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Development of high protein content homemade bread by nutritional yeast fortification for disadvantaged communities

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Abstract: The main objective of the study was to develop high protein content homemade bread through fortification with nutritional yeast. Fortified bread boosts the nutritional status of poor people and reduces the incidence of protein energy deficiency diseases. The homemade bread was reformulated by adding various concentrations of nutritional yeast in the range 1-15% (w/w) to wheat flour. The bread was baked using the straight dough method. Protein, carbohydrate and moisture content of the fortified bread were evaluated. Sensory evaluation was conducted on bread samples to evaluate the bread acceptance levels. The results of the study revealed that the protein content increased with an increase in concentration of nutritional yeast. Addition of nutritional yeast decreased the loaf height but increased the weight of the loaves. The test panels accepted bread fortified with 1-3.5% nutritional yeast but bread with higher amounts of nutritional yeast (5-15%) were generally unacceptable. This study shows the potential of using nutritional yeast in improving protein quality of homemade bread consumed by economically disadvantaged communities.

Keywords: Bread, Fortification, Nutrition; Protein, Yeast

1. Introduction

Bread is the main product of wheat which is manufactured commercially (bulk and refined bread) and domestically (homemade bread). Shrinandan [1] propounded that the commercial bread has for the past years until now been improved and researches have been carried out to increase the nutritional and baking properties of the dough through fortification and use of dough improvers. Fortification is performed on homemade bread which is consumed by poor people in rural communities. Homemade bread contains basic ingredients and lack crucial nutrients such as proteins and vitamins.

One way of improving the nutritional quality of homemade bread is fortification with nutritional yeast. Yeast fortification is a way of enhancing bread protein content [2]. Nutritional yeast is utilized by biscuits manufacturing companies, as vitamin supplements. It is also used in pharmaceuticals and animal feeds as a source of proteins and vitamin supplements [3].

Nutritional/food yeast is derived from deactivated yeast mainly Saccharomyces Cerevisae in form of a powder or flakes used to enhance nutritional value of food. Nutritional yeast is often made from expired yeast, yeast out of specifications or dust yeast from driers [4]. It is produced via a heat killing process that renders it completely inactive to humans [5]. The proteins from nutritional yeast are of high biological value (HBV) [6]. Nutritional yeast is rich in the vitamin B complexes which are not destroyed during exposure to high temperatures [7]. It is also rich in calcium, phosphorus, manganese, magnesium, zinc, copper, proteins and essential amino acids.

Nutritional yeast has several health benefits. According to Bekatorou et al [8], nutritional yeast is a rich source of proteins which are necessary for replacing worn out tissues or recovery after infections. Nutritional yeast contains 18

amino acids and is considered to be 55% high quality protein. It is a rich source of B vitamins which aid in lowering stress, help in metabolism, prevent cancer and ensure a healthy skin. Nutritional yeast is low in fat and hence low in cholesterol content. Nutritional yeast also contains gluthanione, an antioxidant and beta glucan which stimulates the immune system [9]. Of the 15 minerals that it contains, nutritional yeast consists of chromium a trace mineral which is known as glucose tolerance factor (GTF) [10] which is essential in the prevention of diabetes, lowers blood pressure and fluctuating blood sugar. Nutritional yeast maintains optimum cholesterol levels, improves blood production and also improves liver health and function [8].

Production of proteins from yeast is advantageous compared to conventional protein sources such as plants and animals [11]. Microorganisms have high protein content and short growth times, leading to rapid biomass production [12, 13]. The use of fungi yeast, especially for single cell protein (SCP) production is more convenient as they can easily be propagated using cheap raw materials and easily harvested due to their bigger cell sizes and flocculation abilities [14]. Bekatorou et al [8] pointed out that SCP are considered as potential sources of dietary protein for humans and that these food grade yeasts are rich sources of proteins, carbohydrates, B vitamins, minerals and essential amino acids mainly lysine which is a limiting amino acid in cereals. Plant proteins are also of low biological value due to the absence or little amounts of limiting amino acids [15].

This study reports on fortification of homemade bread with nutritional yeast produced from a local company (Anchor Yeast) in Zimbabwe. The fortificant is a by-product from Anchor Yeast specifically manufactured as per customer request. Fortification of homemade bread has a potential of boosting the nutritional status of people at high risk of protein deficiency diseases in Zimbabwean poor communities.

2. Method

2.1. Formulation of Flour Mixtures

Variable quantities of nutritional yeast (0-15% w/w) were mixed with wheat flour (286 g). This was followed by addition of salt, sugar, 2 g live yeast and about 120 ml water to each mixture to make dough. Proofing of the dough was done at a standard time of 50 minutes at 30oC in a ferment meter before baking for 45-50 minutes at 220oC. These dough mixtures and bread samples were evaluated for nutritional value, bread rheology, baking quality and sensory evaluation.

2.2. Nutrient Analysis

Moisture content was determined using near infrared analyzer 8100 series. The crude protein and carbohydrate content of the samples were determined using Kjedahl [16, 17] and Lane-Eylon [18] methods respectively.

3. Results and Discussion

3.1. Nutrient Analysis

Table 1 shows the nutrient composition and some physical qualities of bread. An increase in nutritional yeast concentration resulted in increase in the protein content of bread. The nutritional yeast used to fortify bread contains high quality protein which was reflected in the fortified bread. Bekatorou et al [8] proposed that nutritional yeast is a rich source of protein. Therefore the consumption of nutritional yeast fortified bread means exposure to higher quantity and quality protein. The nutritional yeast fortified bread had a slightly higher carbohydrate content compared to the non fortified bread sample. The slight increase in carbohydrate concentration shows that nutritional yeast contains very small quantities of carbohydrates.

Table 1. *Nutrient composition some physical properties bread and flour samples.*

Sample	Nutrient yeast content (%)	Nutrient content (%)		Bread		
		Protein	Carbohydrate	Water content (%)	Height (cm)	Mass (g)
A	0	19.5	44.2	52	6.0	398
B	1	21.4	44.8	54	6.2	398
C	3.5	24.4	45.0	59	6.3	407
D	5	27.7	45.4	67	6.8	412
E	10	29.5	46.8	73	6.3	420
F	15	31.4	47.9	78	6.3	428

The loaf size of the bread increased upon addition of nutritional yeast. An increase in the loaf height of up to 11% depicts slight changes in flour properties. As the concentration of nutritional yeast increased beyond 10%, the loaf height decreased significantly by 5%. This was due to the reduced ability of dough to entrap air as a result of the dilution effect on gluten upon addition of non wheat flour to wheat flour. Introduction of a large quantity of nutrient yeast affects gluten which is formed from the two proteins in flour, glia din and gluten in [19]. Upon addition of water, glia din and gluten in become hydrated and through kneading these proteins line up and become elastic forming a three dimensional network which traps carbon dioxide produced by the fermenting yeast. The gas retaining capacity of gluten polymers and ability to form a three dimensional network is reduced by an increased concentration of nutritional yeast consequently deteriorating the bread quality. This is in agreement with work done by Conforti and Davis [20]. The low gluten content of non wheat flours such as soy flour and flaxseed caused a decrease in size and quality of bread produced. Other studies reported a significant decrease in loaf specific volume and sizes, associated with coarse bread production upon replacement of wheat with non wheat flours such as amaranth [21].

An increase in loaf weight was observed with the introduction of nutritional yeast. This can be attributed to increase in water absorption with nutritional yeast blending. Proteins have a high hydration capacity due to the amino

acid composition and structure. The recommended weight of standard bread is 700-800 g and should approximately be between 300-400 g when baked with a pan half the size of the commercial pan used in bakeries [22]. The results show that the weight of the homemade bread was within standard commercial specifications when blended with a maximum of 3.5% nutritional yeast.

3.2. Sensory Evaluation

3.2.1. Appearance of Bread

Vaclavik and Christian [23] described appearance of food as the size, color, structure, transparency of turbidity and degree of wholeness or damage of the product. Structure and color are important in baked goods for example bread should have white and brown color and should have many holes uniformly spread throughout otherwise a slight drift from normal will be judged as a quality defect. Fig. 1 shows consumer responses to the appearances of bread samples. All the bread samples were baked using white flour and the change in color was a result of incorporation of different nutritional yeast concentrations. The darker color noticed in bread samples with higher concentrations of nutritional yeast was a result of enhanced Maillard reactions [24] between reducing sugars and proteins. Most people preferred the appearance of bread sample C since it resembled the color of brown bread available on commercial market. This shows that many consumers prefer brown bread to white bread when considering color only. Sample F was regarded as unacceptable by the respondents due to its dark brown color which they perceived as unattractive.

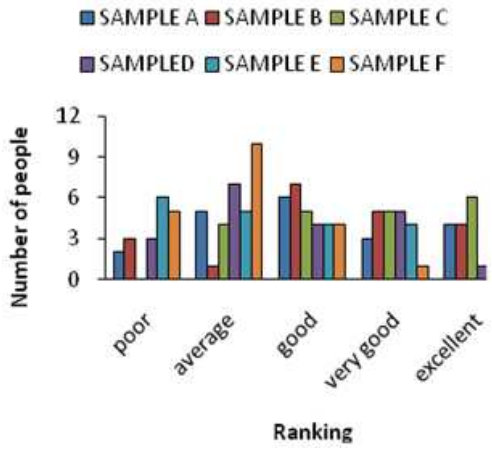

Figure 1. *Appearance/color of bread samples as perceived by consumers.*

3.2.2. Taste of Bread

Taste was the main attribute in rating of the samples since addition of the nutritional yeast had an effect of changing the taste of the bread. Tepper and Ulrich [25] defined taste as a combination of five major tastes: salty; sweet; sour; bitter and umami. Taste is detected by taste buds at the tips, sides and back of the tongue and the sensitivity to a particular taste depends on the concentration of the substance responsible for the taste. The responses to the taste of different bread samples are shown in Fig. 2. The respondents liked the taste of sample A most which scored an overall of 74%. This was largely because it had the taste of what they already perceive as normal and fresh bread taste. Samples C and B had high scores of 73 and 68% respectively largely due to the cheese like taste of the nutritional yeast which was appealing to most respondents who originally prefer cheese. Bread samples D to F were regarded as unacceptable for human consumption as a result of a bitter aftertaste experienced by the consumers.

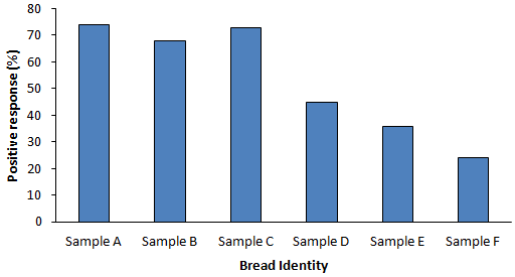

Figure 2. *Responses to bread samples taste.*

3.2.3. Flavor of Bread

Flavor is one of the major sensory properties which are decisive in acceptance and selection. Vaclavik and Christian [23] defined flavor as a combination of smell and taste which is largely subjective. Fig. 3 shows consumer responses to bread flavor of different nutritional yeast concentration. As the level of nutritional yeast increased, the typical flavor associated with bread decreased. The respondents accepted flavor of bread samples A, B and C but rejected bread samples with 10 and 15% nutritional yeast as a result of strong yeast smell. Consumers are more likely to accept products that they are familiar with. Any deviation in flavor is deemed as quality defect.

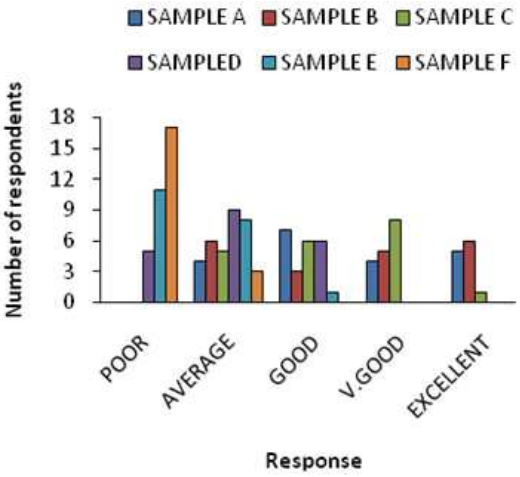

Figure 3. *Consumer bread flavor responses.*

3.2.4. Bread Texture

Texture refers to those qualities of food that can be felt with fingers, tongue, palate or teeth [26]. The texture of bread samples is shown in Fig. 4. The respondents found the texture of samples A, B, C and D as highly acceptable with sample C scoring the highest score (69%). Samples E and F

were regarded as unacceptable in terms of texture due to the high amounts of moisture in the bread samples which resulted in a lumpy crumb structure instead of an open texture.

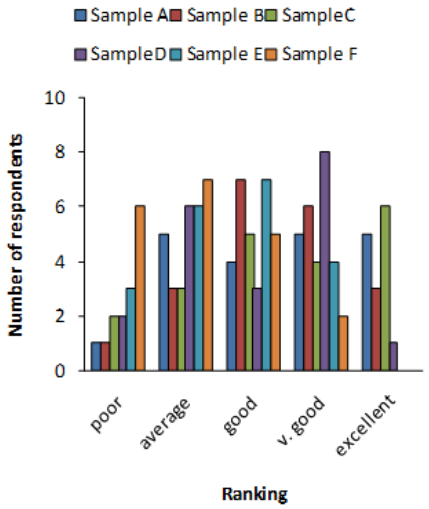

Figure 4. *Texture of bread samples as perceived by consumers*.

4. Conclusion

The protein content of the homemade bread was improved through nutritional yeast fortification. Development of nutritional yeast fortified bread has the potential of improving nutritional status of financially disadvantaged communities resulting in creation of a new market for the nutritional yeast produced at a local yeast manufacturing company. The protein content of the fortified bread was improved from 19.5 to 31.4%. The flavor and taste greatly influenced consumer acceptance of the product. Addition of artificial flavorings to mask the strong flavor of the nutritional yeast could help improve the taste and consumer acceptability of the fortified bread

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