Chemical And Technological Properties of Bread Produced with Garlic Extract as An Additive

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ABSTRACT

This study investigated chemical and technological properties of bread produced with garlic extract as an additive with the view of extending its shelf life beyond its present status. Dangote wheat flour, salt and sugar were purchase from Dangote accredited distributor in Ile-Ife while garlic extract used was obtained using a documented procedure. Bread samples with garlic extract as an additive were produced using documented procedures. Properties such as weight loss, specific volume, density and SEM structural analysis were carried out on the bread sample using standard procedures. The proximate composition values ranged from 26.68 – 28.01%, 1.13 – 1.46%, 9.84 – 10.37%, 1.43 – 1.45%, 57.56 – 59.95% and 0.95 – 1.13% for moisture content, ash, protein, fibre, carbohydrate and fat, respectively. The mineral composition values ranged from 153.64 – 164.82 mg/100g, 73.45 – 78.89 mg/100g, 76.19 – 79.04 mg/100g and 21.35 – 25.85 mg/100g for potassium, calcium, phosphorus and magnesium, respectively. The samples weight loss increased progressively as storage day increased though a decline in weight loss was observed as proportion of garlic extract increased. Similar trend was observed for solid density of the samples. The SEM structural analysis of the bread samples showed increased alteration in protein matrix of baked bread structures. The sensory data showed that as addition of garlic additive beyond 3 ml, the samples preference became lower. In conclusion, the study therefore established the possibility of incorporating garlic extract into bread formulation with the aim of promoting its acceptability beyond its present status.

KEYWORDS

Technological properties
Breadfruit
Garlic
Additive

1. INTRODUCTION

Bread is one of the staple foods consumed on daily basis in both developed and developing countries despite its very short shelf life. It is usually baked from wheat dough though many research works had been done on its partial replacement (Nwakego et al., 2015; Villacres et al., 2020; Dopazo et al., 2023). It is baked in different types, shapes, sizes and texture, depending on national and regional traditions. It may be leavened by naturally occurring microbes (sourdough, chemicals such as baking soda), genetically modified yeast and high-pressure aeration, which creates the gas bubbles that fluff up bread (Emeje et al., 2009). At times, additives such as chemical preservatives (acetic acid, potassium acetate, sodium acetate) are added to improve flavour, texture, colour, shelf life, nutritional values and ease of production. The preference for bread apart from taste and good eating quality certainly reflects in the convenience it offers to both urban and rural consumers requiring no preparation (Emeje et al., 2009). The countries with the highest consumption of bread include U.S. (14.7 mt), China (9.3 mt), Russia (8.7 mt), the UK (6.2 mt), Germany (5.2 mt), Egypt (4.6 mt) and Italy (3.9 mt), and altogether, these account for approximately 41% of global consumption.

The highest annual growth rate in bread and bakery products consumption between 2007 and 2016 were +15.0%, +10.0% and +10.1% growth in China, UK and Egypy, respectively. Consequently, China saw its share of the global consumption surged from 2% in 2007 to 7% in 2016. Worldwide consumption of bread is a major contributor to the agricultural industry and global economy because it drives the sales and production of ingredients such as wheat flour, yeast, sugar and margarine. In Nigeria the market for bread contributes an average economic growth rate of 3.5% per annum in the past few years (Ewa, 2018).

Despite its wide acceptability, its freshness is an important parameter that determines consumers' acceptance. During storage, bread quality is rapidly lost due to staling, leading to a significant product waste all over the world (Fadda et al., 2014). In order to delay bread staling and reduce its loss of freshness, different formulations and processes have been employed. Some of these include addition of emulsifiers, amylases, lipases, hydrocolloids and high-sugar recipes while the processes employed include long fermentation (using dough systems which require long bulk fermentation prior to dough mixing such as sourdough or yeast pre-ferments like sponges), freezing, proper packaging, process optimization and product size optimization (Cauvain, 2012; Villacres et al., 2020; Dopazo et al., 2023). Bread also undergoes physical, chemical and microbiological changes which affect its shelf-life. Some physical and chemical changes accounted for loss of freshness - desirable texture and taste and progressive firming-up of the crumb. While microbial changes initiated by bacteria, yeasts and molds often lead to production of mycotoxins and formation of off-flavors (Axel, et al., 2017). In this study, chemical and technological properties of bread produced with aqueous garlic extract as an additive were investigated with the view of promoting its acceptability beyond its present status.

2. MATERIALS AND METHODS

2.1. Source Of Materials

Dangote wheat flour, salt and sugar were obtained from Dangote accredited distributor in Ile-Ife; while garlic, vegetable fat, yeast, milk and improver were procured from Sabo central market, Ile-Ife, Osun state.

2.2. Preparation Of Garlic Extract

Fresh garlic bulb (100 g) was peeled with stainless kitchen knife, cleaned with potable water, mixed with 200 ml distilled water and grinded in a blender (Century Electric Products, China; Model No: CB-8231-M) for 15 min at speed 5 (Bajac et al., 2018). The solid part of the garlic marsh was separated by filtration (Figure 1).

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2.3. Preparation Of Bread Using Garlic Extract as An Additive

A dough (1 kg) was prepared from recipe presented in Table 1 using a kneading machine with a processing time of 10 min. Subsequently, 1 kg of the dough was moulded into round shapes. The rounded dough loaves were put inside a proofing chamber for 45 min at 32 °C and 80% relative humidity. After proofing, the leavened loaves were baked in an industrial oven (Electric Oven SL-9 Infrared Food Oven, Hubert, China) for 15 min at 180 °C. The baked breads were allowed to cool to room temperature (28 °C) prior to its storage (Figure 2).

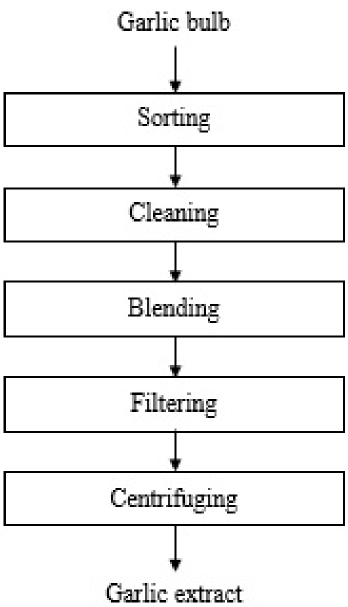

Figure 1: Production of garlic extract (Bajac et al., 2018)

Table 1: Formulation of bread based on 1 kg of flour

Ingredient amount (g)	Amount (g)
Wheat flour	1000
Yeast	25
Salt	22
Water (ml)	616
Aqueous garlic (ml)	0 – 10

2.4. Proximate Analysis of Bread Sample

Proximate composition of bread samples, including moisture, ash, crude fat, crude fiber and crude protein, were determined according to the methods of Association of Official Analytical Chemists (AOAC 2000). The nitrogen factor of 5.70 was used for crude protein calculation. The carbohydrate content (%) was calculated by subtracting the contents of crude ash, fat, fiber and protein from 100% of dry matter.

2.5. Mineral content determination of bread sample

The determination of selected mineral elements was carried out by atomic absorption spectrophotometry method (Fashakin *et al.,* 1991). The ground sample (0.5 g) was weighed into 75 ml digestion flask and 5 ml digestion mixture was added and left overnight in a hood. It was then digested for 2 h at 150 °C, then left to cool for 10 min. Three milliliter of 6 M hydrochloric acid was added and digested for another 1.5 h. It was cooled and 30 ml of distilled water was added. The tube was vigorously stirred. A sample aliquot was then transferred to the Auto-analyzer (Technician AAU model) for total mineral analysis at 420 nm. The remaining fraction was used to determine the other elements (calcium, magnesium, phosphorous, manganese, copper, iron and zinc) on the Atomic Absorption Spectrophotometer (Perkin Elmer, model 402) while potassium was determined by flame photometry (Model PFP7/C).

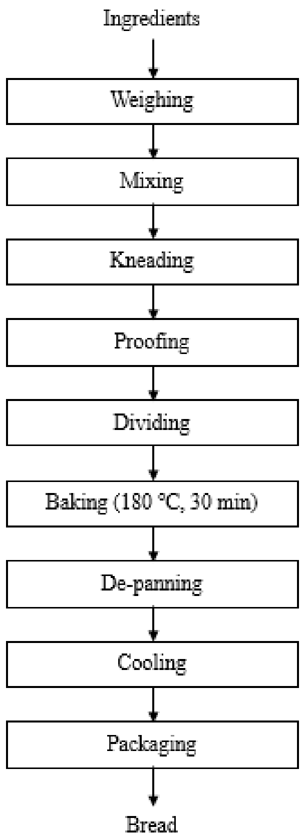

Figure 2: Flow chart for the production of bread (Kumar, 2019)

2.6. Weight Loss Determination of The Bread Sample

The bread samples were weighed by a weighing balance (XP 204, Mettler Toledo GmbH, Switzerland). The weight loss (%) was calculated using equation 1:

$$W.L = \frac{W_{day1} - W_t}{W_{day\,1}} \times 100 \quad (1)$$

where: W.L = weight loss (%); W_{day1} = weight of the bread on day 1 and W_t = weight of the bread on a certain measuring day (t). Measurements were performed in triplicate.

2.7. Specific Volume Determination of Bread Sample

Loaf volume was measured by *gaari* (cassava flake) displacement method. A dried graduated container was filled with *gaari* to the brim. The volume was recorded and the garri was empty into a jar. The loaf was placed inside the dried graduated container and then filled to the brim with *gaari*. The remaining *gaari* was then measured thereafter inside the dried graduated cylinder was taken as loaf volume. The loaf weight was then measured using weighing balance (XP 204, Mettler Toledo GmbH, Switzerland). The specific volume of the loaf was then calculated using the equation 2:

$$SV = \frac{LV}{LW} \quad (2)$$

Where: SV = Specific volume (cm^3/g); LV = loaf volume (cm^3) and LW = loaf weight (g)

2.8. Solid density measurement of bread sample

The density of bread solid was determined in triplicate using equation 3:

$$\rho = \frac{M}{V} \quad (3)$$

Where: ρ = density of bread sample (g/cm^{3}); V = loaf volume (cm^3) and M = loaf mass (g)

2.9. Structure Analysis Using Scanning Electron Microscopy (SEM)

Scanning electron microscopic studies of the bread samples were carried out using a LEO 435 VP, Cambridge Model scanning electron microscope. Before loading the sample into the system, it was coated with gold using poloron SEM coating system E-5000. Average coating time was 2 – 3 min. Thickness of the coating was 200 – 300 nm, which was calculated using the equation 4:

$$T = 7.5 * I\,t \quad (4)$$

Where I = current (mA), t = time (min), T = thickness (A°).

The coated sample was loaded on to the system and the image was viewed under 20 kV potential using a secondary electron image. The image was captured using a 35mm Ricoh camera (LEO 435 VP Operator M369anual version V2.04, Issue I of March, 1996).

2.10. Sensory Evaluation of The Bread Sample

A twenty semi-trained panelist used for sensory studies was from the Department of Food science and Technology of Obafemi Awolowo University, Ile-Ife, South-Western Nigeria. This number of panelists was considered adequate for rough product screening and for evaluating acceptance and/or preference (Adebayo *et al.,* 2018). Criteria for selection was that panelists were 18 and above years of age; regular consumers of bread and garlic; and not allergic to any food. When panelists arrived, they filled a consent form approved by the University Institutional Review Board and receive instructions on how to use the sensory booth signal lights to communicate with the server. The panelists were instructed to evaluate appearance and colour first and taste each sample afterwards to evaluate flavour, texture and overall liking. A rating scale of l – 7 points (1 = dislike very much; 7 = like very much) was used (McWatter *et al.*, 2004). The formulated products were evaluated 3 h after production. Water and unsalted crackers were provided to panelists to cleanse their palates between samples and covered expectoration cups if they did not wish to swallow the samples. Samples were identified with 3 – digit code numbers and presented monadically in a random sequence to the panelists. Panelists were asked if they would buy the product if it were commercially available and how much they would be willing to pay (lower, same, or higher price) compared with similar commercial products. They were asked to comment freely on the samples. Evaluation was conducted in a climate-controlled sensory evaluation laboratory equipped with individual partitioned booths without special lighting.

2.11. Statistical Analysis

Data obtained was analyzed descriptively and inferentially using Turkey's posthoc test (Design-Expert 7.00) for Window.

3. RESULTS AND DISCUSSION

The proximate composition of bread produced using garlic extract as an additive is presented in Table 2. The analysis of variance showed significant differences ($p \leq 0.05$) among the bread samples. The moisture content values of the bread sample ranged from 26.88 – 28.01% with samples A and D having minimum and maximum values, respectively. The results showed that there is no significant difference in moisture content of the bread samples as the garlic extract addition increased from 3 – 10 ml. The samples moisture content indicates that the products may exhibit appreciable shelf stability which will extend the usefulness of the products. The moisture content values compared favourably with 16.75 – 37.13% reported by Latif *et al.* (2005) for bread produced from wheat flour with varied additives. The moisture content values obtained fall within the recommended moisture content of baked products of 35% by Standard Organization of Nigeria (SON). Latif *et al.* (2005) reported that moisture content is crucial in determining economic value because excessive moisture content has been linked to bread's short shelf life due to the fact that it promotes microbial proliferation. The fat content of the bread samples ranged from 0.95 – 1.13%. A corresponding increase in fat content was observed as the addition of garlic extract increased. The fat content values are lower compared to 2.3 – 4.0% reported by Sidhu *et al.* (1999). The fibre content values ranged from 1.43 – 1.45% with no significant difference ($p \leq 0.05$).

Table 2: Proximate composition of bread treated with garlic extract as additive

Sample	Moisture content (%)	Ash content (%)	Crude Protein (%)	Fibre (%)	Carbohydrate (%)	Fat (%)
A	26.68 ± 0.24^{b}	1.13 ± 0.02^{b}	9.84 ± 0.01^{b}	1.43 ± 0.02^{a}	59.95 ± 0.28^{a}	0.95 ± 0.21^{b}
B	27.65 ± 0.01^{a}	1.43 ± 0.02^{a}	9.90 ± 0.63^{b}	1.43 ± 0.28^{a}	58.60 ± 0.49^{b}	0.97 ± 0.02^{b}
C	27.91 ± 0.07^{a}	1.44 ± 0.01^{a}	10.17 ± 0.05^{ab}	1.45 ± 0.01^{a}	57.94 ± 0.01^{bc}	1.07 ± 0.02^{a}
D	28.01 ± 0.04^{a}	1.46 ± 0.01^{a}	10.37 ± 0.14^{a}	1.45 ± 0.01^{a}	57.56 ± 0.22^{c}	1.13 ± 0.21^{a}

Values reported are mean ± standard deviation in triplicate. Mean values for each column bearing a different superscript roman letter are significantly different ($p \leq 0.05$). A: Control sample (100% wheat flour bread); B: 100% wheat flour bread + 3 ml of garlic extract; C: 100% wheat flour bread + 5 ml of garlic extract and D: 100% wheat flour bread +10 ml garlic extract

The slight increase in fibre content with increase in inclusion of garlic extract is quite normal as it is known that garlic is an ingredient that can offer a range of nutritional benefits such as fiber, anti-oxidants, vitamins and minerals. The crude protein values ranged from 9.84 – 10.3% which was significantly lower than 13.3 – 15.7% reported by Sidhu *et al.* (1999). The increase in protein content of the bread samples as garlic extract increased may be associated with protein content of the extract. The ash content values of the bread samples ranged from 1.13 – 1.46%. The increase in ash content values observed in garlic-treated bread indicated that they are more nutrient-dense that the whole wheat bread. Buccella *et al.* (2016) reported that ash content in wheat flour is an important parameter in determining wheat flour quality. The carbohydrate content values ranged from 57.56 – 59.95% with samples D and A having minimum and maximum values, respectively. The observed decrease in carbohydrate values as garlic extract increased may be associated with low carbohydrate content of garlic (Mongi *et al.,* 2011). Most cloves of garlic contain traces of carbohydrates, usually 0.5 g per clove. This makes garlic a great low-carb option for adding flavor to various dishes. This is ideal for those looking to reduce their carb intake.

The mineral composition of bread samples treated with garlic extract is presented in Table 3. The potassium content of the bread samples ranged from 153.64 – 206.78 mg/100 g with sample A and D having the minimum and maximum values, respectively. The values obtained compared favourably with 200 – 240 mg/100g recommended by World Health Organization (WHO). Potassium is responsible for maintaining the composition constancy of the cell and intracellular fluid, maintaining acid – base balance, ensuring intercellular contacts. It also help to maintain osmotic pressure, the acid – base balance of the body and activate several enzymatic reactions (Olusanya, 2008). Calcium content of the bread sample ranged from 73.45 – 78.89 mg/100g. The sample A has the least value indicating that calcium content increased as garlic extract increased.

Table 3: Mineral composition of bread using garlic extract as additive (mg/100g)

Sample	Potassium	Calcium	Phosphorus	Magnesium
A	153.64±0.14[c]	73.45±0.01[c]	76.19±0.50[b]	21.35±0.01[b]
B	159.49±0.08[b]	75.83±0.01[b]	78.54±0.01[a]	25.54±0.16[a]
C	159.81±0.04[b]	78.78±0.27[a]	79.04±0.01[a]	25.76±0.03[a]
D	164.82±0.14[a]	78.89±0.08[a]	78.16±1.24[a]	25.85±0.08[a]

Values reported are mean ± standard deviation in triplicate. Mean values for each column bearing a different superscript roman letter are significantly different ($p \leq 0.05$). A: Control sample (100% wheat flour bread); B: 100% wheat flour bread + 3 ml of garlic extract; C: 100% wheat flour bread + 5 ml of garlic extract and D: 100% wheat flour bread +10 ml garlic extract

The calcium contents of all samples were below the recommended adult calcium intake of 1000 – 1200 mg/day (Gordon and Margaret, 2002). This intake is required to build higher bone mass. The

Phosphorus values ranged from 76.19 – 78.16 mg/100g with sample D having the highest value. Phosphorus compounds are involved in most important processes of energy exchange. Adenosine triphosphoric acid (ATP) is an accumulator of energy, thinking and mental activity is associated with its transformation, as well as the energy life support of the organism. Magnesium is a macronutrient and 90% of modern people suffer from its insufficiency (Umelo *et al.,* 2014). The physiological purpose of magnesium is due to its participation in a number of important enzymatic processes as a co-factor. Magnesium also participates in the conversion of phosphate to ATP. It is an anti-stress macronutrient and has a positive effect on the reproductive system. The magnesium content of the sample ranged from 21.35 – 25.85 mg/100g. High level of this element is key because it is involved in protein synthesis, normalize the function of the kidney and bile ducts, and has a positive effect on the functioning of the cardiovascular and nervous systems.

Effect of garlic additive on bread weight loss is presented in Figure 3. The bread weight loss values ranged from 0.067 - 1.503% with the samples coded-named A and D having the highest and lowest values, respectively. The result showed that as garlic concentration increased, there is corresponding reduction in the weight reduction of the samples.

Effect of garlic additive on specific volume of bread at different storage duration is presented in Figure 4. The specific volume value ranged from 2.86 - 3.79 cm^3/g, 2.36 - 2.80 cm^3/g, 2.13 - 2.72 cm^3/g, 2.08 - 2. 63 cm^3/g, 1.37 - 2.15 cm^3/g at day 1 - 5 respectively. The samples coded-named A and D having the highest and lowest values, respectively. The result showed that as garlic concentration increased, there is corresponding reduction in the specific volume of sample. The result also indicated that as storage duration progressed from day 1 to day 5, there is corresponding decrease in specific volume. The values obtained

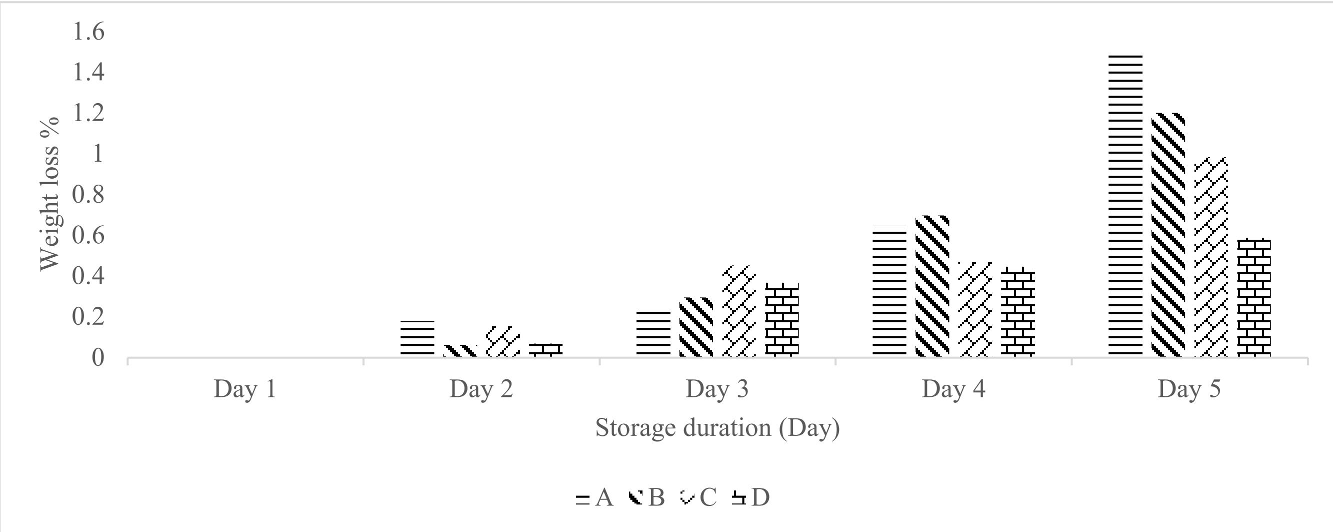

Figure 3: Effect of garlic additive on weight loss during storage.

A: 100% wheat flour; B: 100% wheat flour + 3ml of garlic; C: 100% wheat flour + 5ml of garlic; D: 100% wheat flour + 10ml of garlic.

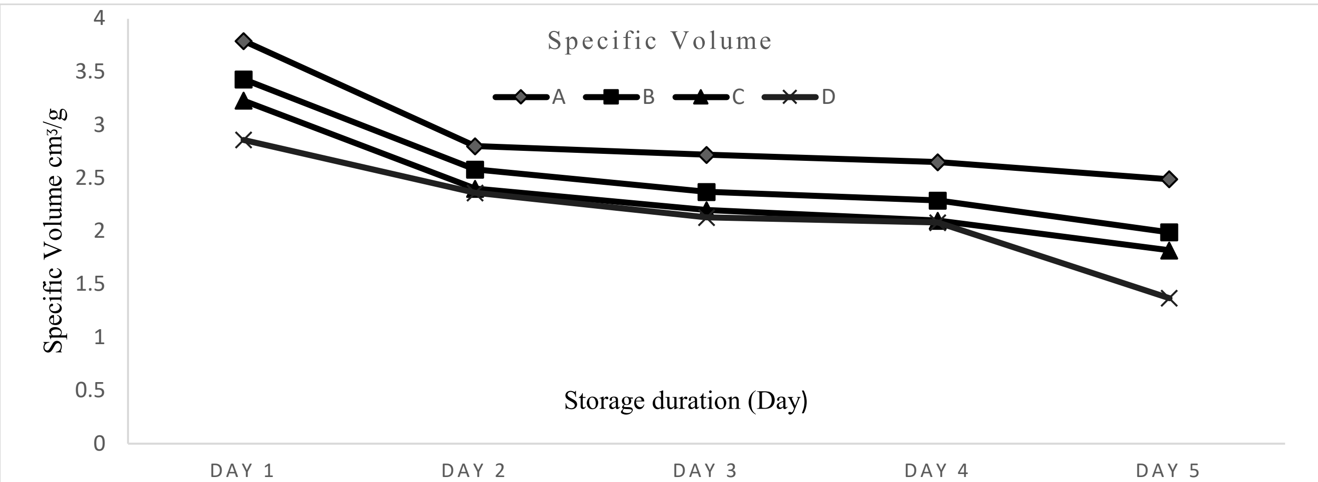

Figure 4: Effect of garlic additive on specific volume bread at different storage days.

A: 100% wheat flour; B: 100% wheat flour + 3ml of garlic; C: 100% wheat flour + 5ml of garlic; D: 100% wheat flour + 10ml of garlic

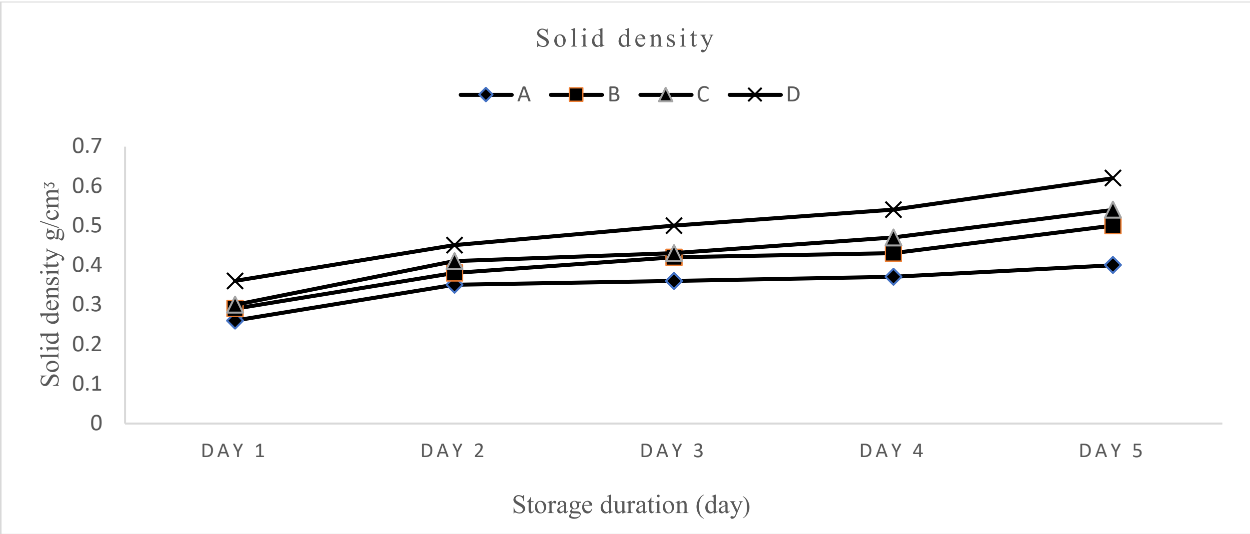

Figure 5: Effect of garlic extract as additive on bread density.

A: 100% wheat flour; B: 100% wheat flour + 3ml of garlic extract; C: 100% wheat flour + 5ml of garlic extract; D: 100% wheat flour + 10ml of garlic extract.

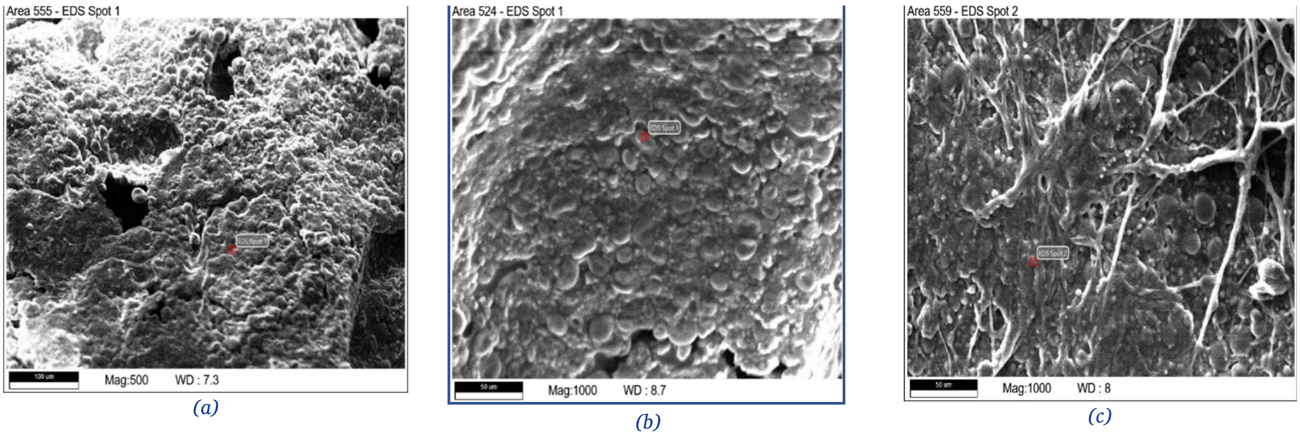

Plate 1: Scanning electron micrographs of garlic treated bread samples at different storage days (a) at day 1 (b) at day 3 (c) at day 5

compared favourably with 2.08 - 3.39cm^3/g and 2.16 - 3.51 cm^3/g after production for bread made using breadfruit and breadnut-wheat composite flour and substituting part of wheat flour with whole wheat flour (Malomo *et al.*, 2011; Ngozi, 2014). This indicates that the additive has a small impact on the specific volume of baked bread due to its potential to interfere with yeast activity (Fadda *et al.*, 2014). The specific volume of a loaf is a good indicator of bread quality. It represents the ability of gluten strands to retain enough gas released during fermentation and dough proofing. Higher gas retention ability will lead to a higher specific volume (Nada and Hasan, 2015). According to Standard Organisation of Nigeria (SON), a loaf specific volume for whole-wheat bread should not be less than 2.0cm^3/g.

Effect of garlic additive on density of bread at different storage duration is presented in Figure 5. The density values ranged from with 0.26 to 0.36 g/cm^3, 0.35 – 0.45 g/cm^3, 0.36 – 0.50 g/cm^3, 0.37 – 0.54 g/cm^3, 0.40 – 0.62 g/cm^3, at day 1 – 5, respectively. The samples coded-named D and A having the highest and lowest values, respectively. The result showed that as garlic concentration increased, there is corresponding increase in the sample's solid density. Increasing the volume of garlic extract in the sample resulted in denser bread samples making the bread samples more compact and heavier, the increase in the value of the bread density may be due to the increase in high moisture retention.

Scanning electron micrographs of garlic treated bread samples at different storage days was presented in plate 1. On day 1, starch granules merged into a single body and were completely encased by the surrounding gluten protein. The air bubbles that were trapped in the dough before baking may be related to the visible pores at day 1. As the days progress to day 3 the net like connections that held the gluten proteins and starch granules together began to weaken and at day 5 it broke down, this resulted in visible structural changes that significantly altered the internal structure of the bread. As the starch granules gathered and created an uneven distribution within the bread structure, the alterations became obvious. This accumulation of starch also influences the size of the pores, causing them to expand beyond their previous sizes.

Sensory evaluation of garlic additive on bread is presented in Table 4. The taste value ranged from 6.05 to 3.55 with the samples coded-named A and D having the highest and lowest values, respectively. There was significant difference ($p \leq 0.05$) between the samples. This indicates that sample A was liked moderately while samples C and D were liked slightly. Although, sample D was neither liked nor disliked. The aroma value ranged from 5.85 to 3.55 with the samples coded-named A and D having the highest and lowest values, respectively. The result showed that there was significant difference ($p \leq 0.05$) in all the sample with exception of A, B and C. This indicates that sample A, C and B was liked moderately and slightly. Although, sample D was neither liked nor dislike. The colour value ranged from 6.05 to 5.65 with the samples coded-named A and D having the highest and lowest values, respectively. The result showed that there was no significant difference ($p > 0.05$) among the samples. This indicates that all the samples were liked moderately. The texture value ranged from 6.05 to 5.00 with the samples coded-named A and D having the highest and lowest values, respectively.

Table 4: Sensory evaluation of bread with garlic as an additive

Sample code	Taste	Aroma	Colour	Texture	Appearance	Overall acceptability
A	6.05 ± 0.82[a]	5.85 ± 0.87[a]	6.05 ± 0.82[a]	6.05 ± 0.75[a]	6.00 ± 0.85 [a]	6.10 ± 0.78 [a]
B	5.25 ± 1.01[ab]	5.35 ± 1.08[a]	5.90 ± 0.91[a]	5.55 ± 1.05[ab]	6.05 ± 1.05 [a]	5.65 ± 0.87[ab]
C	5.05 ± 1.05[b]	5.55 ± 0.75[a]	6.05 ± 0.88[a]	5.65 ± 0.93[ab]	5.08 ± 1.05 [a]	5.15 ± 1.22[b]
D	3.55 ± 1.27[c]	3.55 ± 1.27[b]	5.65 ± 0.87[a]	5.00 ± 0.79[b]	5.08 ± 0.76 [a]	3.6 ± 1.18[c]

A: Control sample (100% wheat flour bread); B: 100% wheat flour bread + 3 ml of garlic extract; C: 100% wheat flour bread + 5 ml of garlic extract and D: 100% wheat flour bread +10 ml garlic extract

The result showed that there was significant difference ($p \leq 0.05$) between samples A and B. However, there was no significant difference ($p > 0.05$) between samples A, B and C. This indicates that samples A, B and C were liked moderately and sample D was liked slightly. The appearance value ranged from 6.00 to 5.80 with the samples coded-named A and D having the highest and lowest values, respectively. The result showed that there was no significant difference ($p > 0.05$) between the samples. This indicates that all the samples in terms of appearance were liked moderately. The overall acceptability value ranged from 6.10 to 3.60 with the samples coded-named A and D having the highest and lowest values, respectively. The result showed that there was significant difference ($p \leq 0.05$) between all the samples. This indicates that samples A, B, and C were liked moderately and slightly. Although, sample D was neither liked nor disliked.

4. CONCLUSION

The study showed that the samples moisture content values ranged between 29.1 – 34.8 % and is still within acceptable limit; the incorporation garlic extract as additive minimized the samples weight loss during storage while addition of garlic additive led to decrease in the samples specific volume; addition of garlic extract interfered with protein matrix of the baked bread samples: there is more void spaces in the sample structure as concentration of garlic additive increased and; storability effect of garlic additive was effective at high proportion but the intense aroma on the bread made it unacceptable. The study therefore provided chemical and engineering data on bread produced with garlic extract as an additive with the aim of promoting its acceptability beyond its present status.

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