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Original Research Article

Development of Sorghum-Based Shortbread Biscuits

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Abstract: Sorghum has proven to be a super-rich component of nutrition and adds a superb flavour to gluten-free baking. The purpose of this study was to develop shortbread biscuits from sorghum flour. The objectives of the study are to develop a shortbread biscuit using sorghum flour and to determine whether the sorghum-based shortbread biscuits would be acceptable to consumers commercially. To produce biscuits from sorghum flour, sorghum was milled, sieved, mixed, rolled, cut, and baked. An experimental and a descriptive approach design was used for the study. Sixty (60) respondents were purposively selected for the study. Questionnaires were used to collect information from the respondents. Sensory evaluations of the properties such as texture, flavour, taste, appearance and colour were examined. The study found that most of the respondents had seen and tasted sorghum flour and thus, would be able to give vivid responses to questions about sorghum flour and its products. Sorghum as flour in baking is good and can be a perfect substitute for wheat flour in the preparation of many baked products. Thus, the bakery industry will be able to produce shortbread biscuits all year round as a snack.

Keyword: Sorghum, flour, shortbread, biscuit.

INTRODUCTION

Sorghum flour has proven to be a super-rich component of nutrition and adds a superb flavour to gluten-free baking. The sorghum flour has been involved in the production of foods such as porridges, pancakes, beer and flatbreads throughout different cultures in different countries. In Northern America, this grain can be cooked like quinoa or rice, milled into flour or popped like popcorn (Schober and Bean 2008, Qi, Chen *et al*., 2017). It is commonly used in animal feed and ethanol fuel production (Adeyeye 2016, Marston, Khouryieh *et al*., 2016). Due to its very mild taste, sorghum flour is a great choice to incorporate into sweet bread and biscuits. The bakery industry globally is considered one of the major industries in food processing. Baking products are gaining popularity as processed foods because of their availability, ready-to-eat convenience and reasonably good shelf life (Marston, Khouryieh *et al*., 2016, Reddy, Pranusha *et al*., 2019).

Biscuits for instance are important in the world of snack foods owing to their varieties in taste, crispiness and digestibility. Experimentation has proven that wheat, sorghum and gritz can be added to form compound flours used in the production of baked products (Reddy, Pranusha *et al.*, 2019, Karrar, Musa *et al.*, 2020), (Niraula 2018). It has become imperative for the food industries to explore diverse methods to improve their productivity in terms of food preservation, food safety and sustainable packaging through standardized technology. In the food industries, food product development, also called new product management, is a series of steps that includes the conceptualization, design, development and marketing of newly created or newly rebranded goods or services (Schober and Bean 2008, Adeyeye 2016). In a new product development, substances or elements that are combined to get a finished product matter. In most developed countries, the law requires that ingredients should be listed according to their relative weight in products (Marston, Khouryieh *et al*., 2016). The quality of all ingredients should meet the requirements presented in the international standards specified for them (Reddy, Pranusha *et al*., 2019, Karrar, Musa *et al*., 2020).

To further work on the product, a pretesting of the product must be done. Thus, sensory analysis together with consumer preference examines the properties (texture, flavor, taste, appearance, smell etc.) of a product or food through the sense (sight, smell, taste, touch and hearing) of the panelist. This type of analysis has been useful for centuries in accepting or rejecting food products (Marston, Khouryieh *et al*., 2016, Queiroz,

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da Silva Aguiar *et al*., 2018). When consumers decide whether they like a product, the taste is the most important factor as a sense of taste is the sensory partially responsible for the perception of taste. Taste receptors in the mouth sense the five taste modalities; sweetness, sourness, saltiness, bitterness and umaminess (Carson, Setser *et al*., 2000, Adeyeye 2016). Generally, much of what is called taste is a complexly tangled matrix of flavour, aroma chemicals and texture (Niraula 2018, Queiroz, da Silva Aguiar *et al*., 2018). All foods, whether fast foods, home-cooked dishes, restaurant cuisine, or commercial products, are characterized by their flavour, which is a combination of flavour aromatics with taste or gustatory component (Adeyeye 2016, Reddy, Pranusha *et al*., 2019). Texture is the physical characteristic of a food matrix as it is masticated to release flavours and taste, and is an important contributor to the total sensory process. Food texture is a major factor in the sensory evaluation of food quality, and it is critical or important in the quality, grading and marketing of solid food (Marston, Khouryieh *et al*., 2016, Reddy, Pranusha *et al*., 2019).

Over the years, wheat flour has been the undisputed compound flour used in bakery. Due to its deficiency in some dietary supplements, other flour combinations have been tested but the level of consistency of wheat flour has rarely been matched (Marston, Khouryieh *et al*., 2016, Karrar, Musa *et al*., 2020). In as much as sorghum production is predominant in countries such as Cameroun and Ghana, there is a lack of industrialization concerning the production of the crop. Therefore, this reduces the production of industrialized products such as biscuits, pastries/confectioneries and other bakery products made out of sorghum flour. Because of this, the study used sorghum flour as a substitute for wheat flour in the production of shortbread biscuits, given that, aside from the nutritional qualities of sorghum, it has also been rated as having good sensory attributes in the area of flavour and appearance 2016, Niraula 2018). This would help bakery workers acquire a different perspective on flour in the sense that, wheat flour could be substituted with sorghum flour in the production of biscuits. The study would further broaden the mindsets of consumers on the many uses of sorghum flour as it could also be used for other baking foods such as bread, cookies and cake.

MATERIALS AND METHODS

The target population used for this study was the students of the Hospitality Management (HM) Department of Takoradi Technical University. A sample size of sixty (60) respondents was selected for the study and it employed non-probability sampling techniques in selecting its sample of respondents - the purposive sampling technique. Purposive sampling was used to select the respondents from hospitality management (HM) evening students. This sampling technique was applied on the day of the experimentation, where students from the HM department were chosen. The study resorted to the use of a structured questionnaire as the data collection instrument and was made up of both open-ended and close-ended questions. A set of questionnaires for the respondents based on the objectives of the study were categorized under various segments such as the brief demographic feature of respondents, utilization of sorghum flour in biscuit making, determining the sensory and acceptability by consumers when commercialized as confectionery products in Ghana.

Production and Technological Characterization of Sorghum Flour

After operations of cleaning and shelling, sorghum flour was produced by milling grains in an MGE3 hammer mill and the powder obtained was sieved through a sieve of 0.5 mm mesh. Figure 1 depicts the flow chart for the sorghum flour.

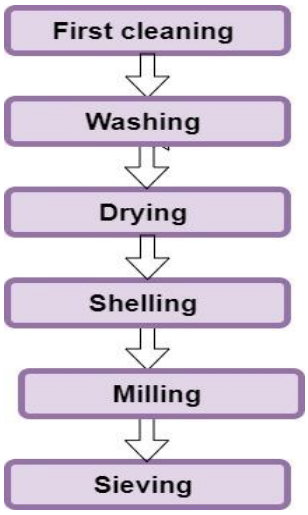

Figure 1: Flow chart for sorghum flour

Cleaning grains is the removal of unwanted materials from the grain and washing is the sorting of

the products according to quality as this stage is indispensable before storage. The drying stage is the process of exposing the grain to the sun to prevent spoilage. Shelling is the removal of the husk (deshell) covering of the grains while milling is the process in which grain is ground into smaller pieces. Sieving is separating particles of different sizes to get the finest flour.

A pictorial process describing the standard using sorghum flour to develop shortbread biscuits.

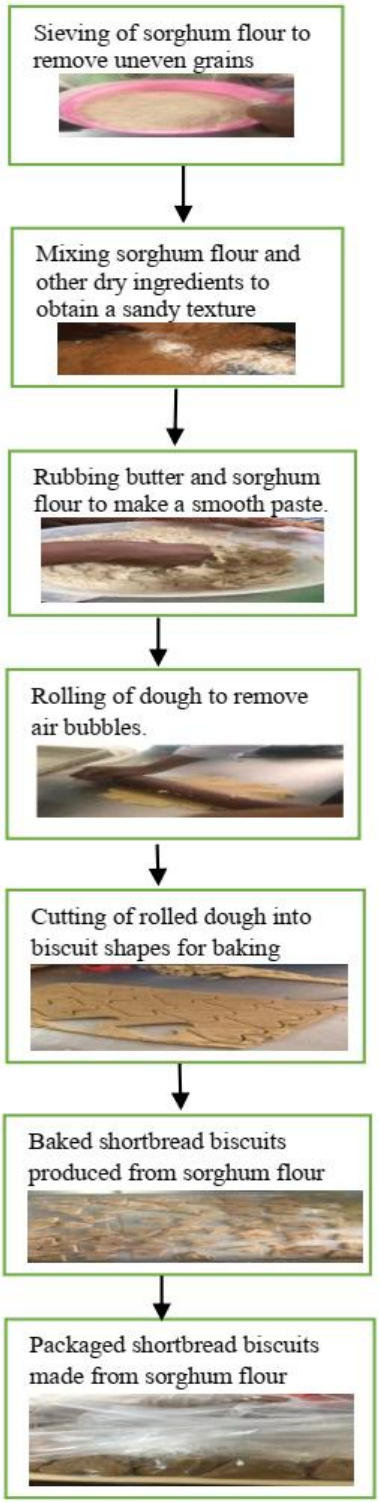

Figure 2: Product development of sorghum flour shortbread biscuit

RESULTS AND DISCUSSIONS

Knowledge of Sorghum Flour in biscuit-making

The respondents were required to give their opinions and knowledge on sorghum flour and its usage in the bakery or food industry. Depicted in Figure 3 is the responses from the respondents.

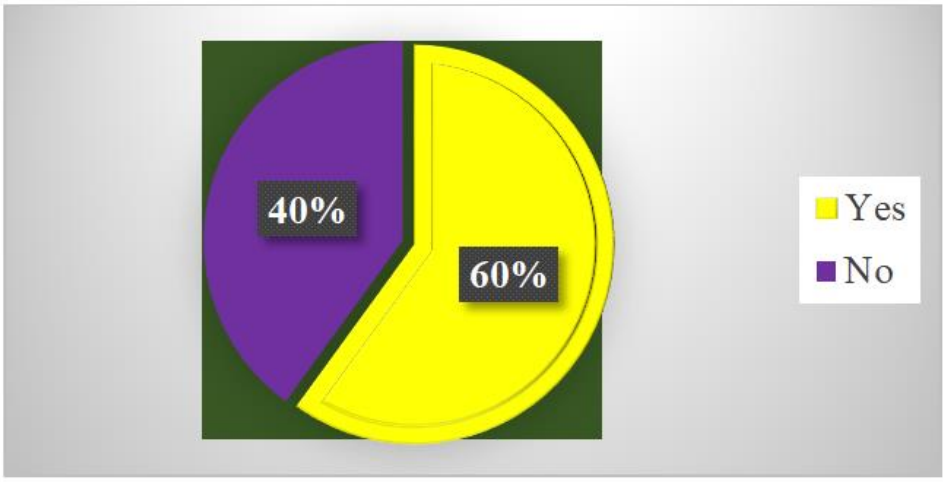

Figure 3: Knowledge of respondents on sorghum flour production

It can be seen from Figure 3 that, a majority of 60% of the respondents affirmed (Yes) that, they have heard or read about sorghum flour and its usage but the remainder of 40% representing the minority also stated otherwise (No) concerning the same statement. This shows that sorghum flour is not a new trend given that most of the respondents have known about its existence. Taking into cognizance that production of the sorghum is fifth most important cereal crop in the world after rice, wheat, maize and barley, and this cereal is mostly grown in Sub-Saharan Africa, after maize (Carson, Setser *et al*., 2000, Schober and Bean 2008, Marston, Khouryieh *et al*., 2016, Hadebe, Modi *et al*., 2017, Reddy, Pranusha *et al*., 2019).

A follow-up on 'tasted products made from sorghum flour before' had a majority of 68% affirmative. Respondents had seen and tasted sorghum flour and thus, would be able to give vivid responses to questions about sorghum flour and its products allude to (Hadebe, Modi *et al*., 2017, Reddy, Pranusha *et al*., 2019) experimentation that wheat, sorghum and grits can be added to form compound flours used in the production of baked products. Further, sorghum flour, as postulated by (Adeyeye and Agriculture 2016, Karrar, Musa *et al*., 2020), due to its very mild taste, is a great choice to incorporate into other flour for sweet breads, biscuits, or the like preparation. However, the acceptability of the taste will depend on the consumer's intake of these baked products.

As a follow-up question; the respondents who affirmed tasting sorghum flour (52%) were asked to mention the bakery products sorghum flour was used and their responses are presented in Figure 4.

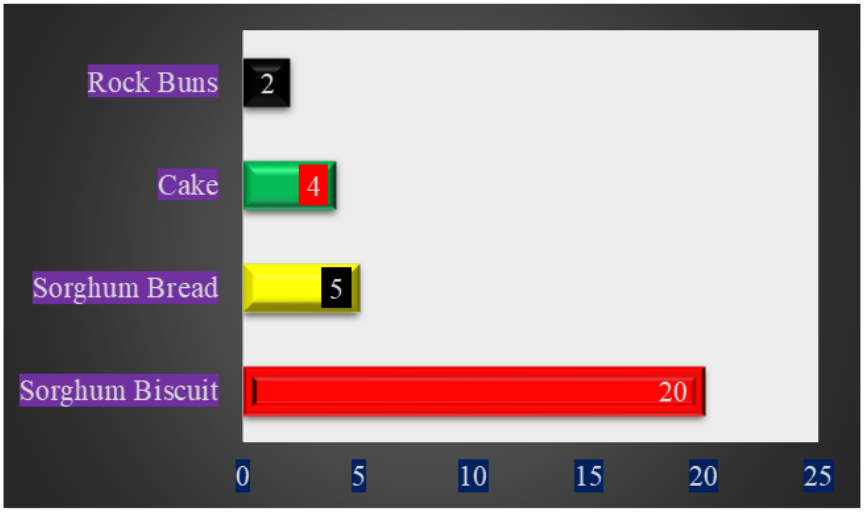

Figure 4: Tasted baked sorghum flour product

From Figure 4, it can be realized that 20 respondents representing a majority of 65% mentioned *sorghum biscuits* as the baked products they had tasted before and 2 representing 6% stated *rock buns* made from sorghum flour. Hence, it can be implied that baked sorghum products are already available on the market and in variety as well but the most popular sorghum flour baked products are biscuits. According to (Queiroz, da Silva Aguiar *et al*., 2018, Karrar, Musa *et al*., 2020), mainstream Europe and America have also made strides in the substitution of sorghum flour in the production of some bakery products such as cakes, cookies, biscuits, breads and muffins. As stated by (Queiroz, da Silva Aguiar *et al*., 2018, Karrar, Musa *et al*., 2020), due to its very mild taste, sorghum flour is a great choice to incorporate into sweet bread or biscuits. A question posed to solicit views on 'sorghum flour being a suitable replacement for wheat flour' is presented in Figure 5.

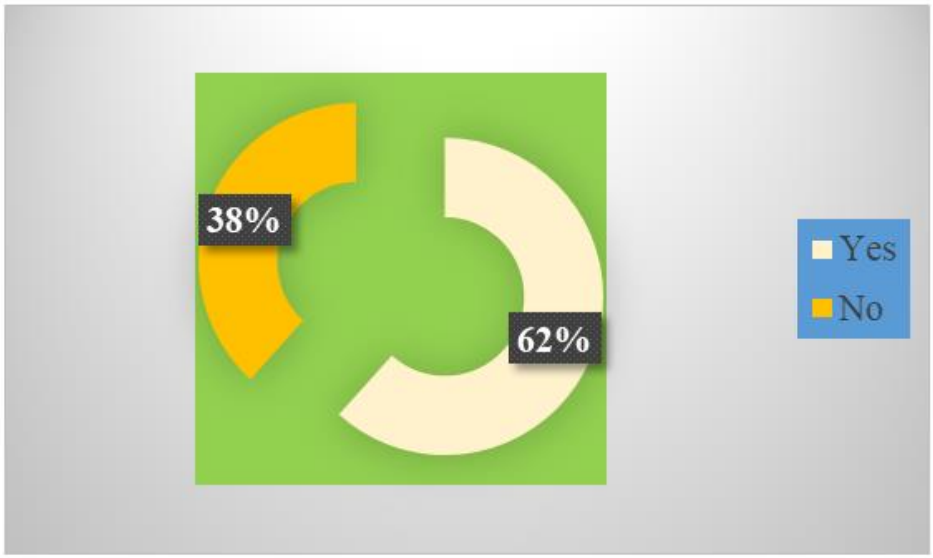

Figure 5: Can sorghum flour replace wheat flour in baking

From Figure 5, it can be seen that a majority, representing 62% of the respondents were of the view that, sorghum flour can replace wheat flour in baking but, the remainder of 38% of the respondents thought otherwise. This shows that sorghum flour used in baking would be warmly accepted by many people thereby showing that, a market for sorghum flour baked products is available. In line with (Marston, Khouryieh *et al*., 2016, Karrar, Musa *et al*., 2020), sorghum flour has a smoother texture that seems more appreciated by people. From the responses, it can be implied that most consumers of baked products no longer enjoy the monopoly of wheat flour being the base for every baked product. However, the availability of sorghum for flour at all times is a major concern according to some of the respondents who would prefer wheat flour to be maintained for baking given its nationwide availability. Truly, sorghum is available for selling in the market and use in Ghanaian households, however, there is a challenge in terms of quantity to merit exportation.

Sensory Evaluation of Sorghum Flour Biscuit

The sensory attributes of the baked products were analyzed using the five (5) main sensory attributes which are appearance, colour, taste, flavour and texture.

Table 1: 100% Sorghum Flour Biscuit

Property	**Ingredient**	**D**	**N**	**S**	**V.S**	**No.**	**{%}**
Appearance	Size	9 (15)	19 (32)	21(35)	11 (18)	60	100
	Colour	7 (12)	24 (40)	11 (18)	18 (30)	60	100
	Shape	10 (17)	16 (27)	24 (40)	10 (17)	60	100
	Rough	4 (7)	11 (18)	23 (38)	22 (37)	60	100
	crispness	11(18)	17 (28)	19 (32)	13 (22)	60	100
	TOTAL	**60**					
Colour	Bright	3 (5)	24 (40)	15 (25)	18 (30)	60	100
	Dull	19 (32)	14 (23)	20 (33)	7 (12)	60	100
	Pale	20 (33)	18 (30)	12 (20)	10 (17)	60	100
	TOTAL	**60**					
Taste	Sour	6 (10)	26 (43)	20 (33)	8 (13)	60	100
	Salty	9 (15)	22 (37)	19 (32)	10 (17)	60	100
	Sweet	4 (7)	22 (37)	23 (38)	11 (18)	60	100

Property	Ingredient	D	N	S	V.S	No.	{%}
	Bitter	5 (8)	20 (33)	24 (40)	11 (18)	60	100
	TOTAL	**60**					
Flavour	Rancid	6 (10)	18 (30)	22 (37)	2 (3)	60	100
	Spicy	7 (12)	18 (30)	21 (35)	19 (32)	60	100
	TOTAL	**60**					
Texture	Smooth	6 (10)	16 (27)	24 (40)	14 (23)	60	100
	Rough	8 (13)	28 (47)	10 (17)	14 (23)	60	100
	Coarse	4 (7)	18 (30)	21 (35)	17 (28)	60	100
	Crispy	13 (22)	14 (23)	15 (25)	18 (30)	60	100
	TOTAL	**60**					

1= Dissatisfied, 2= Neutral, 3= Satisfied, 4= Very Satisfied

Table 1 is a representation of the sensory evaluation conducted for 100% sorghum flour-based biscuits. The numbers in the bracket of the table represent the percentage while the numbers before the bracket is respondents. The first part was about the appearance of the product and this was evaluated using five (5) key attributes which are; size, colour, shape, roughness and crispness. For size; 32 respondents representing 53% were satisfied and very satisfied respectively with the size of the product. About colour; almost one-half of the respondents (29) representing 48% were satisfied and very satisfied respectively with this aspect of the product's appearance. However, a strong number of 24 respondents representing 40% remained neutral on this occasion. In addition, 34 respondents representing 57% were satisfied and very satisfied respectively with the products' shape. Also, 45 respondents representing 75% were satisfied and very satisfied respectively with the roughness of the products.

Lastly, with appearance, the crispness of the product was tested and the results show that 32 respondents representing 54% were satisfied and very satisfied respectively with the products' crispness but, 11 respondents representing 18% were dissatisfied with this aspect of the product. It can be implied that on the appearance of the 100% sorghum flour-baked biscuits, a majority of the respondents were satisfied with the product. The appearance of the product was appreciated given that, sorghum grains come in different colours and as such they give off a pleasing appearance. Sorghum grains can typically be white, pale orange, tan, red, dark brown and brownish-red, but the major commercially available ones are black, white and red. The colour of the taste (seed coat or pericarp) are genetic character controlled by the R and Y genes (Queiroz, da Silva Aguiar *et al*., 2018, Reddy, Pranusha *et al*., 2019). Colour was also tested based on product brightness, dullness and paleness and the results showed that; on brightness, a majority of 33 respondents representing 55% were satisfied and very satisfied respectively with this aspect of the product but, a strong number of 24 respondents representing 40% also remained neutral on the brightness of the product.

Furthermore, on the dullness of the product, 27 respondents representing 45% were satisfied and very satisfied with the products' dullness but, this was contested by 19 respondents representing 32% who were dissatisfied with the products' dullness. On the paleness of the product; 22 respondents representing 37% were satisfied and very satisfied respectively with this attribute, but this was closely opposed by 20 respondents representing 33% were dissatisfied. This implies that the majority of the respondents were satisfied with the colour of 100% sorghum-based flour biscuits but, the aspects of dullness and paleness were not very satisfactory. In support of this claim, (Queiroz, da Silva Aguiar *et al*., 2018, Reddy, Pranusha *et al*., 2019) both stated that sorghum grains can typically be white, pale orange, tan, red, dark brown and brownish-red, but the major commercially available ones are black, white and red.

The next attribute is the taste of the product and this was measured using the sourness, saltiness, sweetness and bitterness of the 100% sorghum flour biscuits. On the sourness of the product, 28 respondents representing 46% were satisfied and very satisfied respectively but, 26 respondents representing 43% remained neutral on this aspect of the product. On the saltiness of the product, 29 respondents representing 49% were satisfied and very satisfied with the product's salt content. However, 22 respondents representing 37% remained neutral. Concerning the sweetness of the product, 34 respondents representing 56% were satisfied and very satisfied respectively with the product whilst, 22 respondents representing 37% once again remained neutral. On the bitterness of the product, 35 respondents representing 58% were satisfied and very satisfied with the bitterness level with, 20 respondents representing 33% choosing neutrality. It can thus be implied that the taste of 100% sorghum flour-baked biscuits is satisfactory even though a substantial number of the respondents were undecided on the products' sourness, saltiness, sweetness and bitterness levels. As stated by (Queiroz, da Silva Aguiar *et al*., 2018, Karrar, Musa *et al*., 2020), due to its very mild taste, sorghum flour is a great choice to incorporate into sweet bread or biscuits.

The next sensory attribute evaluated was flavour which was measured using rancidness and

spiciness of the 100% sorghum-based flour-baked biscuits. The results showed that 24 respondents representing 40% were satisfied and very satisfied with the products' rancidness. However, 18 respondents representing 30% were neutral on the products' rancidity. On the spiciness of the product, a strong number of 40 respondents representing 67% were satisfied and very satisfied with the products' spiciness but, 18 respondents representing 30% once again chose to be neutral with regards to the products' spiciness. This implies that the flavour of 100% sorghum-based flour baked biscuits is generally satisfactory but, once again some respondents were undecided on this attribute. According to (Queiroz, da Silva Aguiar *et al*., 2018, Reddy, Pranusha *et al*., 2019), sorghum flour has proven to be a super-rich component of nutrition and adds a superb flavour to gluten-free baking.

Lastly, the texture of the product was tested using; smoothness, roughness, coarseness and crispness. On the matter of smoothness, the results showed that a greater number of 38 respondents representing 63% were satisfied and very satisfied with the products' smoothness whereas, 16 respondents representing 27% chose neutrality. Next up was the roughness of the product and the results showed that almost half of the respondents (28) representing 47% chose to be neutral but, 24 respondents representing 40% were satisfied and very satisfied respectively with the products' roughness.

Also, the coarseness of the product was tested and the results showed that 38 respondents representing a majority of 63% were satisfied and very satisfied with the product's coarseness, 18 respondents representing 30% chose to be neutral. In the case of the crispness of the product, results showed that 33 respondents representing 55% were satisfied and very satisfied with the products' crispness but, 14 respondents representing 23% and 13 respondents representing 22% chose to be neutral and were dissatisfied with the crispness of the product respectively. This shows that the texture of the 100% sorghum-based flour-baked biscuits was also generally satisfactory with very little levels of dissatisfaction. The texture of products baked using sorghum flour has proven to be satisfactory and this was further reiterated by (Adeyeye and Agriculture 2016, Queiroz, da Silva Aguiar *et al*., 2018) who proclaimed that, while some gluten-free flours, such as rice flour, can add a gritty texture to biscuits, cookies or bread; sorghum flour has a smoother texture that seems more appreciated by people recorded in the aspects of smoothness and crispiness of the products.

Determine the Acceptability of Sorghum Biscuits

With regards to the acceptability of the sorghum biscuit, responses from the respondents are depicted in Figure 6 taking into consideration the sensory attributes of the products.

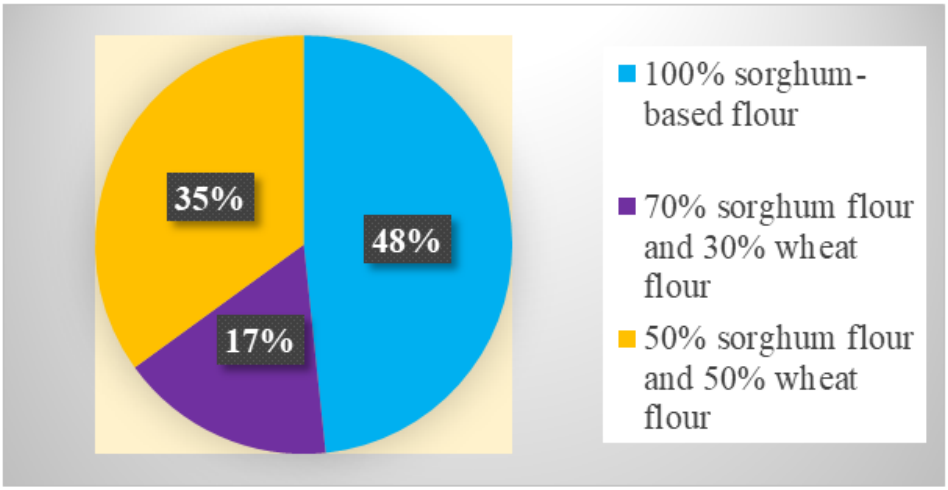

Figure 6: Products enjoyed the most

Figure 6 is an illustration that presents the results gathered from respondents about the products they enjoyed the most. It can be seen that 48% which is the majority enjoyed the 100% sorghum-based flour biscuits whilst, 35% also enjoyed 50% sorghum flour and 50% wheat flour whereas, a minority of 17% also enjoyed the 70% sorghum flour and 30% wheat flour products. This indicates that sorghum-based flour products like shortbread biscuits would attract patronage commercially. Naturally, human beings desire to explore new products and until new surfaces in the market, old products continue to be the best. The desire for a new product explains the 48% of the acceptability level. Thus, sorghum-baked products would be accepted to augment the already-known wheat flour products.

Determine the Production of Sorghum Biscuits Commercially

When respondents were asked if sorghum biscuits should be produced commercially, all the respondents (60) responded in the affirmative. However, their reasons for these responses varied as depicted in Figure 7.

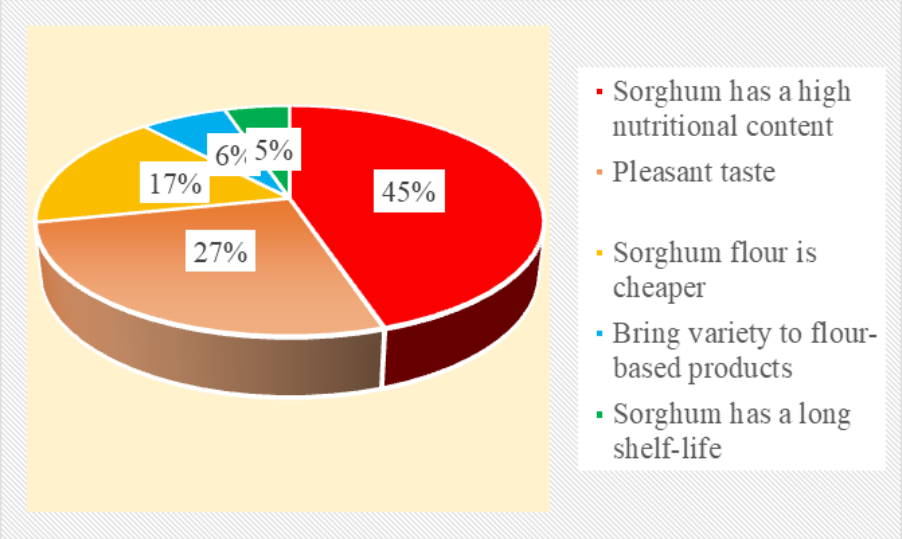

Figure 7: Commercialization of sorghum shortbread biscuits

Figure 7 shows that the majority of 45% of the respondents wanted sorghum-based shortbread biscuits commercialized because sorghum has a high nutritional content. This was followed by a good number of 27% of the respondents who stated that sorghum-based biscuits have a pleasant taste hence, commercialization of the products. In addition, 17% of the respondents claimed sorghum flour is cheaper in comparison to wheat flour whereas, 6% also stated that, sorghum flour products will bring variety to baked products. Lastly, 5% of the respondents who represented the minority also stated that sorghum flour has a long shelf-life and thus makes economic sense to use it in baking shortbread biscuits commercially.

This indicates that sorghum-based flour shortbread biscuits will bring several benefits to the confectionery section in catering and the most important of it all is that shortbread baked using sorghum flour will be very nutritious and tasty and thus, would satisfy customers.

CONCLUSION AND RECOMMENDATION

It can be concluded that most of the respondents had seen and tasted sorghum flour and thus, would be able to give vivid responses to questions about sorghum flour and its products. It was also found out that baked sorghum products are already available on the market and in variety as well but the most popular sorghum flour baked products are biscuits. Respondents were satisfied with the overall outcome of all the products with the 100% sorghum-based flour shortbread biscuit gaining the best of the reviews concerning appearance, colour, taste, flavour and texture.

However, the taste of all three (3) products was enjoyed by respondents which is an important sensory attribute required among baked products such as biscuits. On the other hand, it was found that sorghum flour products must be commercialized because it will bring several benefits to the confectionery section in catering. Also, the clamour for sorghum flour to substitute wheat flour is mainly because sorghum is believed to have a higher nutritional content.

On the contrary, the argument that sorghum flour must not replace wheat flour was primarily driven by consumers' desire for product variety as well as competition on the market. The commercialization of sorghum-based baked products was advocated for by a majority of the respondents and in addition to baked products preserving the unique taste of sorghum and crop expansion to produce more flour would be necessary to make sorghum-based flour products a success. Further, bakers should be encouraged to use sorghum flour as the base of pastry and confectionery products. This will be profitable in Ghana if processing and further utilization are promoted in biscuit making. The potential of the crop will also be very real if the products are sold, thus enhancing income generation.

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