

# Effects of Varying Heating Temperatures on the Physicochemical Properties of Chicken Tallow Obtained from Broilers

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**Abstract:** The physicochemical properties of oil and fat have considerable influence on their performances for various areas of application. These fat and oil properties, such as specific gravity, density, moisture content, free fatty acid, peroxide value, iodine value, acid value, saponification value etc., are important parameters for assessing the quality of the fat and oil and could aid in identifying their suitability for specific application. These properties could be affected by different processing conditions such as time, pressure and temperature. The present study reported on the effects of heating temperature on the physicochemical properties of Chicken tallow obtained from Broilers. The Chicken tallow was processed at three different heating temperatures namely 25°C, 50°C and 75°C, and the physicochemical contents (*i.e.* acid value, iodine value, peroxide value, free fatty acid *etc.*) were analyzed. The moisture content, density and specific gravity of the Chicken tallow showed a similar trend by way of decreasing with increase in heating temperatures. While the acid and iodine values increased with increasing temperature, on the other hand, the free fatty acid and peroxide values showed decrease with increasing temperatures. The saponification value presented highest result at 50°C heating temperature. This research indicated that, the varying heating temperatures can have potential effects on the physicochemical properties of the Chicken tallow.

**Keywords:** Chicken, Tallow, Oil, Physical, Chemical, Properties, Temperature

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## 1. Introduction

Poultry production in Nigeria is extensively expanding annually, with the country taking the position of the largest annual egg producer and the second largest country in Africa in terms of chicken production. Almost about 80 million Nigerians are practicing the business of poultry production either on a small or medium scale enterprises. The products mostly obtained from poultry source include egg, manure and meat. Poultry meat is expected to account for about 14% of Nigerian meat consumption by the year 2029 [1]. The accelerated expansion in the Nigerian sector of poultry production will translate to an increase in generation of by-products such as Chicken tallow. The utilization of these chicken tallow can add value to the business of poultry production, thereby reducing the possibility of landfilling

these valuable by-products as waste.

The Chicken tallow or fat is often separated from the fatty tissue of animal carcass through rendering technology. In this technology, the fat is melted and then removed from the non-fat matrix where it was embedded. Previous works have reported on the effect of rendering condition on the physicochemical properties of chicken fat [2-3].

It is noteworthy that, fat and oil have wide range of domestic and industrial applications which cut across areas such as food for human and animals, energy, cosmetics, medicine and other manufacturing industries. Thus, the knowledge about the properties of the fat and oil is imperative in order to appraise and determine their suitability for a given application. The most common factors that affects the properties of oil and fats include temperature, pressure and time [3].

The physicochemical properties of oils and fats are significantly influenced by various processing or handling temperatures, which consequently can affect the overall quality of the material. Oil for instance, when heated at a frying temperature of up to 185°C for 6 hours can result in the formation of polar lipophilic aldehydes. Similarly, low density lipoprotein (*aka* bad cholesterol) can be formed when oil is heated at elevated temperatures. Low density lipoproteins can cause arterosclerosis, a complicating heart disease [4]. Also, subjecting oil or fat to high temperatures can increase rancidity resulting from increase in acid value as well as high free fatty acid. The oxidative deterioration of oil and fat are measured by the peroxide value. Polyunsaturated fatty acids can undergo peroxidation where oxidation products are generated that can have detrimental effects on the palatability and health benefits of the oil and fat [5].

Similarly, other oil and fat properties which can be affected by temperature included; measure of unsaturation of fatty acids (Iodine value), measure of amount of alkali (mg KOH/g of sample) needed to saponify a given amount of the oil (Saponification value), the number of milligrams of KOH required to neutralize the free fatty acids present in one gram of fat (free fatty acid value) etc. In the present work, we reported on the effect of processing temperature on the physicochemical properties (acid value, peroxide value, iodine value, free fatty acid value etc.) of Chicken tallow.

## 2. Materials and Methods

### 2.1. Materials

The materials used in this research include; Chicken tallow, Laboratory equipment and apparatus (such as oven, density meter, weighing balance, hot plate, digital thermometer etc.), and analytical grade laboratory chemicals and reagents obtained from BDH England, used as received without further modification.

### 2.2. Methods on Sample Collection and Preparation

#### 2.2.1. Sample Collection

The Chicken tallow was collected from Birnin-Kebbi Central Market, Kebbi State Nigeria. The sample was mechanically collected mainly from broilers after slaughtering and meat processed. About 2kg fat embedded beneath the skin of the chicken was carefully removed and collected in a clean plastic container.

#### 2.2.2. Sample Preparation

The collected Chicken tallow was in a crude form containing some skin remnant and other impurities. In order to obtain the pure fat free from any impurities, the fat was placed in a beaker and distilled water was added. Thereafter, the beaker containing the fat and water was placed in an oven set at 30°C for 2 hrs, after which decantation was employed to obtained the pure liquid fat, while the impurities that settled at the bottom of the beaker was kept separate. The purified fat was then kept in a refrigerator for further analysis.

### 2.3. Determination of the Effect of Varying Temperatures

To determine the effects of varying temperatures, a 5g each of the Chicken tallow was weighed, heated on a hot plate and placed separately in an oven set at 25°C, 50°C and 75°C respectively. The experiment was performed at atmospheric pressure for 2hours. Thereafter, the samples at each temperature were further analyzed for their physicochemical properties such as density, acid value, peroxide value, saponification value, free fatty acid value, iodine value *etc.*

### 2.4. Determination of Chemical Properties of Test Samples

#### 2.4.1. Determination of Acid Value

Titrimetric method was employed to determine the acid value and free fatty acids. A 5g sample of the fat processed at 25°C was added into a conical flask and treated with 25 cm<sup>3</sup> ethanol and then 3 drops of phenolphthalein indicator was added. This mixture was then titrated with standard solution of 0.1M KOH until a faint permanent color appeared. The experiment was repeated in triplicate to obtain mean and standard deviation. Similar procedures were followed for the samples processed at 50°C and 75°C respectively. The titre values obtained were recorded and used to calculate the acid value following equation (1).

$$\text{Acid Value} \left( \frac{\text{mgKOH}}{\text{g}} \right) = \frac{\text{titre value} \times 56.1 \times 0.1}{\text{wt of the oil (g)}} \quad (1)$$

Where 56.1 is the atomic weight of KOH, while 0.1 is its molar concentration used.

#### 2.4.2. Determination of Peroxide Value

Determination of the peroxide value was conducted by weighing 5g of the fat processed at 25°C into a clean dried boiling tube. Then, 1g powdered KI, 20 cm<sup>3</sup> of admixture in the ratio of 3:2 glacial acetic acid and chloroform was added. The tube was transferred and placed in a boiling water and boiled vigorously for 30 minutes. Thereafter, 25 cm<sup>3</sup> of water was added, swirled and titrated against 0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution until the yellow color almost disappeared. Starch solution (0.5 cm<sup>3</sup>) was added and shaken vigorously and further titrated carefully until the blue color disappeared. Afterward, a blank titration was performed accordingly. Similar procedures were performed for the fat samples processed at 50°C and 75°C respectively. The peroxide value was calculated using equation (2).

$$\text{Peroxide Value} = \frac{N \times (vb - vs) \times 1000}{\text{wt of the oil (g)}} \left( \frac{\text{Meq}}{\text{kg}} \right) \quad (2)$$

Where N = molarity of thiosulphate, vs = volume of thiosulphate used in the test sample, vb = volume of thiosulphate used in the blank.

#### 2.4.3. Determination of Saponification Value

The saponification value of the fat sample processed at 25°C was measured by adding 5g of the fat into a 250 cm<sup>3</sup>

capacity flask fixed with reflux condenser and 25cm<sup>3</sup> of 0.1M methanolic KOH solution was added into the flask. Refluxing was performed over a water bath for 1 hour and allowed to cool. Thereafter, 3 drops of phenolphthalein indicator was added and titrated with 0.1M HCl until the solution becomes colorless. A blank titration was also performed following the same procedures. Similar procedures were performed for the fat samples processed at 50°C and 75°C respectively. The saponification value of the oil was then calculated using equation (3).

$$\text{Saponification Value} = \frac{(vb - vs) \times 56.1 \times M}{\text{wt of the oil (g)}} \quad (3)$$

Where vb = volume in cm<sup>3</sup> of 0.1 HCl required for blank, vs = volume in cm<sup>3</sup> of 0.1M HCl required for the test samples, M = molarity of HCl.

#### 2.4.4. Determination of Iodine Value

The Iodine value of the fat sample processed at 25°C was measured by adding 5g of the test sample into a conical flask, 5 cm<sup>3</sup> of 5% HCl was added and the mixture was stirred into a homogeneous mixture. Thereafter, 25 cm<sup>3</sup> of Wij's solution was added and the mixture was kept in the dark for 40 minutes to enable the reaction reach completion. Thereafter, the mixture was removed and 20 cm<sup>3</sup> of KI solution was added followed by 100 cm<sup>3</sup> of distilled water. The mixture was afterward, titrated with 0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.5H<sub>2</sub>O solution until the color almost disappear. 3 drops of 1% starch indicator was added to give blue-black color and titrated against 0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.5H<sub>2</sub>O solution continued by adding thiosulphate until the color disappeared. Afterward, a blank titration was performed accordingly. Similar procedures were performed for the fat samples processed at 50°C and 75°C respectively. The Iodine value was calculated using equation (4).

$$\text{Iodine Value} = \frac{(vb - va) \times 126.9 \times M}{\text{wt of the oil (g)}} \quad (4)$$

Where va and vb = titre values for the test samples and blank respectively, M = molarity of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.5H<sub>2</sub>O solution, 126.9 = atomic weight of Iodine.

#### 2.4.5. Determination of Free Fatty Acids

The analysis of the free fatty acids was conducted by inserting 5 g of the fat samples into 100 cm<sup>3</sup> flask and then 75 mL of isopropyl alcohol (neutral alcohol), was added. Thereafter, 1 mL of phenolphthalein indicator was added. The mixture was titrated against 0.25 M NaOH and shaken vigorously until the faint pink color which persists for at least 1 min was obtained. The free fatty acid was then calculated using equation (5). The procedure was followed for all the test samples processed at 25°C, 50°C and 75°C respectively.

$$\% \text{ Free Fatty Acid} = \frac{mL \times 0.25 \times 282 \times 100}{5 \times 1000} \quad (5)$$

Where: 5 = is the weight of the test sample, mL = mL of

NaOH required, 0.25 = molarity of NaOH solution and 282 = equivalent weight of free fatty acid in which the results are to expressed.

### 2.5. Determination of Physical Properties of Test Samples

#### 2.5.1. Determination of Densities

The density of the Chicken tallow processed at various experimental temperatures (viz. 25°C, 50°C and 75°C respectively) was determined by weighing the volume of 5g of the test sample using weighing balance. Thereafter, the density was calculated using equation (6).

$$\text{Density (gcm}^{-3}\text{)} = \text{Mass/Volume} \quad (6)$$

#### 2.5.2. Determination of Specific Gravities

Specific gravity is the ratio of the density of a substance to the density of reference substance. The reference substance is nearly always water though the ratio of oil density and ratio of water density is given in equation (7) which was used to calculate the specific gravity of the Chicken Tallow processed at various experimental temperatures (viz. 25°C, 50°C and 75°C respectively).

$$\text{Specific gravity} = \text{density of test sample/density of water (7)}$$

#### 2.5.3. Determination of Moisture Content

The moisture content of the test sample was determined by thermal drying in an air circulation oven until a constant weight at a temperature slightly above the boiling point of water is achieved. The test sample (5g) processed at various heating temperatures (viz. 25°C, 50°C and 75°C respectively) was placed in the weighed crucible and inserted in an oven set at 105°C for 24 hours. The moisture content was calculated using equation (8).

$$\text{Moisture content (\%)} = \frac{\text{loss in weight}}{\text{weight of test sample}} \times 100 \quad (8)$$

## 3. Results and Discussion

The results of all the analyses on physical and chemical properties of the Chicken tallow conducted at varying heating temperatures are presented in Table 1 and Figures 1 to 5 respectively. The varying temperatures tended to slightly decrease the moisture contents of the Chicken tallow, at 25°C, the moisture content recorded was 1.15% which decreased to 0.89% when the temperature reached 75°C (Table 1). The lower the moisture content of the Chicken tallow, the better its quality because moisture is regarded as impurity which can devalue the properties of the Chicken tallow and limits its application.

**Table 1.** Results of physical properties of the oil at different temperatures.

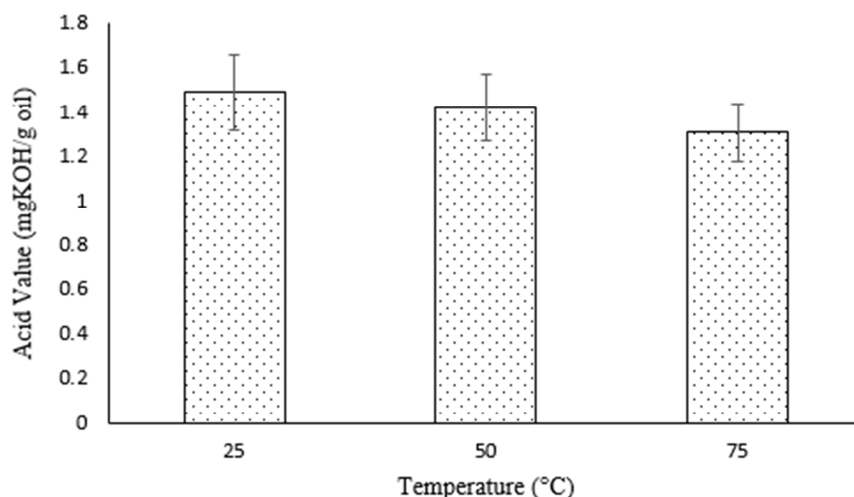
Parameter	Temperature °C		
	25	50	75
Moisture Content (%)	1.15 ± 0.05	0.92 ± 0.08	0.89 ± 0.06
Density (gcm <sup>-3</sup> )	0.86 ± 0.02	0.85 ± 0.01	0.84 ± 0.01
Specific gravity (kgm <sup>-3</sup> )	1.07 ± 0.03	1.04 ± 0.02	1.02 ± 0.05

It can also be seen in Table 1 that, the densities of the

Chicken tallow slightly decreases with increasing temperature, a similar trend can be seen for the specific gravities of the Chicken tallow. Previous report in the literature also noted that, the density of all oils decreased as temperatures increased. The authors observed some variation between oils in the temperature coefficients of the change in density. The density differentials between oil and water and their temperature coefficients varied markedly between the different oils as reported by Porter and Lammerink [2]. It can also be seen in Table 1 that, the specific gravities of the Chicken tallow tended to decrease with increasing

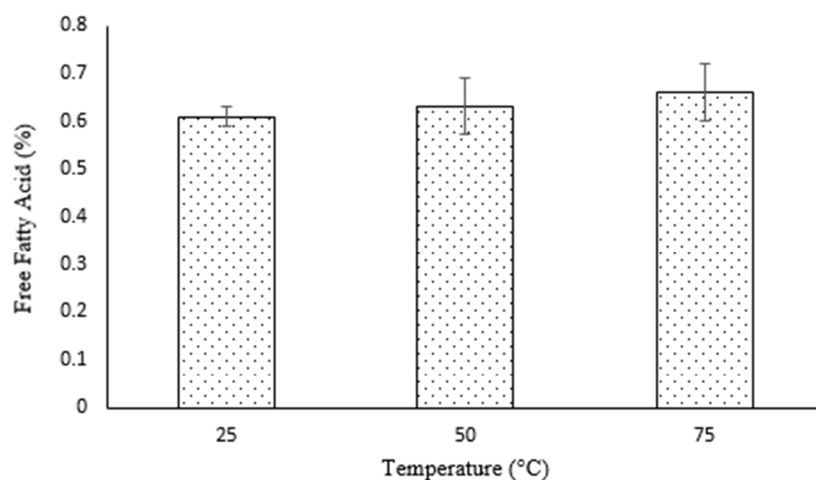
temperature. This is generally the case of most liquids including fats and oils, which tend to increase with decreasing temperature owing to the fact that the liquids become denser by contracting at lower temperature, thus at lower temperature their viscosity increases and vice versa.

The result of the acid value of the Chicken tallow as presented in Figure 1 tended to decrease with increasing temperature. The acid value is a general indication of the edibility of fat and oil. The fat or oil are considered edible when their acid values have not exceeded 4 mg/g as previously reported by Esuoso and Adetokun [1].



**Figure 1.** Results of Acid value of the chicken tallow at varying temperatures.

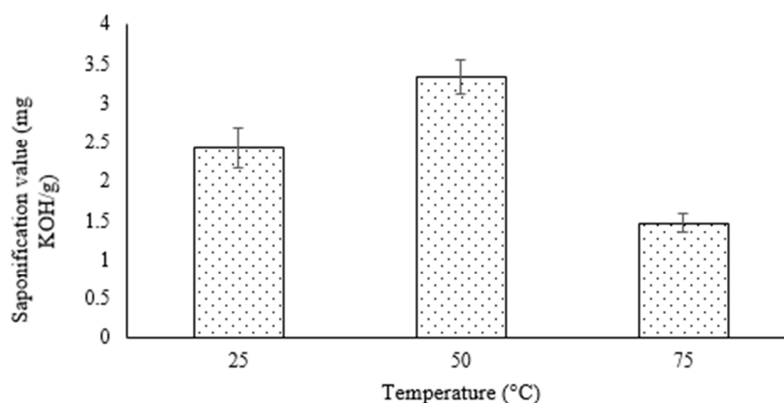
The results of the acid values of the Chicken tallow at varying temperatures as presented in Figure 1 gave lower values than 4 mg/g which implies that, the change in temperatures does not affect the condition of edibility of the Chicken tallow.



**Figure 2.** Free Fatty Acid value of the chicken tallow at varying temperatures.

The result of the free fatty acid (FFA) of the Chicken tallow presented in Figure 2 showed that the FFA increases with increasing temperature. The elevation of temperature during heating process changed the fatty acid content of all samples, thereby affecting chiefly their polyunsaturated fatty acids (PUFAs) fractions [13-15].

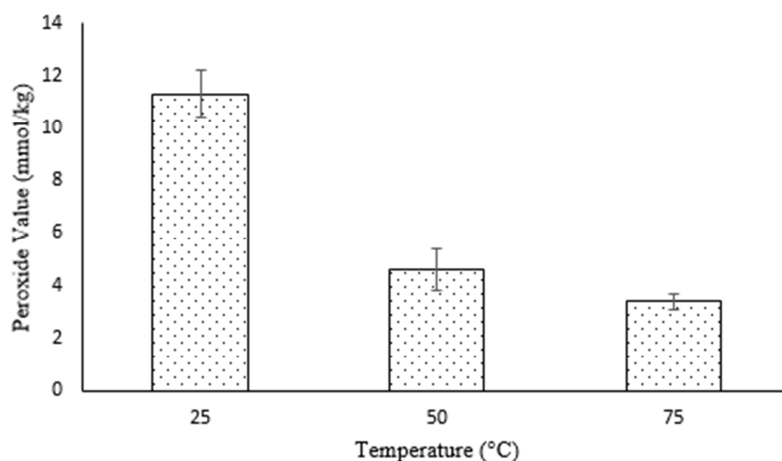
The saponification value (SV) result obtained at varying heating temperatures of the Chicken tallow are presented in 3. The SV increases slightly from 25°C to 50°C heating temperatures and then slightly decreases when the heating temperature attained 75°C, this finding agreed with the previous literatures [4, 6-8].



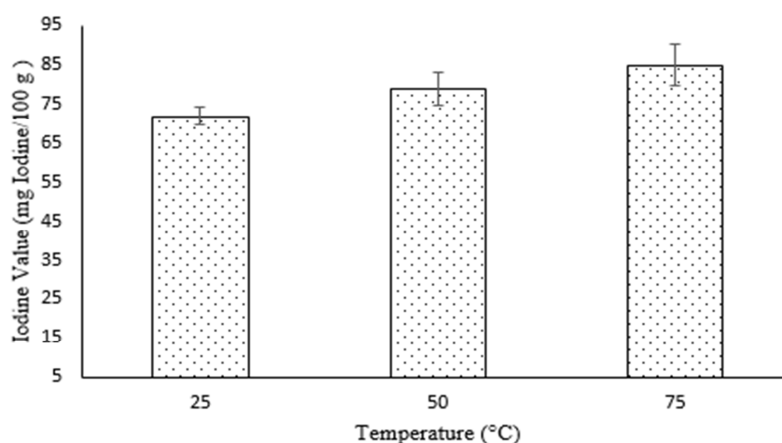
**Figure 3.** Saponification value of the chicken tallow at varying temperatures.

It is worthy to note that, when the SV is high, then the fatty acids average length becomes low, as a result, the mean molecular weight of triglycerides becomes lighter and vice versa. Thus, fats or oils possessing high SV (e.g. coconut and palm oil) are practically more suitable for making soap [9].

The results of the peroxide value (PV) of the Chicken tallow at varying heating temperatures are given in Figure 4. The PV recorded highest value at 25°C and then decreases with further increase in temperature, thus at 75°C, the PV recorded the least result.



**Figure 4.** Peroxide value of the chicken tallow at varying temperatures.



**Figure 5.** Iodine value of the chicken tallow at varying temperatures.

The PV gives information about the primary oxidation state of the Chicken tallow and its tendencies to become rancid. The results in Figure 4 implies that at lower heating temperature, the Chicken tallow is more susceptible to being

damaged by free radicals by way of producing aldehydes and ketones that can cause the tallow to smell musty and rancid [10-12].

The iodine value (IV) results of the Chicken tallow

recorded at varying heating temperatures are presented in Figure 5. It can clearly be seen that, the IV tended to increase with increase in heating temperatures. The IV gives information about the degree of unsaturation in fats, oils and waxes [5, 8, 9].

It is important to note that, the higher the IV, the more unsaturation are present in the fat. The presence of unsaturation indicates the presence of double bonds. The halogens react very readily with the double bond, as such, increase in the heating temperature increases the unsaturation of the Chicken tallow, thereby increases its reaction potentiality with iodine.

## 4. Conclusion

The physicochemical properties of the Chicken tallow tended to vary with varying heating temperatures. The physical properties of the Chicken tallow studied namely moisture content, density and specific gravity all maintained a similar trend by way of decreasing with increase in heating temperatures. On the other hand, the chemical properties tended to show disparities. The acid and iodine values increased with increasing temperature, while the free fatty acid and peroxide values showed decrease with increasing temperatures. The saponification value showed fluctuations in the recorded results suggesting that, at a heating temperature of 50°C, the chicken tallow is more susceptible to soap making.

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