to the fact that control cookies used 100% wheat flour which has gluten, whereas substitutions from 5-20% with spice-blend respectively, reduced the amount of flour used for formulation of spice-blend cookies. This is similar to the reports of Hasrini et al. [27] for cookies produced from modified cassava flour (Mocaf) enriched with rich nutrition vegetable powder.

Inclusion of the spice-blend improved the fat, ash and fibre contents of the cookies in a dose-responsive pattern as the spice-blend increased. The crude fat content of control cookies was below that of the spice-blend cookies. The higher crude fat of the spice cookies could have come from the initial content of the spice materials used. Higher ash content is indicative of higher mineral content of the spice-blend cookies, which was reflected in the rich and high quantity of minerals. The increase in Mg, K, P and stability of Fe, Ca, Zn and Cu are indications that the cookies could support the daily requirements of these micronutrients in the diet. These observations agree with Macías et al. [28] who fortified cookies with mesquite flour.

Foods with high fibre content are advantageous for the wellbeing of the gut and whole human health, including lowering of cholesterol levels, blood sugar control, improved digestion and preventing colon cancer [29-31]. The fibre content of the cookies could therefore support the quality and daily requirements for dietary fibre.

The carbohydrate content of the control cookies was not significantly different, though the control cookies had slightly higher content. Carbohydrates are sources of energy needed by the body for metabolism, though the main source of carbohydrates in this case comes from the wheat flour. The energy values of the fortified cookies agree with previous reports and suggest that the cookies could add up to 30% of the daily caloric needs of the diet [32].

Sensory evaluation report of darker colour for the spice-blend cookies could be as a result of decomposed or transformed polyphenols or carotenoids. Generally, the fortified cookies were highly accepted, because the lowest overall acceptability score was 5.58 for MC4 (20% spice-blend). However, the MC1 cookies (5% spice-blend) had the highest overall acceptability score. This is similar to the report of Costa de Camargo et al. [33] that 2.5% peanut skin-fortified cookies and cookies made with defatted maize germ flour [34] were well accepted. The other spice-blend cookies were however not well accepted because increasing the quantity of the spice to 10, 15 and 20% resulted in excessive spiciness ('hotness'). The low phenolic content of the cookies could be as a result of thermal degradation and transformation which occurred during the baking process. The reduced TPC reported here agrees with previous studies that baking always leads to a general decrease in TPC, even at 150 °C, although some residual phenolics are left when baking is done at this temperature [17,34]. The low TPC of the cookies could account for the reduced antioxidant activity as phenolic content often correlate with antioxidant activity. The observed ABTS and DPPH radicals scavenging activities of the cookies were therefore, most likely enhanced by other components, such as β-carotene and ferulic acid which can contribute to antioxidant activities; [35] or Maillard reactions, since antioxidant activity due to non-enzymic browning and Maillard reactions have been reported in cookies [36]. Dietary antioxidants especially polyphenols have great therapeutic potential and help in maintaining oxidative stability of foods.

The outcome of this study agrees with previous studies on antioxidant properties of cookies fortified with foxtail millet and ginger powder, mushroom flour, minor millets, peanut skins, or oat-buckwheat dough and cookies with added spices or herbs [17,24-25,33,37].

Alpha-amylase is one of the vital enzymes involved in the breakdown of starch to glucose, thus, its inhibition could be effective in maintaining glucose homeostasis for diabetes since only glucose is readily

absorbed by the intestinal lumen. Alpha-amylase inhibition is therefore useful in evaluating extracts and foods for their capacity to modify post-prandial glycaemic response.

Acarbose has the capacity to delay glucose absorption by inhibiting the upper gastrointestinal glucosidases resulting in reduced postprandial hyperglycemia in a dose-dependent manner; thus, it is a common drug for treating patients with type 2 diabetes, though with negative side effects. Therefore, inhibitory effects of the cookies against α-amylase were evaluated using acarbose as a positive control. The moderate α-amylase inhibition demonstrated by the spice-blend cookies implies that the cookies can support the dietary management of postprandial hyperglycemia. According to Kamruzzaman et al. [38] a nutrient preload (consumption of a small amount of macronutrient at a fixed interval (30-60 min) before a meal) could reduce postprandial glycemic excursion. This is consistent and agrees with reports from other studies that foods, plant or spice extracts that possess mild α-amylase inhibition could be suitable alternatives for drugs currently in use for inhibiting α-glucosidase and α-amylase which have the disadvantage of negative side effects like bloating, diarrhea and flatulence [38-40].

CONCLUSION

Fortification with the spice blend not only improved nutritional quality, but also enhanced bioactivity characteristics as evidenced by the antioxidant and alpha-amylase inhibitory activities of the cookies. In terms of physical attributes and overall acceptability, MC1 (5% spice blend) was the closest to the control. Although MC4, MC3 and MC2 showed higher antioxidant and alpha-amylase activities, they were organoleptically unacceptable because they were too spicy ('hot'). These results as shown in the proximal, mineral and energy values, indicate that cookies fortified with 5% spice-blend apart from being good sources of nutrients; also possess antioxidant and α-amylase inhibition activities and therefore has potential as a therapeutic healthy snack that could prevent malnutrition and hyperglycemia in type 2 diabetes.

Overall, the findings support dietary polyphenols from spices as functional food ingredients with health benefits.

Future Perspectives: These results indicate that cookies fortified with 5% spice-blend are good sources of nutrients, possess antioxidant and α-amylase inhibition activities and has potential as a therapeutic healthy snack that could prevent malnutrition and hyperglycemia in type 2 diabetes. Further studies including use of natural sweeteners and clinical evaluations are therefore necessary and in view.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Abbreviations: MC1: 95% wheat flour + 5% Spice-blend cookies, MC2: 90% wheat flour + 10% Spice-blend cookies, MC3: 85% wheat flour + 15% Spice-blend cookies, MC4: 80% wheat flour + 20% Spice-blend cookies, DPPH+: 2, 2-diphenyl-1-picrylhydrazyl radical, ABTS+: 2,2-azinobis-3-ethylbenzo-thiazoline-6-sulfonate radical, TPC: Total phenolic content

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