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Effects of Processing Methods on *In-Vitro* Protein Digestibility of Cookies Produced from Sesame Seed Flour Blends

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ABSTRACT

Sesame seeds (*Sesamum indicum*) were processed into flour using defatting, cooking, roasting, germination and fermentation processing methods. The processed sesame seed flour (SSF) was used at four substitution levels of 5, 10, 15 and 20% to wheat flour (WF) to produce cookies. Thereafter, the effects of the five processing methods on the total nitrogen, soluble nitrogen and *in-vitro* protein digestibility of the produced cookies were studied. The result of the study revealed that substitution of wheat with 20% roasted, defatted and cooked sesame seed flours gave total nitrogen content of 2.15, 2.09 and 1.90%, respectively. Increasing substitution level of defatted, cooked and fermented SSF to WF led to decreasing *in-vitro* protein digestibility values of the cookies from 61.36 to 30.75%, 37.21 to 32.98% and 63.28 to 32.99%, respectively. While increasing substitution levels of wheat flour with germinated sesame seed flour was observed to increased the *in-vitro* protein digestibility of the cookies from 34.82 to 51.39%. In terms of the roasted SSF, 10% substitution level to WF had the highest *in-vitro* protein digestibility value of 52.27% while decreasing values (43.55 to 27.38%) were recorded from 15 to 20% substitution levels, respectively. *In-vitro* protein digestibility of cookies produced from wheat in composite with processed sesame seed flour was significantly (P<0.05) higher than that of the control (100% wheat flour cookies). Hence, sesame seeds can be processed into flour via the studied processing methods and used in substitution to wheat in the production of cookies to improve its protein digestibility.

Keywords: Processing Methods, *In-vitro* Protein Digestibility, Sesame Seeds, Flour Blends, Total and Soluble Nitrogen, Functional Ingredients.

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INTRODUCTION

Cookies are regarded as confection-food with low moisture content (Albert, 1999). They are nutritive snacks obtained from single or composite dough which has been transformed into digestible and more appetizing products through the action of heat in the oven (Singh et al., 2000). Cookies are classified based on ingredient composition and processing techniques (Albert, 1999). Due to increased demand for functional products, attempts are being made to improve the nutritive value and functionality of cookies by modifying their nutritive composition. This involves the use of non-wheat flour with an attempt to increase the protein content, fibre content, general quality characteristics of the cookies and as such, overcome the problems of high cost of wheat flour due to its importation in Nigeria and other countries whose climates are unfavourable for wheat cultivation. These limitations have prompted the search for available or underutilized crops, tubers and fruits with functional attributes to be incorporated as composite flours for the production of baked products (Chinma et al., 2011). Based on this, cashew-apple, *Moringa* leaf, rice/soybean blend, sorghum/soybean blend, sesame seed among others has been processed and incorporated in the production of cookies to add functional benefits such as fibre, protein and other nutritional values to the products (Ebere et al., 2015; Emelike et al., 2015a; Adeyeye, 2018; Adeyeye et al., 2019; Akusu et al., 2020). Sesame seeds (*Sesamum indicum*) are tiny, flat oval seeds with a nutty taste. It is an important oil seed believed to have originated from tropical Africa with the greatest diversity (RMRDC, 2004). Sesame seed is a staple food among many ethnic groups in Nigeria and it is cultivated in most areas of the middle belt, some Northern States of Nigeria (Olanyanju et al., 2006) and the temperate zones of the world. Myanmar is a major producer of sesame followed by India, China, Ethiopia and Nigeria (Nidhi et al., 2018). Sesame is an important source of oil (44 to 52.5%), protein (18 to 23.5%), carbohydrate (13%) (Kahyaoglu and Kaya, 2006; Bamigboye et al., 2010) and crude fibre (Obiajunwa et al., 2005), Johnson et al. (1979) revealed that sesame seed contains 50% oil which is highly resistant to oxidation and 25% protein which has unique balance of essential amino acids and minerals. Among all the oil seed proteins, sesame protein is the most nutritious as it is a rich source of methionine (sulphur containing amino acid) (Narsinga-Rao, 1985) and tryptophan (Manikantan et al., 2015).

The seeds are also rich sources of mono-unsaturated fatty acid (oleic acid) and equally rich sources of many minerals such as calcium, phosphorus, manganese, zinc, magnesium and potassium which play vital roles in the body (Makinde and Akinoso, 2013). The seeds are consumed fresh, dried or blended with sugar or consumed for its medicinal qualities. It is also used as a paste in the preparation of some local soups. Since amino acids such as methionine and tryptophan are missing from several other sources of vegetable proteins; soybean, sesame meal or flour as their rich sources can be added to recipes to give a better nutritional balance (Chemonics, 2002). Processed sesame seeds are used in bakery products such as cake, hamburger, buns, cookies, confectionery purposes and many snack foods (Nagaraj, 2009). Sesame seeds can also be consumed directly as a highly nutritious foodstuff (Naturland, 2002). Because of its greater and varied utility, it is considered as the “Queen of oilseeds”. The nutritional value of processed foods depends on their nutrient content and the bioavailability of nutrients present in the materials used in its preparation or production. The nutritional quality of sesame seed and its products can be enhanced by processing technologies such as roasting, cooking, defatting, germination and fermentation prior to consumption. These various processing technologies have helped in transforming food ingredients into healthier products with maximum nutritional value to ensure nutrient security of the population in developing countries (Kumar et al., 2010). Processing, however, can enhance or reduce the bioavailability of proteins (Nestares et al., 1999). Cooking (boiling) and roasting are the most common domestic processing methods (Hassan, 2011). They are considered good for the elimination of heat-labile anti-nutritional factors present in oilseeds (Manikantan et al., 2015).

The widespread and long-standing tribute to sesame lies in its high oil content, nutritious protein and savoury roasted flavour (Namiki, 1995). Cooking has been reported to improve the nutritional and functional properties of plant seeds (Jirapa et al., 2001; Yagoub and Abdalla, 2007). Cooking, roasting, defatting, germination and fermentation can also reduce malnutrition by making macro and micronutrients available for easy absorption. Hence, increasing the utilization of sesame seeds. Although numerous studies about the nutritional characteristics of sesame seeds exist, there is little information on protein digestibility and availability in value-added products formulated from cooked, defatted, roasted, germinated and fermented sesame seed flours. Industrial processing and utilization of sesame have not been fully developed in Nigeria as its utilization is restricted to producing regions while for the most part, the surplus crop is commercialized, bulked and exported. Therefore, the objective of this study was to produce cookies from the blends of cooked, defatted, roasted, germinated and fermented sesame seed flours in composite with wheat and to access the total nitrogen, soluble nitrogen and *in-vitro* protein digestibility of the cookies.

MATERIALS AND METHODS

Sesame seeds were purchased from an open market in Anyigba, Kogi State. Wheat flour and other bakery ingredients were purchased from the confectionery store in Port Harcourt, Rivers State. They were transported in airtight high-density polyethylene bags to the Food Chemistry Laboratory in the Department of Food Science and Technology, Rivers State University, Port Harcourt, all in Nigeria. All chemicals and reagents used in the analysis were of analytical grade and obtained from the same Laboratory.

Processing of Sesame Seed Flours

Sesame seed flours were processed using five processing methods such as defatting, cooking, roasting, germination and fermentation. Defatted sesame seed flour was produced according to the method described by Emelike et al. (2015b). The method described by Makinde and Akinoso (2013) was used to produce cooked sesame seed flour. Roasted and germinated samples were produced as described by Mohamed et al. (2007); Okoli and Adeyemi (1989), respectively while fermented samples produced using Akindahunsi (2004) method. Afterward, all the flour samples were package separately and stored for analysis.

Formulation of Flour Blends and Production of Cookies from the Blends

Sesame seed flours and wheat flour including the ingredients used in the production of cookies were formulated using Akusu et al. (2020) formulation method as shown in Table 1. Cookies were produced as described by Aliyu (2009) with some modifications. Processed sesame seed flour, wheat flour, margarine, salt, sodium bicarbonate, milk and vanilla flavour were accurately weighed. The ingredients except flours were mixed thoroughly in a Kenwood mixer (a 3-speed hand mixer), it was then transferred to a bowl. The flours and sodium bicarbonate were added with continuous mixing for 15 min while gradually adding 50 ml of water until a smooth dough was obtained. A piece of this dough was cut, placed on a clean platform then rolled out using a rolling pin until the desired uniform texture and thickness were obtained. Cookie-cutter was used to cut the sheet of the dough into required shapes and sizes. These were placed on a margarine greased baking tray and transferred to a reheated oven and baked at 200°C for 15 to 20 min. After this, the baked cookies were brought out from the oven, removed from the baking tray and placed on a clean tray to cool down. The cookies were then packed after cooling in polyethylene sachets of appropriate thickness and permeability using an impulse sealing machine prior to analysis and sensory evaluation while cookies with 100% wheat flour were produced and

Table 1. Formulation blends of wheat/processed sesame seed flours for cookie production.

Samples	WDS C1	WDS C2	WDS C3	WDS C4	WCS C1	WCS C2	WCS C3	WCS C4	WRS C1	WRS C2	WRS C3	WRS C4	WGS C1	WGS C2	WGS C3	WGS C4	WFS C1	WFS C2	WFS C3	WFS C4	WFC
WF (g)	95	90	85	80	95	90	85	80	95	90	85	80	95	90	85	80	95	90	85	80	100
DSSF (g)	5	10	15	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CSSF (g)	0	0	0	0	5	10	15	20	0	0	0	0	0	0	0	0	0	0	0	0	0
RSSF (g)	0	0	0	0	0	0	0	0	5	10	15	20	0	0	0	0	0	0	0	0	0
GSSF (g)	0	0	0	0	0	0	0	0	0	0	0	0	5	10	15	20	0	0	0	0	0
FSSF (g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	15	20	0
Sugar (g)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Margarine (g)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Water (ml)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Milk (g)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
$NaHCO_3$ (g)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Salt (g)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Flavour (ml)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Source: Akusu et al. (2020)
KEY: WF = wheat flour, DSSF = defatted sesame seed flour, CSSF = Cooked sesame seed flour, RSSF = Roasted sesame seed flour, GSSF = germinated sesame seed flour, FSSF = fermented sesame seed flour.
WDSC1 = WF/DSSF cookies (95/5%), WDSC2 = WF/DSSF cookies (90/10%), WDSC3 = WF/DSSF cookies (85/15%), WDSC4 =WF/DSSF cookies (80/20%).
WCSC1 = WF/CSSF cookies (95/5%), WCSC2 = WF/CSSF cookies (90/10%), WCSC3 = WF/CSSF cookies (85/15%), WCSC4 = WF/CSSF cookies (80/20%).
WRSC1 = WF/RSSF cookies (95/5%), WRSC2 = WF/RSSF cookies (90/10%), WRSC3 = WF/RSSF cookies (85/15%), WRSC4 = WF/RSSF cookies (80/20%).
WGSC1 = WF/GSSF cookies (95/5%), WGSC2 = WF/GSSF cookies (90/10%), WGSC3 = WF/GSSF cookies (85/15%), WGSC4 = WF/GSSF cookies (80/20%).
WFSC1 = WF/FSSF cookies (95/5%), WFSC2 = WF/FSSF cookies (90/10%), WFSC3 = WF/FSSF cookies (85/15%), WFSC4 = WF/FSSF cookies (80/20%).
WFC = Control (100% wheat flour cookies).

used as product control.

In-Vitro Protein Digestibility

The *in-vitro* protein digestibility of cookie samples was determined using the procedure outline by Mertz et al. (1984) and modified by Monsour and Yusuf (2002). A known weight of each sample equivalent to 16 mg nitrogen was weighed into a flask and suspended in 15 ml of 0.1M HCl containing 1 mg of porcine pepsin and incubated at 37°C for 3 h. The pepsin hydrolyzed suspension was then neutralized with 0.5M NaOH and incubated with 6 mg of pancreatin in 7.5 ml of phosphate buffer (pH 8.0) for 24 h at 37°C. After the incubation, the sample was treated with 15 ml of 10% Trichloroacetic acid (TCA). The mixture was filtered through Whatman No 1 filter paper. The TCA soluble fraction was assayed for nitrogen estimation using the micro Kjedahl method and a blank sample was also determined. The protein digestibility was calculated by the following formula:

$$\text{Protein Digestibility}\ \% = \frac{\text{Nitrogen in Supernatant} - \text{Nitrogen in Blank}}{\text{Nitrogen in Sample}} \times 100$$

Total nitrogen was therefore calculated from the nitrogen obtained earlier using the Kjeldahl method.

Statistical Analysis

All the analyses were carried out in duplicate. Data obtained were subjected to Analysis of variance (ANOVA), differences between means were evaluated using Tukey's multiple comparison test and significance accepted at P≤0.05 level. The statistical package in Minitab 16 computer program was used.

RESULTS AND DISCUSSION

Effects of Defatting on *In-Vitro* Protein Digestibility of the Produced Cookies

As shown in Table 2, the total nitrogen in the cookie samples increased significantly (P<0.05) with an increase in percentage substitution of processed sesame

Table 2. Effect of defatting on *In-Vitro* protein digestibility (%) of cookies produced from the flour blends.

Sample	Total Nitrogen (%)	Soluble Nitrogen (%)	*In-Vitro* Protein Digestibility (%)
WDSC1	1.74^{e}±0.00	1.07^{a}±0.00	61.36^{a}±0.00
WDSC2	1.88^{d}±0.00	0.86^{b}±0.06	45.99^{b}±3.10
WDSC3	2.21^{b}±0.00	0.41^{d}±0.04	18.69^{d}±1.56
WDSC4	2.09^{c}±0.00	0.64^{c}±0.00	30.75^{c}±0.00
WFC	2.88^{a}±0.00	0.30^{e}±0.01	10.42^{e}±0.65

Mean values bearing different superscripts in the same column differ significantly (P<0.05), ± Standard deviation of triplicate samples.
Key:
WDSC1: Wheat-Defatted Sesame Cookies 95:5%, WDSC2: Wheat-Defatted Sesame Cookies 90:10%, WDSC3: Wheat-Defatted Sesame Cookies 85:15%, WDSC4: Wheat-Defatted Sesame Cookies 80:20%, WFC: Wheat Flour Cookies 100%.

Table 3. Effect of cooking on *In-Vitro* protein digestibility of cookies produced from the flour blends.

Sample	Total Nitrogen (%)	Soluble Nitrogen (%)	*In-Vitro* Protein Digestibility (%)
WCSC1	1.62^{e}±0.01	0.60^{c}±0.05	37.21^{b}±0.10
WCSC2	1.77^{c}±0.00	0.85^{a}±0.11	48.38^{a}±0.86
WCSC3	1.67^{d}±0.00	0.33^{d}±0.00	19.60^{d}±0.00
WCSC4	1.90^{b}±0.00	0.63^{b}±0.00	32.98^{c}±0.00
WFC	2.88^{a}±0.00	0.30^{e}±0.01	10.42^{e}±0.65

Mean values bearing different letters in the same column differ significantly (P<0.05), ± Standard deviation of triplicate samples.
Key:
WCSC1: Wheat-Cooked Sesame Cookies 95:5%, WCSC2: Wheat-Cooked Sesame Cookies 90:10%, WCSC3: Wheat-Cooked Sesame Cookies 85:15%, WCSC4: Wheat-Cooked Sesame Cookies 80:20%, WFC: Wheat Flour Cookies 100%.

seed flour. Cookies produced with 85% wheat and 15% defatted sesame seed flours (WDSC3) gave the highest total nitrogen content of 2.21% while a slight reduction in the value of total nitrogen of sample WDSC4 was observed. Percentage of soluble nitrogen reduced significantly to 0.64% in cookies produced with 20% defatted sesame seed flour in composite with 80% wheat (WDSC4). Soluble nitrogen was high at 0.86% when substituted with 10% defatted sesame seed flour. *In-vitro* protein digestibility (IVPD) of cookies decreased with increase substitution levels of defatted sesame seed flour. Defatted blends gave the highest percentage IVPD of 61.36% at 5:95 (defatted sesame/wheat flour blends) substitution levels while IVPD of sample WDSC2 is in close agreement with the value of 42.48% for defatted amaranth flour reported by Olawoye and Gbadamosi (2017). Protein digestibility is a primary determinant of the availability of amino acids. Hence, it is important in evaluating the nutritive quality of a food product (Hassan, 2011). The result revealed that increasing substitution levels of defatted sesame seed flour to cookies' production led to a decreasing *in-vitro* protein digestibility of the samples. This was not in agreement with that of Klunklin and Savage (2018) as they reported increasing IVPD of biscuit at an increasing substitution level of defatted green-lipped mussel powder. Different defatted food materials involved in these two research could be responsible for variations in the *in-vitro* protein digestibility values of the resultant products.

Effects of Cooking on *In-Vitro* Protein Digestibility of the Produced Cookies

Total nitrogen content increased significantly (P<0.05) from 1.62 to 1.90% for samples WCSC1 to WCSC4, respectively as presented in Table 3. These values were significantly (P<0.05) lower than the control (cookies produced from 100% wheat flour). The protein digestibility of all cookie samples produced from wheat and cooked sesame seed flour blends were significantly (P<0.05) higher than the control with a value range of 19.60 to 48.38%. Increase in protein digestibility of wheat/sesame seed cookies is probably due to increased solubility of sesame seed protein as reported by Akusu et al. (2019) and increased availability of protein due to reduction in phytate and other anti-nutrients by cooking as earlier reported by Akusu et al. (2020).

Effects of Roasting on *In-Vitro* Protein Digestibility of Flour Blend Cookies

Total nitrogen, soluble nitrogen and *in-vitro* protein digestibility of cookies produced from the blends of wheat flour and roasted sesame seed flours ranged from 1.75 to 2.88%, 0.30 to 0.91% and 10.42 to 52.278%, respectively as shown in Table 4. Total nitrogen content of cookies produced from 100% wheat flour was significantly (P<0.05) higher than those produced from wheat/sesame seed flour blends while its soluble nitrogen and *in-vitro* protein digestibility were significantly (P<0.05) lower than those of the blends. Cookies produced with 90% wheat flour in composite with 10% roasted sesame seed flour gave significantly (P<0.05) higher soluble nitrogen and *in-vitro* protein digestibility. Hassan (2011) equally reported an increase in IVPD due to roasting of brown sesame seed from 77.9% for raw and 85.7% for roasted sesame seed. Habiba (2002); Fagbemi et al. (2005); Embaby (2010) equally found in their study that roasting, cooking, autoclaving and microwaving treatments of legume seeds increased the *in-vitro* protein digestibility of the seed samples. Inversely, Osman (2007); Yagoub and Abdalla (2007)

Table 4. Effect of roasting on the *In-Vitro* protein digestibility of sesame flour blend cookies.

Sample	Total Nitrogen (%)	Soluble Nitrogen (%)	*In-Vitro* Protein Digestibility (%)
WRSC1	1.76±0.00[d]	0.63±0.00[c]	37.21±0.00[c]
WRSC2	1.75±0.00[e]	0.91±0.00[a]	52.27±0.00[a]
WRSC3	1.87±0.01[c]	0.81±0.00[b]	43.55±0.00[b]
WRSC4	2.15±0.01[b]	0.58±0.03[d]	27.38±1.82[d]
WFC	2.88±0.00[a]	0.30±0.01[e]	10.42±0.65[e]

Mean values bearing different letters in the same column differ significantly (P<0.05), ± standard deviation of triplicate samples.
Key:
WRSC1: Wheat-Roasted Sesame Cookies 95:5%, WRSC2: Wheat-Roasted Sesame Cookies 90:10%, WRSC3: Wheat-Roasted Sesame Cookies 85:15%, WRSC4: Wheat-Roasted Sesame Cookies 80:20%, WFC: Wheat Flour Cookies 100%.

Table 5. Effect of germination on the *In-Vitro* protein digestibility of sesame flour blend cookies.

Sample	Total Nitrogen (%)	Soluble Nitrogen (%)	*In-Vitro* Protein Digestibility (%)
WGSC1	1.77±0.00[d]	0.62±0.05[c]	34.82±3.08[bc]
WGSC2	1.90±0.00[c]	0.60±0.09[c]	31.58±4.62[c]
WGSC3	1.75±0.00[e]	0.78±0.08[b]	41.66±4.63[ab]
WGSC4	1.98±0.00[b]	1.02±0.03[a]	51.39±1.55[a]
WFC	2.88±0.00[a]	0.30±0.01[d]	10.42±0.65[d]

Mean values bearing different letters in the same column differ significantly (P<0.05), ± standard deviation of triplicate samples.
Key:
WGSC1 = Wheat-Germinated Sesame Cookies 95:5%, WGSC2 = Wheat- Germinated Sesame Cookies 90:10%, WGSC3 = Wheat-Germinated Sesame Cookies 85:15%, WGSC4 = Wheat-Germinated Sesame Cookies 80:20%, WFC = Wheat Flour Cookies 100%.

Table 6. Effect of fermentation on *In-Vitro* protein digestibility of the flour blend cookies.

Sample	Total Nitrogen (%)	Soluble Nitrogen (%)	*In-Vitro* Protein Digestibility (%)
WFSC1	1.13±0.00[d]	0.64±0.14[b]	63.28±3.08[a]
WFSC2	2.04±0.00[b]	0.86±0.03[a]	42.40±1.53[c]
WFSC3	1.19±0.00[c]	0.63±0.00[b]	53.09±0.71[b]
WFSC4	2.09±0.00[b]	0.69±0.07[ab]	32.99±3.10[d]
WFC	2.88±0.00[a]	0.30±0.01[c]	10.42±0.65[e]

Mean values bearing different letters in the same column differ significantly (p<0.05), ± standard deviation of triplicate samples.
Key:
WFSC1: Wheat-Fermented Sesame Cookies 95:5%, WFSC2: Wheat-Fermented Sesame Cookies 90:10%, WFSC3: Wheat-Fermented Sesame Cookies 85:15%, WFSC4: Wheat-Fermented Sesame Cookies 80:20%, WFC: Wheat Flour Cookies 100%.

found that roasting, autoclaving and cooking significantly decreased IVPD in Dicholas lablab seeds and bambara groundnut. This could be associated with different seeds used in these studies.

Effects of Germination on *In-Vitro* Protein Digestibility of the Flour Blend Cookies

The result revealed that total nitrogen, soluble nitrogen and *in-vitro* protein digestibility values ranged from 1.75 to 2.88%, 0.30 to 1.02% and 10.42 to 51.39%, respectively as presented in Table 5. Total and soluble nitrogen contents of the control samples had significantly (P<0.05) higher and lower values than those substituted with sesame seed flour blends, respectively. Thus, *in-vitro* protein digestibility values of the produced cookies were observed to increase significantly (P<0.05) with an increasing substitution level with germinated sesame seed flour. This implies that addiction to germinated sesame seed flour in the formulation of cookies led to an improvement in the protein digestibility of the product and could be attributed to the reduction or elimination of different anti-nutrients. Akusu et al. (2020) reported earlier that various processing methods brought about a reduction in phytate and other anti-nutrients and in-turn, increased the availability of protein. Hence, germination of sesame seed showed a profound effect on protein digestibility. Protein digestibility of legumes and cereals had also been reported to increase as a result of germination (Chavan et al., 1988; Taylor and Taylor, 2002). Giami et al. (1999); Swaisgood and Catignani (1991) acknowledged that germination has the tendency of promoting structural changes of protein such as globulin, thereby increasing chain flexibility and accessibility to proteases, consequently, protein digestibility of the resultant.

Effects of Fermentation on *In-Vitro* Protein Digestibility of the Flour Blend Cookies

Total nitrogen, soluble nitrogen and *in-vitro* protein digestibility ranged from 1.13 to 2.88%, 0.30 to 0.86% and 10.42 to 53.09%, respectively as shown in Table 6. Cookies with fermented sesame seed flour blend gave

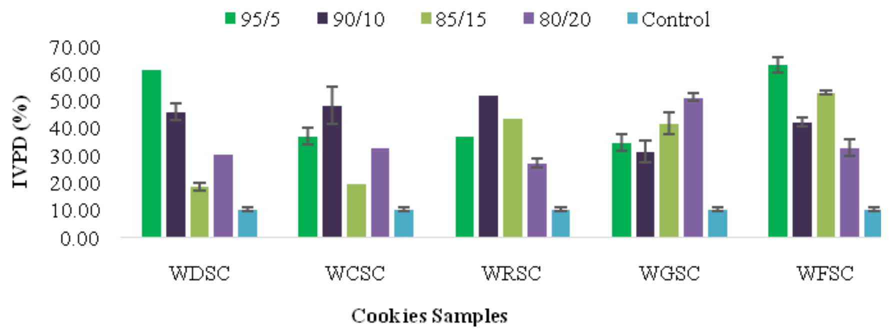

Figure 1. *In-Vitro* protein digestibility of cookies produced from blends of wheat flour and defatted, cooked, roasted, germinated and fermented sesame flour.

significantly (P<0.05) higher soluble nitrogen of 0.86% at 90:10 wheat/fermented sesame seed. Cookies produced with 100% wheat flour had significantly highest total nitrogen value of 2.88% with the lowest soluble nitrogen and *in-vitro* protein digestibility values of 0.30% and 10.42%, respectively. An increase in substitution levels of fermented sesame seed flour led to a continuous increase in IVPD values of the cookie samples. This increase could be associated with the reduction in anti-nutritional factors of the blends as Akusu et al. (2020) reported in their study that fermentation of sesame seed led to a reduction in anti-nutritional factors. Taylor and Taylor (2002) proposed that during fermentation, insoluble proteins (prolamine and glutelin) undergo structural changes that enable them to be more accessible to pepsin attack, instead of being broken down into smaller sub-units. These changes are expected to have a profound effect on the digestibility of the seed protein and could be partly responsible for the increased protein digestibility of cookies produced from the blends of wheat/fermented sesame seed flours in this study. This agreed with Mohiedeen et al. (2010) who reported that fermentation was found to improve the IVPD of two maize cultivars and this was attributed to the partial degradation of complex storage proteins into more simple and soluble products.

In-Vitro Protein Digestibility of Cookies Produced from Blends of Wheat Flour and Defatted, Cooked, Roasted, Germinated and Fermented Sesame Flours

The comparative effects of all the processing methods (defatting, cooking, roasting, germination and fermentation) are presented in Figure 1. Significantly (P<0.05) high IVPD of 63.28 and 61.36% were seen in cookies produced with 5% substitution of fermented sesame flour and defatted sesame seed flour, respectively. This was followed by cookies produced with 15% substitution of fermented sesame seed flour (53.09%) and those produced with 10% substitution of roasted sesame seed flour (52.27%). *In-vitro* protein digestibility of all the composite cookies were significantly (P<0.05) higher than the control (100% wheat flour cookies). Olawoye and Gbadamosi (2017) equally observed that *in-vitro* protein digestibility values of all the processed blended flours were significantly higher than those from whole amaranth flour. This is an indication that the applied processing methods and blending are good measures to increase or improve the protein digestibility of food products.

CONCLUSION

The study revealed that increasing substitution levels of defatted and fermented sesame seed flours to wheat flour led to decreasing *in-vitro* protein digestibility of the cookie samples while increasing substitution ratios with germinated sesame seed flour led to a corresponding increasing *in-vitro* protein digestibility of the products. Cookies produced from cooked and roasted sesame seed flour in composite with wheat flour achieved its highest *in-vitro* protein digestibility at 10% substitution levels. Furthermore, it was noted that *in-vitro* protein digestibility of cookies produced from the flour blends was significantly (P<0.05) higher than the control sample. Hence, sesame seeds can be processed into flour via the studied processing methods and used in substitution to wheat flour up to 10 or 20% as the case may be in the production of cookies to improve its protein digestibility.

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