Research Article

Sorption Isotherm of Oven-Cooked Chicken Salami Determined at Two Different Temperatures (20⁰C and 25⁰C)

Alamuoye Nathaniel Olu[1*], Alamuoye Oluwatoyin Folake[2] and Adetunji Ruth Oluwatobi[1]

[1]Food Science and Technology Department, School of Agriculture and Agricultural Technology, Bamidele Olumilua University of Education Science and Technology, Ikere Ekiti, Nigeria.
[2]Animal Science Department, Faculty of Agricultural Science, Ekiti State University, Ado Ekiti, Nigeria

*alamuoye.nathaniel@bouesti.edu.ng

ABSTRACT

The research assessed the sorption isotherms of oven-cooked chicken salami under two different temperatures. Sorption determination of water activity and monolayer moisture was determined by gravimetric methods of using salt solutions to create the required relative humidity. Oven-cooked chicken salami was prepared from skinless and boneless breast muscle of broiler chicken of 8 weeks of age according to standard procedure. Results showed that the equilibrium moisture content ranged from 23.26 to 70.66 for oven-cooked chicken salami experimented at 20⁰C while at 25⁰C, the equilibrium moisture content was between 20.35 to 76.75. Water activity and monolayer moisture of oven-cooked chicken salami determined at 20⁰C were found to be lower in oven-cooked chicken salami than that of oven-cooked chicken salami experimented at 25⁰C while monolayer moisture of oven-cooked chicken salami determined at 20⁰C was relatively higher than the oven cooked chicken salami at 25⁰C. The findings of this study suggest that the lower monolayer value observed indicates that chicken salami stored at 25°C will exhibit a reduced ability to absorb moisture compared to that stored at 20°C. This implies that the chicken salami will demonstrate greater stability, as it will absorb less moisture, ultimately contributing to an extended shelf life by minimizing the risk of moisture-related biodegradation. The study concluded that the findings of this research could be used to extend the shelf-life of this product and predict appropriate packaging materials for storage and distribution across borders.

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1. Introduction

Delving into sorption isotherms for eateries such as chicken salami baked in ovens, plays an essential part in deciphering the balance of moisture levels and how the item interacts with its surroundings (Bhattarai *et al.,* 2020). Exploring these isotherms under various degrees reveals crucial viewpoints on how water molecules are absorbed and released within the food's structure (Xia *et al*., 2023). This intelligence is vital for upholding the qualities of the product, stability on shelves, and sensory characteristics throughout its storage and handling phases.

The significance of sorption isotherms within the realm of food science, especially when examining oven-baked chicken salami, rests in their capability to shed light on the dynamics of drying and storage between food elements and surrounding environmental influences (Aguirre *et al*., 2021; Hay *et al.,* 2022). Grasping the essence of sorption mechanisms proves vital for ascertaining factors like moisture levels, stability over time on shelves, and the superior quality of meat items through periods of storage and culinary preparation.

The meat products that have been examined for their sorption isotherms include dry ground meat (Aktaş, 2022) and dry red tilapia viscera silage (Echavarría *et al.*, 2021). Owing to the intricate characteristics of sorption isotherms in food items such as chicken salami baked in an oven, it becomes imperative to explore both the definition and varieties of sorption isotherms for precise comprehension of how moisture interacts with the product (Shimizu & Matubayasi, 2023). Sorption isotherms elucidate the balance between a product's moisture levels and ambient water activity (Fredriksson & Thybring, 2018). There exist several sorption isotherm variants, including Type I, II, and III; each demonstrates unique patterns of moisture interaction contingent on the composition and structural attributes of the food item (Vitázek & Havelka, 2018; Echavarría *et al.,* 2021). Grasping these divergent types of sorption isotherms proves fundamental in forecasting how well oven-baked chicken salami maintains its quality and shelf-life over periods.

Thorough investigations into sorption isotherms help refine formulation processes, manage moisture transitions, and lift the standard grade of consumables like oven-cooked chicken salami significantly (Slimane *et al.,* 2022). Grasping this broad spectrum, insight into sorption intricacies stands as critical to guaranteeing safety with foods. When delving into the realm of creating chicken salami through oven cooking, a pivotal point to note is the capacity for diminishing pathogens and advancing food safety throughout its manufacture (Senna *et al.,* 2021). Exploration into temperature-varied sorption isotherms concerning chicken salami cooked in ovens seeks to enlarge existing scholarly works by presenting meticulous breakdown regarding moisture exchanges, facilitating superior governance over trait products and duration before spoilage occurs.

Understanding the moisture sorption tendencies of food items, such as oven-baked chicken salami, is significantly dependent on recognizing how sorption isotherms are affected. Numerous elements such as monosaccharide content, pH levels, and temperature, play a role in shaping the characteristics of sorption isotherms (Wang *et al.,* 2021; Fouad *et al.,* 2024; Arslan & Turhan, 2022). The polysaccharides present in foods impact their adsorption qualities due to their surface area and functional groups, with an increase in polarity potentially raising the enthalpy of adsorption.

Oven baking has been deemed a superior technique for preparing cupcakes compared to air frying, with the incorporation of green tea additives mitigating the disadvantages associated with air frying (Ngan *et al.*, 2023). In contrast, oven roasting has been identified as the optimal cooking method for rabbit meat, attributed to its health advantages and favourable consumer reception, successfully delivering both tenderness and juiciness (Abdel-Naeem *et al.*, 2021). An in-depth examination of the literature currently available on the topic of chicken salami baked in an oven uncovers significant deficiencies in understanding that need further investigation. Research efforts like those aimed at controlling Salmonella in aged meats and crafting dietary programs for young ones offer crucial perspectives on matters of health safety and pedagogy. Yet, there's a conspicuous absence concerning the study of moisture absorption patterns and stability levels at diverse temperatures, specifically related to oven-baked chicken salami. This lack of information regarding how this peculiar food item manages moisture uptake and its points of balance in relation to relative humidity is a significant lacuna in grasping how it maintains its condition over time and keeps its desirable features intact. Tackling such unexplored territories will not only deepen our grasp on the behavioural tendencies of this commodity but also push forward more refined methodologies for upkeep and manufacturing enhancements, bringing advantages across borders to end-users as well as those engaged in culinary production.

This knowledge gap is particularly significant as the moisture content of chicken salami directly affects its quality attributes, including texture, flavour, and shelf-life. Therefore, a comprehensive understanding of the sorption isotherms of oven-cooked chicken salami is essential for optimizing its processing techniques and storage conditions. This research aims to bridge this gap by investigating the sorption behavior of oven-cooked chicken salami under varying temperatures to determine its water activity and monolayer moisture content.

2. Materials and Methods

2.1 Procedure for the Preparation of Oven-Cooked Chicken Salami

750 grams of skinless and boneless breast muscle of broiler chicken of 8 weeks of age were procured from Bolab farm, Ado Ekiti, Nigeria. These were chopped and ground with USHA Mixer Grinder, MG2053N, India. All dry non-meat ingredients (Table 1.0) were introduced to the ground chicken breast, blended evenly, placed in a plastic film bag, and allowed to marinate for 3 h in a refrigerator at 7°C. After marination, the raw mixture was rolled into a long round shape of 12 cm long and 60mm in diameter, 55 g by weight each, and covered with aluminium foil lined with baking paper. The rolled and wrapped chicken samples were arranged separately on the flat oven tray and set into a preheated oven (Thermo Scientific Precision Thermo 3510 Compact Gravity Convection Oven, Model PR305225G, 48.2 litres, USA) at 150°C for 60 minutes to an internal temperature of 85°C with the aid of Stainless Steel Probe Digital Thermometer, China. This procedure was repeated two more times to obtain three replicates for the sorption experiment.

Table 1 Chicken salami non-meat ingredients composition

Ingredients	Composition (G/100g)
Coriander Leaves	3.0
Ginger paste	2.5
Garlic pastes	2.5
Cameroon Pepper	3.0
Chili pepper	3.5
Maggi Seasoning	2.5
Guava leaf Powder	10.0
Bitter leaf Powder	10.0
Curry Powder	4.0
Cinnamon Powder	3.0
Oregano Powder	5.0
Salt	1.0
Egg white	50.0
Total	100

2.2 Techniques of Adsorption

The Moisture content at the equilibrium of chicken salami was determined at 20°C and 25°C using the static gravimetric method (Mallek-Ayadi *et al.,* 2020). Five grams of oven-cooked chicken salami were placed in a plastic mesh bag, over the saturated salt solutions contained in glass jars (UL 180mm). The tightly closed jars were placed in a temperature-controlled cabinet (Lab. Incubator, DNP-9022-1A, England). The samples were weighed daily until a constant weight was reached. Equilibrium moisture content was determined by drying the samples at 105°C for 24 h. All the experiments were conducted in triplicate. Ten saturated salt solutions were prepared to create the needed relative humidities for the determination of equilibrium moisture content at 20°C and 25°C. The selected temperatures were determined based on the fact that in developing nations, meat products are typically stored at ambient temperatures. This approach will facilitate the examination of how temperature fluctuations within the ambient environment influence sorption behavior. The salt solutions used were as reported in Table 2 (Greenspan, 1977).

Table 2 Salt solution for experiment at 20°C

Salt	Aw (20^0C)
Sodium Hydroxide	0.089
Lithium Chloride	0.113
Potassium Acetate	0.231
Magnesium Chloride	0.331
Potassium Carbonate	0.462
Sodium Bromide	0.591
Potassium Iodide	0.699
Ammonium Chloride	0.792
Potassium Chloride	0.851
Potassium Nitrate	0.946

Table 3 Salt solution for experiment at 25°C

Salt	Aw (25^0C)
Cesium Fluoride	0.043
Lithium Chloride	0.113
Potassium Acetate	0.225
Magnesium Chloride	0.328
Potassium Carbonate	0.432
Sodium Bromide	0.576
Potassium Iodide	0.689
Sodium Chloride	0.753
Potassium Chloride	0.843
Potassium Sulfate	0.973

2.3 Quantification of Equilibrium Moisture Content (EMC)

$$\mathrm{EMC} = \frac{We}{Wi}(\mathrm{Mi}+1)-1 \quad \text{(Tantala } \textit{et al.,} \text{ 2019)} \qquad (1)$$

where *We* is the equilibrium weight of the sample (g), *Wi* is the initial weight of the sample (g), and *Mi* is the initial moisture content of the sample (g)

2.4 Monolayer Moisture and Water Activity Determination

GAB equation was rearranged into a second-degree polynomial for the determination of monolayer moisture and water activity and monolayer moisture value (Van Den Berg, 1985).

$$\text{GAB Equation} = = \frac{M}{Mm} = \frac{ABaw}{(1-Baw)(1-Baw+ABaw)} \qquad (2)$$

2.5 Statistical Analyses

IBM SPSS Statistics 20 was used to conduct the statistical analysis, mainly one-way ANOVA with post hoc multiple comparisons with Tukey at an alpha level of 0.05 (Mehta *et al.*, 2011).

3. Results and Discussion

Equilibrium moisture contents which were significantly different ($p<0.05$), ranged from 23.26% to 70.66% at 20°C and from 20.35% to 76.75% at 25°C across the same range of water activity (0.089 to 0.946) (Table 4).

Table 4 Sorption Isotherm of Oven-Cooked Chicken Salami experimented at different temperatures

Water activity (a_w) (20^0C)	Adsorption		Water activity (a_w) (25^0C)	Adsorption	
	EMC (%) Mean±SD	a_w/M		EMC (%) Mean±SD	a_w/M
0.089	23.26±0.020[a]	0.0038	0.043	20.35±0.050[a]	0.0021
0.113	28.53±0.030[b]	0.0047	0.113	25.62±0.040[b]	0.0044
0.231	30.56±0.260[c]	0.0076	0.225	27.65±0.070[c]	0.0081
0.331	32.24±0.040[d]	0.0103	0.328	29.33±0.050[d]	0.0111
0.462	43.13±0.150[e]	0.0107	0.432	40.22±0.060[e]	0.0107
0.591	59.02±0.140[f]	0.0100	0.576	56.11±0.110[f]	0.0103
0.699	59.93±0.080[g]	0.0117	0.689	57.02±0.090[g]	0.0121
0.792	64.88±0.140[h]	0.0122	0.753	58.97±0.150[h]	0.0127
0.851	69.54±0.140[i]	0.0122	0.843	66.63±0.070[i]	0.0127
0.946	70.66±0.160[j]	0.0134	0.973	67.75±0.070[j]	0.0144

Mean ± standard deviation, means with different superscripts on the same coloumn are significantly different ($P<0.05$). EMC = M = Equilibrium Moisture

The fitness of the curve for the oven-cooked chicken salami determined at 20^0C and 25^0C were 0.927 and 0.909 respectively, which indicate a small magnitude of experimental error (González-López *et al.*, 2021). The equation of lines for the sorption isotherm and adsorption curves are shown in Figures 1 and 2, while Figure 3 shows the chicken salami after production.

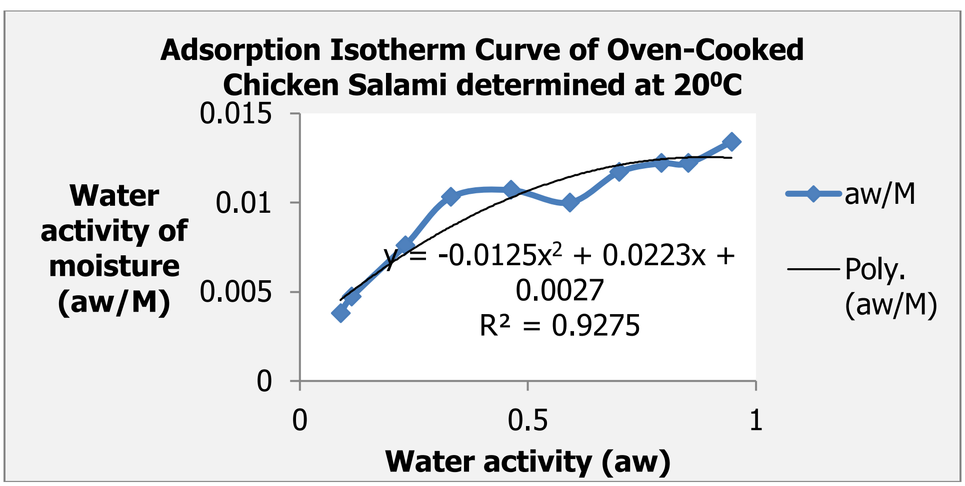

Figure 1 Adsorption Isotherm Curve for Oven-cooked Chicken Salami at 20^0C

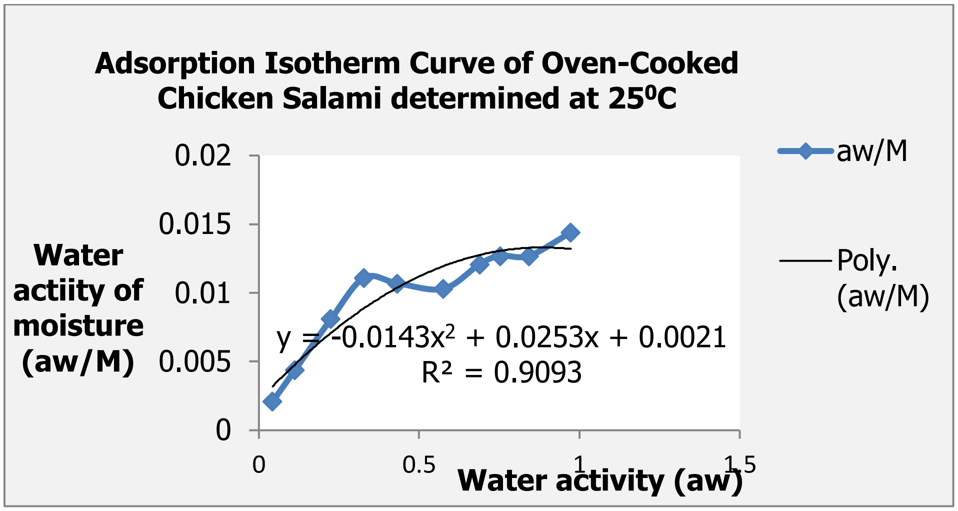

Figure 2 Adsorption Isotherm Curve for Oven-Cooked Chicken Salami at 25^0C

Figure 3 Chicken salami product

Table 5 Analysis of sorption data of oven-cooked chicken salami according to GAB Model

Product sample	Water activity (a_w)	Monolayer value (Mo) (g H_20/g Solid)	R^2
Oven-cooked chicken salami determined at 20^0C	0.331	41.53	0.927
Oven-cooked chicken salami determined at 25^0C	0.309	36.84	0.909

Water activity and monolayer moisture of oven-cooked chicken salami determined at 20^0C were found to be 0.331 a_w and 41.33 g H_2O /g solid respectively. In comparison, oven-cooked chicken salami experimented at 25^0C was 0.309 a_w and 36.84 g H_2O / g solid apiece (Table 5).

The results obtained from the investigation on the effects of temperature on moisture sorption isotherm behaviours of oven-cooked chicken salami show that key parameters such as equilibrium content, product water activity, and monolayer moisture were influenced (Betiol *et al*., 2020; Alhussaini *et al*., 2020). Increased temperatures lead to reduced absorption of moisture, as water molecules may be exhibiting greater mobility within the chicken salami. Additionally, food materials generally tend to retain less water vapor at elevated temperatures. This position agrees with the findings of Liu *et al*. (2023).

Analysis of the sorption isotherm of oven-cooked chicken salami at diverse thermal conditions showcases a pivotal dimension within the realm of scientific inquiry related to food, especially in grasping how this favoured meat item behaves concerning moisture absorption under this condition. Insights into the equilibrium content of moisture in chicken salami under different thermal environments offered precious understanding relevant to its preservation and condition while in storage (Choi, 2018). By dissecting outcomes from experiments on isotherm sorption performed across the two degrees of heat, scholars are equipped to deduce how temperature variations affect water molecule dynamics inside the matrix of chicken salami. Such revelations would aid in shaping guidelines regarding the processing and keeping of foodstuffs aimed at bolstering oven-cooked chicken salami's life span on shelves as well as its appeal sensorily.

The results further showed that fluctuations in temperature could drastically influence the abilities of materials to absorb or desorb water (Amer *et al*., 2019; Ibarra-Bahena., 2022). Studies discussed previously have underscored that both equilibrium moisture levels and the mechanisms of sorption are deeply affected by changes in temperature; as it climbs, equilibrium moisture diminishes for consistent relative humidity values. Moreover, temperature's role within the sorption framework can modify sorption speeds, thus altering how effectively a substance absorbs moisture (Feldmann *et al*., 2019; Yarusova *et al*., 2018). Implementing this knowledge when examining sorption isotherms tied to chicken salami treated with oven heat could unveil significant information regarding the effects of thermal shifts and hydration on the material's capability to bind with water molecules. By fully comprehending how temperatures influence these isotherms, those researching can refine models predicting moistness more accurately and thereby boost both the quality and longevity of products such as oven-ready chicken salami.

Investigation of the moisture uptake in oven-baked chicken salami through the lens of sorption isotherms provided a deep dive into data and trend analysis at changing temperatures. These sorption isotherms studies enrich our understanding of how fluctuations in temperature affect the hygroscopic features of oven-baked chicken salami, aiding in defining its preservation qualities more clearly (Durakova *et al*., 2021; Sahu *et al*., 2021).

4. Conclusion

In conclusion, the effects of temperature on sorption isotherms of oven-cooked chicken salami have been thoroughly examined in this study. It was evident that the temperature significantly impacts water sorption behaviour of oven-cooked chicken salami, with higher temperatures leading to decreased moisture uptake. This effect was more pronounced in the initial stages of sorption, indicating that temperature plays a crucial role in the early stages of moisture absorption. Furthermore, the shape of the sorption isotherms varied with temperature, pointing towards the complex interplay between temperature and water sorption kinetics. These findings highlight the importance of carefully taking into consideration the temperature at which sorption isotherm is conducted to achieve accurate stability and shelf-life prediction. Future research could delve deeper into the mechanisms underlying these temperature-dependent sorption behaviours.

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Conflict of Interest

There is no potential conflict of interest among the authors.

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