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Effect Of Some Chemical Preservatives On The Physico-Chemical Properties Of Grilled Bacon

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Abstract
The physico-chemical properties of grilled bacon (GB) as influenced by some chemical preservatives such as Butyl Hydroxyl Toluene (BHT), citric acid and sugar were investigated. Four samples comprising GB + 0 ppm BHT + 0.5% citric acid + 2% sugar (GBC_1), GB + 0.1 ppm BHT + 0.5% citric acid + 2% sugar (GBC_2), GB + 0.2 ppm BHT + 0.5% citric acid + 2% sugar GBC_3) and the control (GB + 0 ppm BHT + 0% citric acid + 0% sugar; GBC_0) were produced and subjected to physico-chemical tests at temperatures of 20°C, 30°C, 40°C and 50°C for 3 weeks to access their stability, safety and acceptability of bacon. It was observed that the sample preserved with citric acid and sugar (GBC_1) stored at 20°C significantly ($p<0.05$) increased vitamins A and B_1 compared to other samples stored under other temperature conditions. Across all samples, pH significantly ($p<005$) increased as temperature increased from 20°C to 30°C. Incorporation of chemical preservatives significantly ($p<005$) increased total volatile basic nitrogen and thiobarbituric acid as storage time and temperature increased. On the basis of the results obtained, it may be recommended that 0.1 ppm (BHT), 0.5% citric acid and 2% sugar (GBC_2) may be used as chemical preservatives in grilled bacon stored at 30°C for at least 2 weeks without any adverse effect on the evaluated physico-chemical properties of the product.

Keywords: *Bacon, Butyl Hydroxyl Toluene (BHT), Citric Acid, Sugar, Vitamin A, Vitamin B_1, pH, Total Volatile Bases, Thiobarbituric Acid.*

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I. Introduction

Bacon is a cured or smoked belly of a swine (hog) carcass (FSIS, 2011) and it represents a cut of meat taken from the sides, belly, or back of a pig which have less fat. Among the valuable primal cuts from pig carcass, the pork belly accounts for about 9% of live weight, 12.0 – 16.7% of chilled carcass weight and approximately 15.0 – 18.9% of the total carcass value (Stiffler *et al*., 1975; Fredeen, 1980). Thus, pork belly, especially when cured, represents a fairly large economic portion of the pigs' carcass (Mandigo, 2009). According to Pereira and Vincente (2013) pork contains 18.1% and 31.7% protein and fat respectively. The high fat content may therefore predispose bacon to microbial spoilage and lipid oxidation and thereby reducing the shelf life of the product (Soladoye *et al*., 2015).

Meat in general and pork in particular is a very highly perishable product which cannot be stored for appreciable period of time without refrigeration. Cold storage require constant energy supply. However, energy supply in Nigeria is not reliable and epileptic. This calls for research into alternatives to cold storage because chemical preservatives can mitigate the spoilage of meat products. Chemical preservatives such as use of salts, acids and anti-oxidants are non-energy dependent measures for shelf-life extensions.

Chemical preservatives such as Butyl Hydroxyl Toluene (BHT), citric acid, nitrate, nitrite, spices, salt and sugar have been used to ensure safety and stability (Leif, 1994). The extensive use of BHT which is synthetic phenolic anti-oxidants has been reported (Rice-Evan *et al*., 1996; Govari and Pexara, 2015). BHT has also proven anti-microbial properties against bacteria (predominantly gram-negative), fungi, viruses and protozoa (Branen *et al*., 1980; Ray, 2004). Hui (2006) reported the anti-oxidative properties of BHT at 0.02%.

Citric acid and sugar have also been employed to significantly improve sensory, microbial stability and nutritional quality of meat products (Shuming *et al*., 2008). Citric acid according to Pal and Devrani (2018) is effective mould inhibitor while sugar has been used to control water activity as free water bind up in their presence which results in an osmotic imbalance and finally inhibition of cell growth (Ray, 2004). Sugar (0.75 – 1.0%) also help as flavour enhancer; moderates the taste intensity of the salt in the product and also as microbial inhibitors (Rocha, 2011).

The objective of the present study was to evaluate the physico-chemical characteristics of grilled bacon using Butyl Hydroxyl Toluene (BHT), citric acid and sugar as chemical preservatives.

II. Materials And Methods

About 20 kg of pre-rigor cut of pork taken from the belly of a slaughtered pig was purchased from the Benue State Swine and Crop Improvement Programme, Yandev, Gboko, Benue State within 1 h of slaughter; placed in a plastic bucket with ice blocks and transported promptly to the Food Chemistry Laboratory, College of Food Science and Technology, University of Mkar, Mkar where they were trimmed of fat, washed with chilled deionised water and packed in black polyethylene bags and kept in a household deep freezer and used for bacon production within 24 h.

Spices; ground onions, ginger, garlic, chillie, hydrolysed vegetable protein (maggi cubes) were purchased from Gboko main market, Gboko, Benue State. The spices and ground maggi cubes was mixed in a ratio of 1:1 (w/w). Food grade common salt (NaCl) was added to taste.

The samples for the physico-chemical investigation were: -
1)GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
2)GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
3)GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar

These 3 samples, together with the control sample (GBC_0), were used for physico-chemical tests at temperatures of 20ºC, 30ºC, 40ºC and 50ºC weekly for 3 weeks.

Essentially for each product, 5 kg of pork taken from the belly were manually cut into thin slices (approximately 2 x 2 x 2 mm, length, width and thickness) using sharp stainless steel knives. The meat slices were mixed with appropriate ratios of BHT, citric acid, sugar and spices followed by immersing in stainless steel pressure cooker for about 30 mins. The cooked meats together with the resultant stock were pounded using previously washed mortar and pestle into a mash. After separation of the meat stands, they were minimally dried in an air draft oven at 60ºC for 30 mins to enhance the product handling and moisture reduction. After drying, the meats were packaged and storage in plastic containers with tight lids.

The vitamins A and B_1 contents, pH as well as Thiobarbituric acid (TBA) and Total Volatile Bases (TVB) of each of the grilled bacon product incorporated with BHT, citric acid and sugar were carried out immediately following production according to the Official methods (AOAC., 2012). Storage of each sample was at temperatures of 20ºC, 30ºC, 40ºC and 50ºC weekly for 3 weeks.

Statistical Analysis

Data on each sample stored at each temperature were subjected to the analysis of variance (ANOVA) for Completely Randomized Design (CRD) and where significant differences were indicated, the means were separated using Least Significant Difference (LSD) according to the procedures of the Statistical Package (SPSS, 2006).

III. Results

The results show that chemical preservatives affect changes in the physico-chemical properties of grilled bacon stored at different temperatures. The results of the effect of chemical preservatives on vitamin A composition of grilled bacon stored at different temperatures are presented in Table 1. It was observed that there were no significant differences ($p>0.05$) in vitamin A composition of GBC_1 stored at 20º and 30ºC on the one hand and at 30º, 40º and 50ºC on the other hand. However, the vitamin A composition of GBC_2 was significantly lower ($p<0.05$) at 50ºC compared with other samples stored under similar temperature conditions as well as other samples stored at 20º, 30º and 40ºC. Finally, there were no significant differences ($p>0.05$) in vitamin A content of GBC_2 stored at 20º, 30º and 40ºC as well as GBC_3 stored at 20º and 40ºC and GBC_0 stored at 20º and 40ºC. Increase in the level of BHT from 0.1 ppm to 0.2 ppm increased the vitamin A content of grilled bacon stored at 20º, 30º, 40º and 50ºC. At 50ºC, the vitamin A content significantly ($p<0.05$) reduced in GBC_2 when compared with GBC_3.

The results of the effect of chemical preservatives on vitamin B_1 composition of grilled bacon stored at different temperatures are presented in Table 2. It was observed that the vitamin B_1 content of GBC_1 at 20^0 was significantly higher ($p<0.05$) than with other samples stored at temperatures of 30^0, 40^0 and 50^0C. The results also showed that there were no significant differences ($p>0.05$) in vitamin B_1 for GBC_3 compared with other samples at all storage temperature conditions. It was observed that GBC_3 stored under all temperature values had insignificantly lower ($p>0.05$) vitamin B_1 content compared with other samples stored under similar temperature conditions. The study also showed that vitamin B_1 stored at 30ºC was not significantly different ($p>0.05$) from GBC_3 stored at 20º, 30º, 40º and 50ºC. At all storage temperatures, the vitamin A content significantly ($p<0.05$) reduced of GBC_2 compared with GBC_3. Increase in the level of BHT from 0.1 ppm to 0.2 ppm reduced the vitamin B_1 content of GBC_2 and GBC_3 stored at 20º, 30º, 40º and 50ºC.

The results of the effect of chemical preservatives on pH value of grilled bacon stored at different temperatures are presented in Table 3. It was observed that the pH value of the control sample (GBC_0) at 50ºC

storage temperature was significantly higher ($p<0.05$) than other samples stored at 20°, 30° and 40°C as well as other samples stored under all temperature conditions under review. It was also observed that there were no significant differences ($p>0.05$) in the pH value of GBC_0 stored at 40°C, GBC_1, GBC_2 and GBC_3 stored at 30°, 40° and 50°C. Increase in the level of BHT from 0.1 ppm to 0.2 ppm reduced the pH value of GBC_2 compared to GBC_3 stored at 20°, 30° and 40°C. At 50°C, the vitamin A content significantly ($p<0.05$) reduced GBC_2 when compared to GBC_3. Finally, it was observed that the pH values of all samples stored at 20°C were lower than those stored at 30°, 40° and 50°C.

The results of the effect of chemical preservatives on Total Volatile Bases (TVB) of grilled bacon stored at different temperatures are presented in Table 4. It was observed that the TVB of GBC_1 stored at 20°C was significantly higher ($P<0.05$) than other samples stored at 30°, 40° and 50°C. It was also observed that there were no significant differences ($p>0.05$) in TVB for GBC_1 stored at 30°C, GBC_2 stored at 20°C, 30°C and 40°C and GBC_3 stored 20°C and 30°C. Finally, it was observed that the control sample (GBC_0) stored at 40° and 50°C had significantly ($p<0.05$) lower TVB value than other samples stored at 20^0 and 30^0C. Increase in the level of BHT from 0.1 ppm to 0.2 ppm increased the TVB of grilled bacon stored at 20°, 30°, 40° and 50°C.

The results of the effect of chemical preservatives on Thiobarbituric Acid (TBA) value of grilled bacon stored at different temperatures are presented in Table 5. It was observed that the TBA of GBC_1 stored at 20°C was significantly higher ($p<0.05$) than other samples stored at 30°, 40° and 50°C. There were no significant differences ($p>0.05$) in TBA for the control sample (GBC_0) stored at 20°, 30° and 40°C. It was also observed that there were no significant differences ($p>0.05$) in TBA for the control sample (GBC_0), GBC_2 and GBC_3 stored at 30° and 40°C. It was also observed that GBC_2 and GBC_3 stored at 50°C had significantly lower ($p<0.05$) TBA values than other samples stored at 20°, 30° and 40°C. Increase in the level of BHT from 0.1 ppm to 0.2 ppm increased the TBA stored at 20°, 30°, 40° and 50°C. It was observed that the TBA of GBC_2 has lower TBA values than GBC_3 stored at temperatures of 30°, 40° and 50°C.

IV. Discussion

Vitamin A is fat soluble and a component of the visual pigments of rod and cone cells and forms stable association with body fat. The use of Butyl Hydroxyl Toluene which is a synthetic phenolic anti-oxidant according to Govari and Pexara (2015) diminishes the formation of lipid primary radicals. This may be responsible for the decreased vitamin A composition of grilled bacon stored at 20°, 30° and 40°C with the incorporation of BHT in the present study. The level of BHT at 0.02% reported by Hui (2006) was lower than the effective level in the present study.

Thiamin (vitamin B_1) is an energy releasing water soluble vitamin. The results showed that addition of citric acid and sugar significantly increased vitamin B_1 content of grilled bacon stored at 20°C (GBC_1) and this is within the figure reported by Williams (2007) that bacon contain 0.36 mg/100g of vitamin B_1. Vitamin B_1 being a water soluble vitamin is easily destroyed by heat. For all samples with chemical preservatives, vitamin B_1 reduced with increase in storage temperature.

The pH of meat is widely used to access the shelf life and quality of the meat carcass. The pH value of the meat samples in the present study increased with the application of 0.1 ppm BHT, citric acid and sugar when stored at 20° and 30°C. At 50°C, pH of the control sample (GBC_0) was significantly higher than the value (mean pH values of pork is 5.92 ± 0.39) reported by Malik and Sharma (2014) but agrees with the findings of Leistner (2000) who reported that shelf life of meat products increase with high storage temperature and reduce competitive micro-organisms (lactic acid bacteria).

Application of chemical preservatives to all samples increased total volatile basic nitrogen as storage time and temperature increased. This result agrees with the findings of Alea El-Din *et al*. (2021) who reported that TVBN which is often used as a biomarker of protein and amine degradation as it increases with meat spoilage. Cai *et al*. (2011) reported that freshness is also called shelf life. Freshness is regarded as one of the most important parameters to take into account in order to access pork quality (Eggert *et al.*, 2002; Leroy *et al.*, 2003).

Thiobarbituric acid (TBA) is a widely used indicator for the assessment of degree of secondary lipid oxidation. Application of chemical preservatives to grilled bacon in the present study increased TBA at all storage temperatures. This result agrees with the findings of Iheagwara and Okonkwo (2016) who reported that peroxides are oxidized to aldehyde and ketones which impart the disagreeable rancid odours and flavour with increased storage time.

V. Conclusion

The incorporation of 0.1 ppm Butyl Hydroxyl Toluene (BHT), 0.5% citric acid and 2% sugar as chemical preservatives to grilled bacon stored at 30°C may be used for freshness and quality without refrigeration for 2 weeks.

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Table 1: Effect of Some Chemical preservatives on Vitamin A Composition (mg/100g) of Grilled Bacon Stored at Different Temperatures

Sample	Temperature (ºC)				
	20	30	40	50	LSD
GBC_0	3.37^{d}±1.01	3.16^{de}±0.85	3.26^{d}±1.03	3.82^{d}±1.67	0.21
GBC_1	6.44^{a}±3.68	5.93^{ab}±3.23	5.54^{b}±3.23	5.00^{bc}±2.82	
GBC_2	3.48^{d}±2.38	3.31^{d}±0.79	3.20^{d}±0.01	2.67^{f}±0.01	
GBC_3	4.35^{cd}±0.12	4.72^{c}±0.78	3.71^{d}±0.63	3.01^{e}±0.12	

Each result is Mean ± SD of duplicate determinations. Values with similar superscripts in rows are not significantly (p>0.05) different.

GBC_0 = Bacon + 0 ppm BHT + 0% citric acid + 0% sugar (Control)
GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar

Table 2: Effect of Chemical preservatives on Vitamin B_1 Composition (mg/100g) of Grilled Bacon Stored at Different Temperatures

Sample	Temperature (ºC)				
	20	30	40	50	LSD
GBC_0	$0.22^{c}\pm0.01$	$0.25^{b}\pm0.05$	$0.26^{b}\pm0.09$	$0.25^{b}\pm0.11$	0.29
GBC_1	$0.45^{a}\pm0.39$	$0.15^{d}\pm0.10$	$0.22^{c}\pm0.00$	$0.25^{b}\pm0.00$	
GBC_2	$0.27^{b}\pm0.16$	$0.20^{c}\pm0.10$	$0.20^{c}\pm0.10$	$0.20^{c}\pm0.09$	
GBC_3	$0.15^{d}\pm0.08$	$0.13^{d}\pm0.00$	$0.12^{d}\pm0.03$	$0.15^{d}\pm0.03$	

Each result is Mean ± SD of duplicate determinations. Values with similar superscripts in rows are not significantly (p>0.05) different.

GBC_0 = Bacon + 0 ppm BHT + 0% citric acid + 0% sugar (Control)
GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar

Table 3: Effect of Chemical preservatives on pH of Grilled Bacon Stored at Different Temperatures

Sample	Temperature (ºC)				
	20	30	40	50	LSD
GBC_0	$4.20^{c}\pm1.57$	$4.29^{c}\pm1.49$	$5.74^{b}\pm0.29$	$6.74^{a}\pm0.75$	0.32
GBC_1	$4.28^{c}\pm1.47$	$4.65^{b}\pm1.15$	$4.91^{b}\pm0.93$	$5.00^{b}\pm1.00$	
GBC_2	$4.42^{c}\pm0.85$	$5.60^{b}\pm0.61$	$5.81^{b}\pm0.70$	$4.98^{b}\pm1.73$	
GBC_3	$4.28^{c}\pm1.70$	$5.00^{b}\pm1.13$	$5.35^{b}\pm0.58$	$5.51^{b}\pm0.64$	

Each result is Mean ± SD of duplicate determinations. Values with similar superscripts in rows are not significantly (p>0.05) different.

GBC_0 = Bacon + 0 ppm BHT + 0% citric acid + 0% sugar (Control)
GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar

Table 4: Effect of Chemical preservatives on Total Volatile Bases (mg/100g) of Grilled Bacon Stored at Different Temperatures

Sample	Temperature (ºC)				
	20	30	40	50	LSD
GBC_0	$35.82^{d}\pm1.84$	$33.95^{d}\pm1.73$	$25.32^{e}\pm1.03$	$24.83^{e}\pm1.02$	0.97
GBC_1	$64.77^{a}\pm4.79$	$58.03^{b}\pm4.36$	$45.08^{c}\pm3.11$	$38.94^{d}\pm2.78$	
GBC_2	$60.85^{b}\pm4.12$	$57.50^{b}\pm4.00$	$53.55^{b}\pm3.74$	$47.38^{c}\pm3.45$	
GBC_3	$51.45^{b}\pm3.69$	$47.99^{c}\pm3.54$	$45.34^{c}\pm3.50$	$42.81^{c}\pm3.28$	

Each result is Mean ± SD of duplicate determinations. Values with similar superscripts in rows are not significantly (p>0.05) different.

GBC_0 = Bacon + 0 ppm BHT + 0% citric acid + 0% sugar (Control)
GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar

Table 5: Effect of Chemical preservatives on Thiobarbituric Acid (µg/g) of Grilled Bacon Stored at Different Temperatures

Sample	Temperature (ºC)				
	20	30	40	50	SE
GBC_0	$0.83^{b}\pm0.21$	$0.85^{b}\pm0.36$	$0.89^{b}\pm0.02$	$0.72^{c}\pm0.42$	1.00
GBC_1	$1.04^{a}\pm0.42$	$0.93^{b}\pm0.44$	$0.90^{b}\pm0.46$	$0.80^{c}\pm0.37$	
GBC_2	$0.79^{c}\pm0.27$	$0.76^{c}\pm0.26$	$0.66^{d}\pm0.22$	$0.66^{a}\pm0.36$	
GBC_3	$0.88^{b}\pm0.50$	$0.88^{b}\pm0.55$	$0.80^{b}\pm0.46$	$0.65^{d}\pm0.33$	

Each result is Mean ± SD of duplicate determinations. Values with similar superscripts in rows are not significantly (p>0.05) different.

GBC_0 = Bacon + 0 ppm BHT + 0% citric acid + 0% sugar (Control)
GBC_1 = Bacon + 0 ppm BHT + 0.5% citric acid + 2% sugar
GBC_2 = Bacon + 0.1 ppm BHT + 0.5% citric acid + 2% sugar
GBC_3 = Bacon + 0.2 ppm BHT + 0.5% citric acid + 2% sugar