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Investigation of the Effects of Microwave Radiation on the Nutritional Values of Chicken Meat

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Abstract

Microwaves are a form of electromagnetic energy with an electrical origin that can travel both in a vacuum and through matter, ranging from frequencies between 300MHz to 300GHz. They are generated by a tube called a magnetron. A magnetron converts electrical energy to microwave radiation using low-voltage alternating current and high-voltage direct current (Byoung et al., 2000). Foods are essential for human development. They can be cooked using various methods like boiling, blanching, frying, drying, microwaving, etc. Cooking methods affect food nutrients. The nutritional value of chicken cooked with microwave and conventional methods were studied to evaluate the protein, fat, crude fibre, carbohydrate, moisture, ash, and amino acid content. The chickens were 6 weeks old weighing 2.2kg, and 8 weeks old weighing 3.0kg. They were obtained from a local poultry farmer/seller beside Modern Market, Makurdi. They were cooked with a 700w, 2,450 MHz microwave oven. The 6-week-old was microwaved for 23 minutes reaching an internal temperature of 165^{0}F before it was taken out of the microwave and kept aside to stand for about 5 minutes to enhance even heat distribution. The temperature was then measured after standing time and it was 168^{0}F. The 8-week-old chicken was then put through the same process. At 165^{0}F, it was taken out of the microwave. The internal temperature was 167^{0}F after 5 minutes of standing time. Meanwhile, the conventionally cooked chicken was first parboiled for 26 minutes at high heat to an internal temperature of 167^{0}F for the 6 weeks old, and 166^{0}F for the 8 weeks old, after a stand time of 5 minutes. After parboiling, it was then dried over an open flame for 30 minutes (internal temperature 168^{0}F, and 169^{0}F for the 6 and 8 weeks respectively, after 5 minutes of stand time). The uncooked chicken was used as a control sample. The microwaved chicken had more reduction in moisture content compared to the conventionally cooked. Both cooking methods showed an increase (though minimal), in the amino acids except glycine where there was a reduction in the conventionally cooked version. The fibre did not change. The fat content was reduced mostly for the conventionally cooked sample. Ash and protein content differed very slightly for both cooking methods as the conventionally cooked versions showed very little decrease while the microwaved version showed a slight increment. The increment of carbohydrates was a consequence of the difference in concentration of the protein, fat, ash, and moisture. The difference between the microwaved and conventionally cooked chicken was not significant ($p>0.05$).

Keywords: Microwave, Dielectric Properties, Moisture content, Carbohydrate, Protein, Crude fibre, Fat, Ash content, Amino acid

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Introduction

Nutrients like Carbohydrate, protein, fat, ash (minerals), amino acid etc. are essential and beneficial to humans. The amount of heat applied during cooking can cause degradation of nutrients. In other words, the way our foods are cooked can affect their nutritional value either positively or negatively. For instance, boiling vegetables for a short period and using cold water to quickly cool them down (blanching) -helps to slow the loss of vitamins by stopping the action of enzymes (Andress and Harrison, 2006). 50% of Calcium, fibre, and folate are reduced during the boiling of vegetables but we can preserve some of these nutrients if we microwave, grill, or stir-fry the vegetables (Australian Correspondence School, 2022).

Cooking with microwaves is a fairly new concept as it is mostly used for re-heating food that was initially cooked with other cooking sources, but as a result of their fast cooking time, it is becoming more popular for cooking in households (Engineering and Technology History Wiki, 2017; United States Food and Drug Administration, 2017). According to a survey, it is the third most used heating method for domestic needs in the United States (Sloan, 2013). Since microwaves are now used for both cooking and thawing, their safety on our health is still a question to some, as there could be effects on the nutritional value of foods cooked with microwaves compared to other cooking methods due to their interaction with food components.

Foods cooked with microwaves can deteriorate in quality and even be harmful if not well cooked as bacteria in the food might survive (Bill *et al.,* 2012). Due to the complex compositions of foods, the effects of microwaves on food products vary as seen from various studies. That is, microwaves interact differently with different food products.

Valentina and Shivangi (2017) studied microwave heating on proximate composition in fish fillets and fish balls. The results revealed that cooking reduced the moisture content of products with subsequent increases in protein, fat, and ash contents. Ovesen *et al*. (1996) on the effect of microwave heating on vitamins B1 and E, and Linoleic and Linolenic acids; and immunoglobulin in human milk, treated breast milk with (1) conventional heating (in water bath) versus microwave heating; (2) microwave heating at two power levels (30% and 100%); (3) increasing final temperatures; and (4) microwave thawing versus refrigerator thawing. No differences in immunoglobulin and nutrients were demonstrated between microwave and conventional heating. The study showed that microware heating of human milk can be performed without significant losses of examined immunoglobulin and nutrients, provided that final temperatures are below 60^{o}c. Similarly, microwave heating of milk reduced the amount of the amino acid (glutamate and glycine) in the milk as compared to when heated with a water bath conventional heating (Vasson *et al.,* 1998). A 2013 study by Gabor *et al*., showed no major difference between milk and orange juice when compared with microwave and conventional heat treatments except for their colors which were detected by a spectrophotometer as the change in colour was not visible.

Microwave

Microwave ranges between frequencies of 300 MHz and 300 GHz in the electromagnetic spectrum (Decareau, 1985). They propagate in free space at the speed of light. They are related by wavelength and frequency as;

$$\lambda = c/f \qquad 1.0$$

λ is wavelength measured in metres (m), *C* is the speed of light ($3x10^8$m/s) and *f* is frequency measured in hertz (HZ)

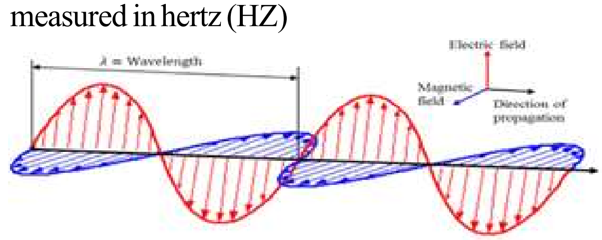

Figure 1: Electromagnetic Wave (Tang, 2015).

Dipolar polarization and ionic conduction are the two important mechanisms in microwave heating of food materials. Water molecules or ions try to align themselves with an electric field moving back and forth leading to energy conversion and subsequently generating heat (Robert, 2007).

Basic Theory of Dielectric Treatment

The dielectric properties are the properties of a material that are important in explaining their interaction with electromagnetic waves. The important dielectric properties parameters of biological materials are the real part of the complex permittivity ($\in'$) or dielectric constant and dielectric loss factor ($\in''$) (Mudgett, 2007). Dielectric constant is the measure of a material's ability to store energy while the loss factor is the material's ability to dissipate energy into heat (Mudgett, 2007). Loss factor in other words is the energy loss as wave passes through the food material. This energy loss is also the amount of energy that can be converted into heat. Therefore, the more the loss factor of the food, the quicker the heating of the food (Geise, 1992; Cemeroglu, 2005; Cao *et al*., 2019) The dielectric constant and loss factor are related thus;

$$\epsilon^* = \in' - j \in'' \qquad 2.0$$

Where j = $(-1)^{0.5}$, indicates a 90^0 phase shift between the real ($\in'$) and imaginary ($\in''$) parts of the complex dielectric constant. The main factors that affect the dielectric properties of food materials are their Frequency, moisture content, temperature, storage time and phase change (Ryynanen, 1995).

The water molecules in the chicken try to align with the electric field of the microwave leading to molecular friction and migrating ions and this movement causes friction which tends to generate heat within the chicken or any other food product. This delivers more heat at a faster rate than conventional heating which relies on conduction and convection to carry heat from the heating source to the food product (Piyasena *et al*., 2003). This is why microwaves cook faster than conventional cooking. Any food with a small amount of water can be heated in a microwave as a result of this mechanism.

Effects of Food Composition on Interaction with Microwave Energy

Food compositions like carbohydrates, proteins, and fat, and their effect on dielectric (heating) properties are crucial as it helps us understand the interaction between the food matrix and electromagnetic fields (Tereshchenko *et al*., 2011).

Carbohydrate: Hydrogen bond and hydroxyl group water interaction play important roles in the dielectric properties of high sugar, maltodextrin, starch hydrolysate, and lactose (Venkatesh and Raghavan, 2004). Dielectric properties of carbohydrates is small at microwave frequencies because it doesn't show dipole polarization at these frequencies (Zhang *et al*., 2007). There is a decrease in dielectric properties due to a decrease in water polarization as a result of starch bonding with water molecules via hydrogen bonding (Bircan and Barringer, 2002).

Protein: Dielectric properties here depend upon protein side chains which may be non-polar with decreasing order of alamine, glycine, leucine, isoleucine, methionine, phenylalanine, and valine (Shukla and Anantheswaran, 2001). As protein content increases, dielectric constant and loss factor increase. The same increase was also reported for milk and soybean protein (Zhu, 2015).

Fat: The dielectric properties of fat are very low compared to water. Fat has a non-polar molecule which results in a low interaction with polarizing electromagnetic waves thereby making fat inert (not generally reactive) in the microwave field (Zhang *et al*., 2007). This indicates that meat with higher fat content has lower dielectric properties than meat with lean tissue. Additionally, an increase of fat content reduced the dielectric constant and loss factor because this increase diluted the water ratio within the food system and resulted in the lower dielectric constant and loss factor (Zhu, 2015). This increase in fat content other than reducing interaction between food and electromagnetic waves, also decreased thermal conductivity (Sablani, 2017).

Salt: Salt is an ionic crystal that is responsible for ionic conduction. Salt decreases the dielectric constant but increases loss factor. Decrease in dielectric constant is due to water within the food system which reduces the free water available for polarization, whilst increase in loss factor is because of increased charged particles in the system.

MATERIALS AND METHODS

Sample collection and preparation

Two locally grown chickens (broilers) were obtained from a local poultry farmer/seller beside Modern Market, Makurdi. The chickens were 6 weeks, and 8 weeks old. The 6 weeks old weighed 2.2kg while the 8 weeks old weighed 3.0kg. The chickens were butchered and divided into 8 cuts for each of the chicken. That is, two drumsticks, two thighs, two wings, and two breasts. The head, neck and legs were not used in this study.

The chicken parts were then washed thoroughly. The 8 cuts from the 6 weeks old were separated into two portions (4 pieces of chicken each). One portion for conventional cooking (parboil then roast), the other portion for microwaving, and the 8 cuts from the 8 weeks old were also separated into two portions (4 pieces of chicken each). One portion is for conventional cooking (parboil then roast), and the other portion is for microwaving. Spices and salt were sprinkled on the cut pieces and mixed thoroughly. The first part of the 6-week-old chicken was parboiled in a pot using a gas cooker for 26 minutes at high heat. The internal temperature was measured to be 167^0F using a food thermometer after a standing time of 5 minutes. This parboiled chicken was then dried over a locally made charcoal stove. This process lasted for 30 minutes and internal temperature was measured to be 168^0F after 5 minutes of stand time. The same process was applied for the 8-week-old chicken with internal temperature being 166^0F and 169^0F for parboiled and dried respectively after a stand time of 5 minutes.

The portion to be microwaved for the 6-week-old was put on a ceramic plate, evenly arranged for uniform heating but it was not covered for direct exposure to microwaves, and was placed in a 700W, 2450MHz microwave oven. It was then let to cook for 23 minutes (halfway through, the chicken was flipped on its other side for even heat distribution). It was brought out every 10 minutes for the internal temperature to be measured using a food thermometer. When the internal temperature was 165^0F, it was taken out of the microwave and kept aside to stand for about 5 minutes to enhance even heat distribution. The temperature was then measured after standing time and it was 168^0F. The 8-week-old chicken was then put through the same process. At 165^0F it was taken out of the microwave. Internal temperature was 167^0F after 5 minutes of standing time. Temperature measurement is to ensure the chicken is not over cooked or under cooked, as the temperature that poultry is considered safe for consumption is a minimum of 165^0F and above (United States Department of Agriculture, 2013). Since the temperature of the chicken continues rising even after being brought out the heat source, it was a bit difficult to maintain a uniform cooked temperature.

The prepared samples (both conventionally cooked and microwaved) chicken, were packaged in clean separate plastic containers and taken to the lab to measure their protein, crude fiber, ash, fat, moisture content, and carbohydrates using AOAC (Association of official analytical chemist) method (2005) and amino acid was determined using the method of Sparkman *et al*., (1958).

Determination of protein

Protein content was determined using Kjeldahl method, according to the procedure of AOAC. Concentrated hydrogen tetraoxosulphate (vi) H_2SO_4 (12ml) and two tablets of selenium catalyst were put into a Kjeldahl digestion flask containing 1g of the sample. The flask was placed in the digester in a fume cupboard, switched on and digested for 45 minutes to obtain a clear, colourless solution. The digest was distilled with 4% boric acid, and 20% sodium hydroxide (NaOH) solution was automatically metered into it in the distillation equipment until distillation was complete. The distillate was then titrated with 0.1mol/L HCL until a violet color is formed, indicating the end point. A blank was ran under the same condition as with the sample. Total protein content was then calculated using the equation 3.0.

$$Protein = [titre\ value\ of\ sample - blank\ titre] \times 0.01 \times 14.007 \times 6(volume\ of digested\ sample) / 1000\ (volume\ for\ distillation) \times weight\ of\ sample \qquad 3.0$$

Determination of Ash content

Ash content refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a food sample. Determining ash content of a food is part of proximate analysis for nutritional evaluation and it is an important quality attribute for some food ingredients (Ismail, 2017). Two grams of samples were weighed into well incinerated crucibles and then ashed in a muffled furnace at $600°C$ for 3 hours. The ash content was calculated using the equation 4.0.

$$Ash\ content\ (\%) = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad 4.0$$

$$where\ W_1 = weight\ of\ empty\ crucible$$

$$W_2 = weight\ of\ crucible + food\ before\ drying$$

$$W_3 = weight\ of\ crucible + ash$$

Determination of moisture content

About 5g of each sample was weighed into petri dishes of a known weight. They were transferred into desiccators immediately to prevent absorption of moisture from the atmosphere. They were then dried in the oven at $105 \pm 1°C$ for 4 hours. The samples were then cooled in the desiccator and re-weighed. The moisture content was calculated applying equation 5.0 below.

$$Moisture\ content\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad 5.0$$

$$Where\ W_1 = weight\ of\ empty\ crucible$$

$$W_2 = weight\ of\ crucible + food\ before\ drying$$

$$W_3 = weight\ of\ crucible + sample\ after\ drying$$

Determination of fat content

About 2g of each sample was weighted on a chemical balance and wrapped in a filter paper. It was then placed in an extraction thimble. Extractor was cleaned, dried in an oven and cooled in desiccators before weighing. Then, 25ml of N-hexane was measured into a round bottom flask. The fat content was extracted with this solvent. After extraction, the solvent was evaporated by drying in the oven. The flask and its content was cooled in a desiccator and weighed for fat content. The percentage fat content was calculated using the equation 6.0.

$$Fat\ content\ (\%) = \frac{weight\ of\ fat\ extracted}{weight\ of\ food\ sample} \times 100 \qquad 6.0$$

Determination of crude fibre content

About 5g of each sample was weighed into a 500ml Erlenmeyer flask and 100ml of trichloroacetic acid digestion reagent was added. It was boiled and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little, and filtered through a 15cm whatman paper. The residue was washed with hot water, stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105^0C. After drying, transferred to a desiccator and weighed (W_1) when cool. It was then ashed in a muffle furnace at $500°C$ for 6 hours, allowed to cool and re-weighed ($W_{2)}$. The percentage fiber was calculated as shown in equation 7.0.

$$Fibre\ (\%) = \frac{W_1 - W_2}{W_0} \qquad 7.0$$

$$Where\ W_1 = weight\ of\ crucible + fiber + ash$$

$$W_2 = weight\ of\ crucible + ash$$

$$W_0 = dry\ weight\ of\ food\ sample$$

Carbohydrate content determination

The carbohydrate content was obtained from the difference between the protein, ash, moisture and fat content from one hundred.

$$Carbohydrate\ (\%) = 100 - \%(protein + fat + ash + moisture\ content) \qquad 8.0$$

Amino acid determination

The amino acid profile of the sample was determined using the method of Sparkman *et al.*

1958. Each sample was dried to a constant weight, hydrolyzed, defatted and evaporated in a rotary evaporator. The hydrolysate was dispensed into a Technicon sequential multisample amino acid analyzer (TSM). The TSM is designed to separate and analyze free, acidic, neutral, and basic amino acids of the hydrolysate. Chromatography obtained would show amino acid peaks corresponding to the magnitude of their concentrations. The chemical score of indispensable amino acid (IAA) was calculated using FAO recommended amino acid scoring patterns (mg g^{-1} protein requirement).

Statistical analysis

All experiments were done in duplicate and the data generated was evaluated statistically by Analysis of Variance (ANOVA). Chi square test was used for analyzing and comparing variation between the groups and means with $(p > 0.05)$ considered as non-significant.

Results

The results for moisture, fat, protein, fibre, carbohydrate, ash, and amino acid content were obtained and have been presented in Table 1 for fresh, cooked and microwaved chicken. Table 2 was the comparison of the amount of difference noticed between the fresh vs. cooked vs. microwaved for proximate, Table 3 was the comparison of the amount of difference noticed between the fresh vs. cooked vs. microwaved for amino acids. The margin of this difference indicated the implications of microwave cooking on the nutritional value of the chicken meat compared to the conventionally cooked version. A large margin means a significant change while a small difference shows no significant change. Table 4, 5, 6, and 7 are statistical data for fresh, cooked and microwaved sample which indicated no significance or difference in content change for all three categories. Figure 2 and 3 were chart representations of proximate results, and amino acids results respectively.

Table 1: Proximate composition (%) and amino acid (mg/100g protein) profile of samples

SAMPLES	A FRESH	B COOKED	C MICROWAVE
MOISTURE	7.812	5.381	4.550
ASH	2.823	2.198	2.977
FAT	15.468	4.880	10.914
FIBER	0.081	0.084	0.087
PROTEIN	23.910	23.754	26.880
CHO	49.903	63.700	54.590
Lysine	4.170	4.830	5.825
Methionine	2.620	2.760	3.650
Threonine	4.655	5.130	5.830
Isoleucine	4.040	4.130	4.780
Leucine	8.930	9.315	12.410
Phenylalanine	5.370	5.600	5.810
Valine	4.960	5.515	7.815
Tryptophan	5.260	5.630	5.885
Histidine	3.855	4.040	4.540
Arginine	6.320	6.840	7.130
Serine	5.450	7.280	8.150
Cysteine	2.980	3.770	3.955
Tyrosine	6.815	7.370	8.125
Alanine	4.150	6.540	7.555
Aspartic acid	8.345	8.815	9.650
Glutamic acid	9.110	9.390	10.455
Glycine	6.050	5.990	9.260
Proline	4.280	4.350	5.550

Table 2: Difference in proximate content change for fresh vs. cooked vs. microwaved samples

SAMPLES (%)	FVC (%)	FVM (%)	CVM (%)
MOISTURE	2.430	3.260	0.830
ASH	0.620	0.150	0.770
FAT	10.580	4.550	6.030
FIBER	0.003	0.006	0.003
PROTEIN	0.150	2.970	3.120
CHO	13.790	4.680	9.110

Key: **FVC** = Fresh versus cooked sample
FVM = Fresh versus microwaved sample
CVM = Cooked versus microwaved sample

Table 4: Case processing summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
SAMPLES * AFRESH	24	100.0%	0	.0%	24	100.0%
SAMPLES * BCOOKED	24	100.0%	0	.0%	24	100.0%
SAMPLES * CMICROWAVED	24	100.0%	0	.0%	24	100.0%

Table 3: Difference in amino acids content change for fresh vs. cooked vs. microwaved samples

SAMPLES (mg/100g)	FVC (mg/100g)	FVM (mg/100g)	CVM (mg/100g)
Lysine	0.660	1.650	0.990
Methionine	0.140	1.030	0.890
Threonine	0.470	1.170	0.700
Isoleucine	0.090	0.740	0.650
Leucine	0.380	3.480	3.090
Phenylalanine	0.230	0.440	0.210
Valine	0.550	2.850	2.300
Tryptophan	0.370	0.620	0.250
Histidine	0.180	0.680	0.500
Arginine	0.520	0.810	0.290
Serine	1.830	2.700	0.870
Cysteine	0.790	0.970	0.180
Tyrosine	0.550	1.310	0.750
Alanine	2.390	3.400	1.010
Aspartic Acid	0.470	1.300	0.830
Glutamic Acid	0.280	1.340	1.060
Glycine	0.060	3.210	3.270
Proline	0.070	1.270	1.200

Key: **FVC** = Fresh versus cooked sample
FVM = Fresh versus microwaved sample
CVM = Cooked versus microwaved sample

Table 5: Sample 'A' Fresh (Statistical Analysis/Chi-Square Test)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.520E2[a]	529	.237
Likelihood Ratio	152.547	529	1.000
N of Valid Cases	24		

a. 576 cells (100.0%) have expected count less than 5. The minimum expected count is .04.

Table 6: Sample 'B' Cooked (Statistical Analysis/Chi-Square Test)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.520E2[a]	529	.237
Likelihood Ratio	152.547	529	1.000
N of Valid Cases	24		

a. 576 cells (100.0%) have expected count less than 5. The minimum expected count is .04.

Table 7: Sample 'C' Microwave (Statistical Analysis/Chi-Square Test)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.520E2[a]	529	.237
Likelihood Ratio	152.547	529	1.000
N of Valid Cases	24		

a. 576 cells (100.0%) have expected count less than 5. The minimum expected count is .04.

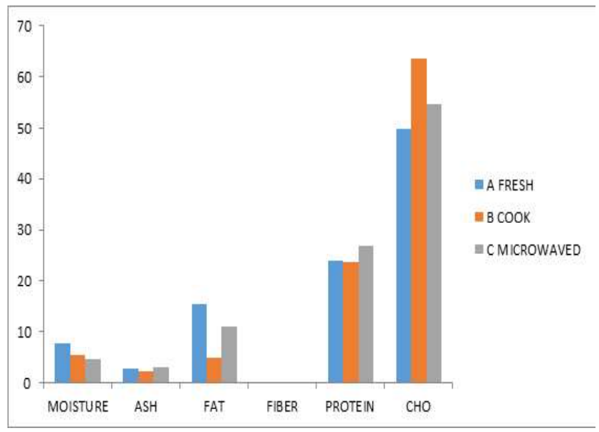

Figure 2: Chart representation of proximate composition results

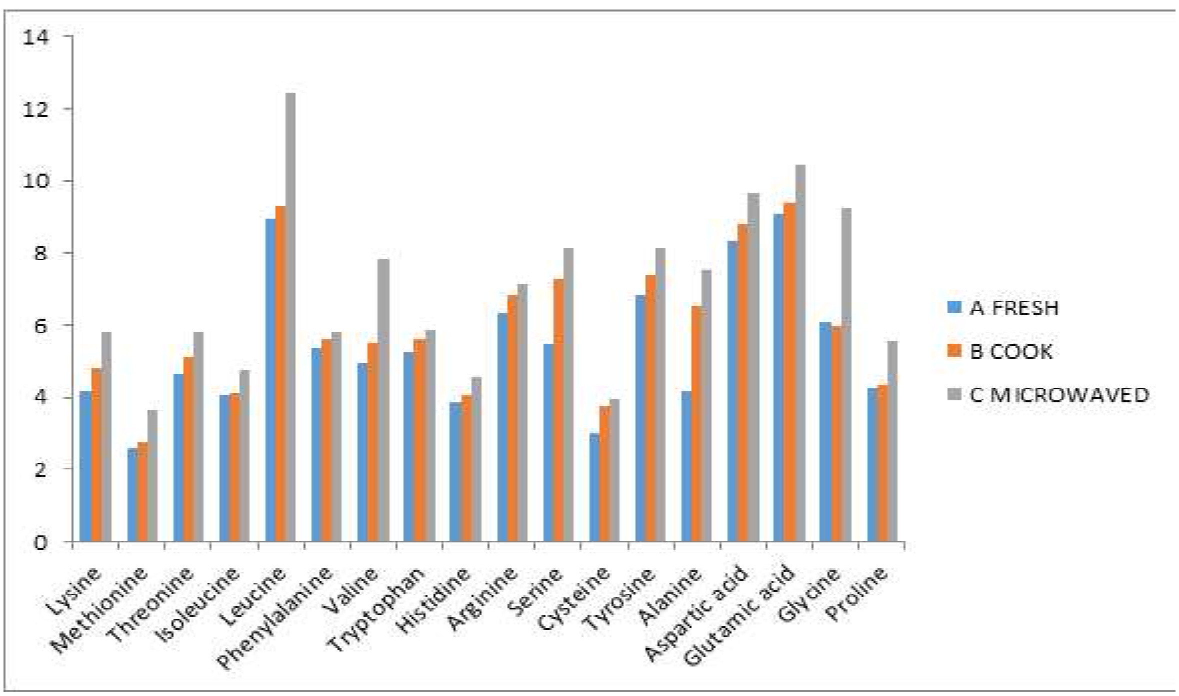

Figure 3: Chart representation of amino acids profile results

Discussions

Moisture content varied between all three categories, with the highest content noticed on the fresh (raw) chicken (7.812%), followed by the cooked (5.381%), and the least moisture was recorded for microwaved chicken (4.550%). The most drop in moisture was between fresh and microwaved chicken (3.260%) as seen in Table 2. Between the cooked and microwaved sample, the decline was the least (0.830%). These results as reflected by ANOVA and chi-square tests showed that the differences are non-significant $(p > 0.05)$. Since the table of value (x^2 tab.) at 0.05 probability was greater than the calculated chi-square value (x^2 cal.), the null (H_0) hypothesis (no significant difference) is accepted. There was a slight reduction in the moisture of the microwaved sample compared to the conventionally cooked (parboiled then dried) chicken and this would be accounted to more agitation of the water molecules and ions (from salt added) in the microwaved chicken since microwave has a very high dielectric property with moisture (dipolar polarization) and ionic conduction (Robert, 2007). This reduction was consistent with Marimuthu *et al*. (2011), where compared to raw snakehead fish, each cooking method reduced moisture content.

Ash content being the total mineral contents like potassium, calcium, iron, copper, magnesium etc. in foods, showed a drop to 2.198% from 2.823% of the control group (fresh chicken) for the conventionally treated, while the microwaved samples ash content increased slightly (2.977%) due to reduced moisture content and processing method of microwaved chicken. Reduction of moisture causes increase in ash (Marimuthu *et al*., 2011). Natural foods have a lower ash content compared to more processed foods (Precisa, 2022). Although the conventionally processed chicken did not show an increase in ash with a reduction of moisture and, this was because the minerals during parboiling absorbed water and got diluted (Onyeike and Oguike, 2003) by the absorbed cooking water or leached out. The margin between the conventional and microwaved chicken was just 0.770%. This effect was statistically non-significant as shown by the chi-square tests (tab. cal., so is accepted).

Fat in fresh chicken was 15.468%. There was reduction of fat in both microwaved and conventionally cooked chicken but the conventionally cooked chicken had the lowest fat (most reduction) due to leaching into the water during parboiling (4.880%), with the microwaved sample retaining more (10.914%). The difference between the fat in the conventional and microwaved chicken is 6.030% as seen in Tale 2. There was about a 70.55% retention of fat by the microwaved sample and it corresponds to the findings in the literature by Zhang *et al*. (2013) where 70.55% of chicken fat was retained after heating in a microwave. This also corresponds with a previous study by Xu *et al*., 2020 where the retention rate of unsaturated fatty acids was higher in microwaves than in conventional cooking. For conventionally cooked (Parboiled then dried) samples, the significant drop in fat resulted from lipid evaporating with water and higher oxidation than microwave treatment. This corresponds to findings by Duan *et al*., 2011, and McCance and Shipp, 1933. Although the conventionally cooked method had a significant effect on the fat, microwaves effect on the fat content of the chicken was not significant considering the difference in margin of the values.

Fibre content had very little to no change at each processing method considering our table. Fibre content of the control group (fresh chicken) was 0.081%, 0.084% for the conventionally cooked and 0.087% when microwaved (Table 1). The fibre noticed is crude fibre which is a residue hence their values being almost insignificant. These results show no significance statistically. The variation between the conventionally cooked and microwaved was just 0.003%.

The protein content between fresh, conventionally cooked, and microwaved samples as seen in Table 1, indicated little to no variation (%) between the fresh sample and cooked sample reading, 23.910 and 23.754, respectively. The difference in change was just (0.150) (See Table 2). There was, on the other hand, an increase in the protein content of the microwaved sample (26.880). The difference in change between the fresh and microwaved sample was about 3% which was same with the conventionally cooked and microwaved chicken. The increase seen was as a result of microwave's interaction with protein causing protein unfolding and aggregation which can expose more amino acids (Gomaa *et al*., 2013); (Kai *et al*., 2021). Gomaa *et al*. (2013) reported protein aggregated extensively when microwave treatment was applied compared to when conventionally heated.

Carbohydrate value was more in the cooked sample than the microwaved; 63.700% and 54.590% respectively. This was because of the level of concentration of the other proximate values in both cooking. The fresh products and the microwaved products had about 5% increment, and the difference between the conventionally cooked and microwaved sample was about 9% increment. These are statistically not significant considering our statistical analysis data.

The amino acids varied for all three groups with the highest being the microwaved group. The trend for all amino acids showed an increase from the control group except for glycine where the increase was only noticed on the microwaved version, as the cooked version had a very slight decrease (see Table 1). The microwaved samples had the most increment compared to the conventionally cooked with the highest increment being leucine (3.480%), followed by alanine (3.400%), and glycine (3.210%). Although the variations were not significant as seen in our statistical data. Excitation of molecules during microwave interaction, rejuvenates and agitate leading to more exposure of amino acids.

The implication of these results was that, microwaves effect on the nutritional value of the chicken was not significant as the margin between the conventionally cooked and microwave cooked samples were small.

Conclusion

We have determined the change in the proximate and amino acid values of chicken meat and observed no significant alteration in nutrition of chicken cooked with microwave compared to boiling and drying over open flame. The microwave radiation does not destroy the food systems but rather retains almost the same standard with our already used to conventional cooking method. In other words, microwaves did not have a significant effect on nutritional contents of chicken meat.

Recommendations

Microwaves should be used in preparing chicken as it has no significant effect on the nutritional value and is a better source of energy for drying compared to coal. Temperature, time, weight, age, and type of chicken, are variables that should be considered while microwaving chicken. Microwave treatment can be combined with conventional cooking methods or used interchangeably for specific nutritional targets. Example, fat content was preserved more under microwave compared to the conventionally cooked, so microwave can be used if we are looking to preserve the fat in chicken diet, or use conventional for reduced fat.

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