sensory acuity, the panellists were presented with randomly coded samples each and were asked to score each attribute based on appearance, taste, aroma, texture, and overall consumer acceptability using a 9-point hedonic scale, where 9 was assigned to like extremely and 1 assigned to dislike extremely.

2.5 Statistical analysis

The data obtained in duplicates from proximate analysis and sensory assessment were subject to one-way analysis of variance (ANOVA) using the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, version 19.0. Armonk, NY: IBM Corp).

Means obtained from the data were compared at $p < 0.05$ for significant differences using Duncan's Multiple Range Test.

3 Results and discussion

3.1 Results of proximate analysis of kokoro from maize-fibre-whey protein-spices blends

The results of proximate analysis of the different blends of the kokoro snacks samples are shown in *Table 2.* Moisture content represents an essential quality parameter in food product, and it maintains quality. The moisture contents of the samples were high and ranged from 51.20% to 36.80%. The control sample C 98:1:1 (maize: Fibersol 2: whey protein) had the lowest (36.80%) while sample **S** 97:1:1:1 (maize: Fibersol 2: whey protein: spirulina) had the highest moisture content.

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Table 2: Results of proximate analysis of kokoro snack samples from maize flour-fibre-whey protein-spices blends

Parameters	**Moisture** (%)	**Protein** (%)	**Ash** (%)	**Fat** (%)	**Fibre** (%)	**CH0** (%)	**EV** (kcal/100g)
C	$36.80^{f}\pm0.29$	$4.46^{a}\pm 0.01$	$1.15^{a}\pm0.02$	$0.02^{c}\pm0.01$	$3.94^{e}\pm0.02$	$53.57^{a}\pm0.06$	232.30^{a}
G	$46.00^{d}\pm0.19$	$4.17^{ab}\pm0.16$	$1.12^{a}\pm0.02$	$0.00^{c}\pm0.00$	$4.20^{d}\pm0.03$	$44.44^{c}\pm0.30$	194.49^{abc}
S	$51.20^{a}\pm0.67$	$3.85^{b}\pm 0.05$	$1.02^{b}\pm0.04$	$0.09^{b}\pm0.01$	$4.61^{b}\pm0.02$	$39.21^{f}\pm0.61$	172.99^{e}
T	48.15c±0.64	$4.24^{ab}\pm0.23$	$0.98^{b}\pm0.01$	0.00c±0.00	$4.26^{cd}\pm0.06$	$42.33^{d}\pm0.80$	186.26^{d}
F	$45.90^{d}\pm0.72$	$4.12^{ab}\pm0.14$	$1.08^{ab}\pm0.05$	$0.13^{a}\pm0.01$	$4.36^{c}\pm0.04$	$44.34^{c}\pm0.84$	195.00^{c}
R	$43.15^{e}\pm0.60$	$4.09^{ab}\pm0.07$	$1.12^{a}\pm 0.00$	$0.08^{b}\pm0.01$	$4.22^{d}\pm0.04$	$47.30^{b}\pm0.58$	206.24^{b}
A	$49.55^{b}\pm0.60$	$3.95^{b}\pm 0.10$	$1.09^{ab}\pm0.04$	$0.08^{b}\pm0.00$	$4.93^{a}\pm 0.06$	$40.34^{f}\pm0.60$	177.89^{e}

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This is in sharp contrast with results obtained from the moisture content of some kokoro snacks made from maize with different flour blends of defatted groundnut (*Uzor-Peters et al.*, 2008), soybean (*Adelakun et al.*, 2004), beniseed (*Ayinde et al.*, 2012), protein hydrolysate from pigeon pea (*Akoja et al.*, 2016), distillers' spent grain (*Awoyale et al.*, 2011), and defatted coconut paste (*Adebowale* & Komolafe, 2018). The higher moisture content may be attributed to the adopted cooking (baking) method rather than frying since oils/fats are able to reach higher temperatures than water. This is over and above the optimum safe moisture level ($\leq 12\%$) for the longer shelf stability of food products.

Therefore, the kokoro snacks sample under study may likely experience shorter shelf life.

The crude protein content ranged from 4.46% to 3.85% with sample **S** 97:1:1:1 (maize: Fibersol 2: whey protein: spirulina) having the least value (3.85%) while the control sample **C** 98:1:1 (maize: Fibersol 2: whey protein) having the highest value (4.46%). These values, however, are not in agreement with crude protein values recorded from previous results of kokoro snacks produced from varying substitution levels of defatted groundnut (*Uzor-Peters et al.*, 2008), beniseed cake (*Ayinde et al.*, 2012), soybean (*Adelakun et al.*, 2004), protein hydrolysate of pigeon pea (*Akoja et al.*, 2016), defatted groundnut paste (*Otunola et al.*, 2012), pigeon pea (*Adegunwa et al.*, 2015), African yam bean (*Idowu*, 2015), and defatted coconut paste (*Adebowale & Komolafe*, 2018). The moderately low crude protein values could be attributed to the fact that the bulk of the ingredients were very low in protein.

Ash content is a measure of the mineral composition of the kokoro snacks blends, and it ranged from 1.15% to 0.98%. The kokoro snacks sample **T** 97:1:1:1 (maize: Fibersol 2: whey protein: turmeric) had the lowest value (0.98%), while the control sample **C** 98:1:1 (maize: Fibersol 2: whey protein) had the highest value (1.15%). These values were lower than those recorded from previous results of kokoro 27 supplemented with varying proportions of protein hydrolysate of pigeon pea (*Akoja et al.*, 2016), defatted coconut paste (*Adebowale & Komolafe*, 2018) but higher than ash content documented for defatted groundnut (*Uzor-Peters et al.*, 2008). However, it is close to that reported for defatted groundnut paste (*Otunola et al.*, 2012).

The crude fat of the kokoro samples was very low and ranged from 0.13% to 0.00%. Kokoro snack samples **G** 97:1:1:1 (maize: Fibersol 2: whey protein: ginger) and **T** 97:1:1:1 (maize: Fibersol 2: whey protein: turmeric) had the lowest values while sample **F** 97:1:1:1 (maize: Fibersol 2: whey protein: Fenugreek) had the highest. These values, however, are in sharp contrast to the

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previous results of kokoro substituted with different proportions of soybean (*Adelakun et al.*, 2004), African yam bean (*Idowu*, 2015), defatted groundnut (*Uzor-Peters et al.*, 2008), protein hydrolysate from Pigeon pea (*Akoja et al.*, 2016), distillers' spent grain (*Awoyale et al.*, 2011), beniseed (Ayinde et al., 2012), and defatted coconut paste (*Adebowale* & *Komolafe*, 2018). The shelf life of the kokoro sample blends may be increased due to their low fat contents because all fats and fat-containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity (*Ihekoronye* & *Ngoddy*, 1985). The low crude fat content recorded may be attributed to the negligible fat contents of the ingredients used. Thus, this low fat content of the kokoro snack may be desirable as high fat consumption has been implicated in the incidence of metabolic syndrome such as obesity, cardiovascular diseases, etc.

The crude fibre content ranged from 4.93% to 3.94%. Control sample **C** 98:1:1 (maize: Fibersol 2: whey protein) had the lowest value (3.94%), while kokoro snack sample **A** 93:1:1:1:1:1:1:1 (maize: Fibersol 2: whey protein: ginger: spirulina: turmeric: fenugreek: red paprika) had the highest crude fibre content (4.93%). These values were higher than those documented for kokoro made from maize flour blends with different proportions of soybean (*Adelakun et al.*, 2004), (*Uzor-Peters et al.*, 2008), distillers' spent grain (*Awoyale et al.*, 2011), African yam bean (*Idowu*, 2015), pigeon pea (*Adegunwa et al.*, 2015), beniseed (*Ayinde et al.*, 2012), defatted groundnut, soybean protein hydrolysate from pigeon pea (*Akoja et al.*, 2016), and defatted coconut paste (*Adebowale* & *Komolafe*, 2018). The high crude fibre content obtained may be attributed to the high fibre contributions from the ingredients.

The carbohydrate content ranged from 53.57% to 39.21%. Kokoro control sample **C** 98:1:1 (maize: Fibersol 2: whey protein) had the highest value (53.57%), while kokoro snack sample **S** 97:1:1:1 (maize: Fibersol 2: whey protein: spirulina) had the least value (39.21%). These values were about the same as the results obtained from kokoro made from maize flour blends with different substitution levels of soybean (*Uzor-Peters et al.*, 2008) but lower than that documented for soybean (*Adelakun et al.*, 2004), beniseed (*Ayinde et a*l., 2012), African 28 yam bean (*Idowu*, 2015), pigeon pea (*Adegunwa et al.*, 2015), protein hydrolysate from pigeon pea (*Akoja et al.*, 2016), defatted groundnut (*Uzor-Peters et al.*, 2008), distillers' spent grain (*Awoyale et al.*, 2011), and defatted coconut paste (*Adebowale* & *Komolafe*, 2018). The low values of carbohydrate may be connected to the relatively low carbohydrate contents of the ingredients.

There was a significant ($p < 0.05$) difference in the energy values of the

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kokoro snacks samples. The energy values were low and ranged from 232.30 kcal/100 g to 172.99 kcal/100g. Control sample **C** 98:1:1 (maize: Fibersol 2: whey protein) had the highest energy value (232.30 kcal/100g), while kokoro snack sample **S** 97:1:1:1 (maize: Fibersol 2: whey protein: spirulina) had the lowest value (172.99 kcal/100g). These values were lower than the previous results of kokoro made from maize flour with varying proportions of pigeon pea (*Adegunwa et al.*, 2015), soybean (*Adelakun et al.*, 2004), beniseed cake (*Ayinde et al.*, 2012), defatted groundnut paste (*Otunola et al.*, 2012), African yam bean (*Idowu*, 2015), protein hydrolysate of pigeon pea (*Akoja et al.*, 2016), defatted groundnut (*Uzor-Peters et al.*, 2008), and defatted coconut paste (*Adebowale* & *Komolafe*, 2018). The low energy values obtained may be attributed to the low values of crude fat, carbohydrate, and protein contents of the kokoro snacks. This is desirable as the kokoro snacks will not be energy laden since studies have proven the relationship between the consumption of energy-laden foods and the occurrence of metabolic diseases such as obesity, cardiovascular disorders, etc.

Values are means of duplicate determinations. Means with different superscripts within the same column are significantly ($p < 0.05$) different.

– **CHO**: Carbohydrate, **EV**: Energy Values (kcal/100 g).

Mean values with different superscripts within the same column are significantly ($p < 0.05$) different. **C** 98:1:1 (maize: Fibersol 2: whey protein); **G** 97:1:1:1 (Maize: Fibersol 2: whey protein: Ginger); **S** 97:1:1:1 (maize: Fibersol 2: whey protein: Spirulina); **T** 97:1:1:1 (maize: Fibersol 2: whey protein: turmeric); **F** 97:1:1:1 (maize: Fibersol 2: whey protein: fenugreek); **R** 97:1:1:1 (maize: Fibersol 2: whey protein: red paprika); **A** 93:1:1:1:1:1:1:1 (maize: Fibersol 2: whey protein: ginger: spirulina: turmeric: fenugreek: red paprika).

3.2 Results of the sensory evaluation of kokoro from maize flour-fibre-whey protein-spices blends

Table 3 shows the results obtained for the nine-point hedonic and multiple comparison tests of the different blends of the kokoro snacks samples. There were significant differences ($p < 0.05$) in the appearance, taste, aroma, texture, and the overall acceptability of the control (98:2 maize-fibre-whey protein) and the maize-fibre-whey protein-spices-based kokoro snacks.

However, there was no significant difference ($p < 0.05$) between samples **T** and **F** (turmeric- and fenugreek-spiced kokoro blends) in terms of all the sensory parameters evaluated. The red-paprika-spiced kokoro blend (R) was

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the most preferred one by the panellists, as reflected in the highest mean sensory score of 8.97, followed by sample **G** (ginger-spiced) with a sensory score of 8.10 and **F** and **T** formulations (turmeric- and fenugreek-spiced kokoro blends) with mean sensory scores of 7.37 and 7.40 respectively.

The **A** formulation (all ingredients-based blend) was the least preferred with a mean sensory score of 4.27 for all the sensory attributes evaluated. The highest mean sensory score and overall acceptability of **R** formulation (red 29 paprika spiced kokoro blend) could be attributed to the incorporation of red paprika as an important and basic ingredient in Hungarian dishes and often the most utilized spice (*Szűcs* & *Szabó*, 2014).

Table 3: Mean scores of sensory evaluations of kokoro from maize flour-fibre-whey protein-spices blends

Sample	**Appearance**	**Aroma**	**Taste**	**Texture**	**Overall acceptability**
C	6.07^{d}	6.07^{d}	6.07^{d}	6.07^{d}	6.07^{d}
G	8.10^{b}	8.10^{b}	8.10^{b}	8.10^{b}	8.10^{b}
S	5.10^{e}	5.10^{e}	5.10^{e}	5.10^{e}	5.10^{e}
T	7.37^{c}	7.37^{c}	7.37^{c}	7.37^{c}	7.37^{c}
F	7.40^{c}	7.40^{c}	7.40^{c}	7.40^{c}	7.40^{c}
R	8.97^{a}	8.97^{a}	8.97^{a}	8.97^{a}	8.97^{a}
A	4.27^{f}	4.27^{f}	4.27^{f}	4.27^{f}	4.27^{f}

4 Conclusions

This research has shown that maize-based fortified bakery products based on kokoro, a traditional Nigerian snack with better nutritional value and consumer acceptance, can be developed with the addition of Fibersol 2, whey protein, and spices at 1% level of fortification with maize flour. This will therefore promote the utilization of all these ingredients in bakery food formulations.

However, the moisture content of the snacks was higher than the optimum safe moisture level (12%) and thus may affect the storability of the snacks. Nevertheless, further research should be done to investigate the effects of packaging materials and storage conditions on the shelf stability of the snacks. In addition, further studies should be carried out to determine the effects of

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higher levels of fortification on the proximate composition and sensorial qualities of the kokoro snacks. This will further help in the evaluation of the optimum level of fortification to achieve optimum results.

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