Investigation ofsorption isotherm of turkey cuts products

ABSTRACT

The study assessed the sorption isotherm of vinegar marinated, soy-sauce marinated turkey breast jerky, oven dried and fried turkey leg. Fresh 3.5kg each of boneless turkey breast muscles were sliced into a long 6.35 mm strips, parallel to the grain. The sliced turkey breast muscles were marinated with non -meat ingredients and apple cedar vinegar and another set with soy-sauce solution prior to drying in the oven to produce vinegar and soy-sauce marinated turkey breast muscle jerky respectively. Fresh 500g each of turkey leg were marinated with non meat ingredients without vinegar and soy-sauce. One portion was oven dried while the other portion was fried to produce oven dried and fried turkey leg.The results of impact of vinegar and soy-sauce marinades, oven drying and frying on turkey meat products significantly alters the moisture absorption characteristics of the different turkey meat products investigated. Soy-sauce marinated turkey breast jerky had 0.147 water activity while vinegar marinated turkey breast jerky had 0.185.However, monolayer moisture of soy-sauce marinated was higher(20.211)than vinegar marinated turkey breast jerky(17.832) which implies that vinegar marinated turkey breast jerky may not tolerate a relative higher relative humidity than vinegar marinated turkey breast jerky in storage. Oven dried turkey leg had a comparatively lower water activity (0.193) to fried turkey leg (0.183) which also suggest that, the oven dried product can be stored effectively at the water activity of fried turkey leg while fried turkey leg will deteriorate if stored at the water activity of oven dried turkey leg. Generally, the four products investigated cannot be easily deteriorated by microorganisms if moisture adsorption is prevented as their water activities are far lower compared to the water activity rangerequired by most microorganisms. In conclusion, findings can be harnessed to boost longevity on shelves, and uplift the entirety quality of these meat products.

Keywords: Breast, Jerky, Leg, Oven-dried, Marination, Soy-sauce, Vinegar.

1. INTRODUCTION

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In food science research, delving into sorption isotherms, especially within food specimens like turkey flesh, is profoundly pivotal. Prehending the nuances and meanings of sorption dynamics in edible substances is essential for identifying their capabilities to absorb and release moisture, a factor that substantially influences product excellence, longevity on shelves, and safety measures. Through the examination of sorption isotherms, scholars can uncover critical details regarding how water molecules interact with components within foods; this knowledge plays a key role in refining processes related to preservation and storage of edibles (1).

Investigating the sorption isotherm specific to vinegar marinated turkey breast jerky, one of the four products under study in this research would offer a window into understanding its monolayer moisture, water activity, and susceptibility to bacterial development (2). This study is directed towards enriching our comprehension regarding the moisture management of vinegar-marinated turkey breast jerky with an end goal of elevating both quality standards for consumers' safety. The goal of this sub-study is to delve into the connection between moisture levels and water activity within vinegar marinated turkey breast jerky. Through executing a series of tests across different levels of water activity while monitoring moisture amounts accordingly, our objective is to formulate a dependable absorption graph explicitly for turkey breast jerky marinated in vinegar. This investigation shall enrich comprehension regarding how stable the jerky remains over time. In conclusion, findings from this research are poised to offer crucial insights beneficial not only to entities within the food sector but also end-users.

The absorption isotherm of oven-dried turkey leg represents a vital factor for grasping the moisture absorption trends of this meat variant. Through scrutinizing the absorption tendencies of oven-dried turkey leg, insights into its moisture uptake and release traits can be uncovered; these are critical for refining processing and preservation methods (3, 4). The absorption isotherm can further assist in creating appropriate encasing substances to block moisture decrement or increment throughout preservation and storage (5).

In relation to soy-sauce marinated turkey breast jerky, the sorption isotherm investigation would offer key insights regarding the equilibrium moisture levels under varying atmospheric conditions. By examining this particular jerky's sorption isotherm, investigators would be equipped to identify ideal preservation

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settings that ensure its preferred texture, taste, and overall excellence in quality (6, 7). The aim of this investigation lies in enhancing the conception around the behaviour of this product towards moisture absorption, especially those marinated in soy sauce; it aspires to furnish critical data beneficial for improving storage methods and product innovation within the culinary industry. Through diligent experimental procedures and thorough analysis, this exploration endeavors to reveal pivotal details assisting producers in crafting top-notch soy-sauce marinated turkey breast jerky that boasts an improved shelf-life and attractiveness to consumers.

Frying technique achieves a crunchy surface while preserving the inner moisture, offering an eatery encounter that is both succulent and rich in taste (8, 9). Comprehending aspects like the water activity and monolayer moisture of the fried turkey leg is crucial for assessing its absorption graph pattern and forecasting its longevity before spoilage (10, 11, 12). Various elements may determine the sorption isotherm of fried turkey leg, and impact its equilibrium moisture content and how it absorbs moisture.

Understanding the impact of marinade and processing techniques on the sorption isotherm characteristics of turkey meat products is vital for comprehending how various marination methods and processing methods influence both quality and longevity of these meat items.

Marination extends shelf-life and enhances the color, flavor, and tenderness of meat products, making them more desirable to consumers (13, 14). Specific marinades, such as those containing apple and lemon juice, have been reported to improve the sensory properties and tenderness of poultry meat (15) The use of traditional Chinese spices and condiments in marination have also significantly enhanced the aroma profile of beef (16) Marination could also reduce the growth of pathogenic microorganisms, thereby improving the microbiological safety of meat products (17).

Marination with grape vinegar and other fruit vinegars to improve the texture of meat, making it more tender had been reported (18) For instance, grape vinegar marinated meat had shown high sensory evaluation scores for flavor (19), pomegranate vinegar had resulted in darker steak, while apple vinegar had also been reported to produce a lighter color in meat products (20). However, marination with grape vinegar resulted in lower moisture content of meat products (21). Soy sauce marination significantly

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increased collagen solubility and myofibrillar fragmentation, leading to decreased shear force and improved tenderness in beef (22)

The objective of this investigation is to bridge this knowledge gap by examining the effects diverse marinades and processing techniques have on turkey meat products' sorption isotherms. By scrutinizing variations in moisture levels, water activity, and the configuration of the marinated turkey meat's isotherms, this research could offer crucial information for food industry professionals seeking to refine marination techniques that bolster both quality and durability of turkey meat products. Investigating the absorption curve specific to vinegar marinated turkey breast jerky, oven dried turkey leg, soy-sauce marinated turkey breast jerky and fried turkey leg offers a window into understanding their humidity levels, water activities, and susceptibility to bacterial development.

2. MATERIALS AND METHODS

2.1 Procurement of turkey cuts

Different turkey cut types including turkey breast and leg were purchased from a reputable grocery store in Ado Ekiti, Nigeria. The cut types were processed into four different products. The products include vinegar marinated turkey breast jerky, soy-sauce marinated turkey breast jerky, oven dried turkey leg and fried turkey leg.

2.2 Preparation of vinegar marinated turkey breast muscle jerky

Fresh 3.5kg each of boneless turkey breast muscles were sliced into a long 6.35 mm strips, parallel to the grain. The sliced turkey breast muscle was spread on a flat tray separately containing non -meat ingredients (¼ cup dried quava leaf meal, 2½ teaspoon brown sugar, ½ tablespoon of each spice (red pepper, black pepper, chili pepper, garlic, thyme, curry powder and onion powder), 1 teaspoon of maggi seasonings (monosodium glutamate and 1 teaspoon of salt (NaCl),the ingredients were mixed and sprayed on the top of products again and covered with polythene and chilled at 7^{o}C for 24 hrs. 100ml of distilled water was measured into a glass mixing bowl and 50 ml of apple cedar vinegar was added and mixed together, each strips of marinated turkey was placed into the solution, thoroughly mixed with hand,

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covered with polythene bag and chilled for 6 hours at 7^{o}C. Marinated turkey muscles were spread on the oven rack, allowed to totally drain before transferred to oven for drying at 93^{o}C for 24 hours (23).

2.3 Preparation of soy-sauce marinated turkey breast muscle jerky

The 3.5 kg of boneless turkey breast were wrapped with water proof polythene bags and freeze at -18^{o}C for 6hrs. Frozen 3.5 kg each of boneless turkey breast muscles were sliced into a long 6.35 mm strips, parallel to the grain. Non-meat ingredients were mixed together inside a large size zip-lock bag for the preparation of marinade. This comprised 2cups of soy sauce, ¼ cup dried quava leaf meal, 2½ teaspoon brown sugar, ½ tablespoon spices (red pepper, black pepper, chili pepper, garlic, thyme, curry powder and onion powder), 1 teaspoon of maggi seasonings (monosodium glutamate) and 1 teaspoon salt (NaCl)and gently shaken to ensure evenly mixed with marinade. Each turkey slice was packed into the marinade bag, zipped and manually mixed thoroughly with hands to allow the marinade into the muscle strips, the marinated breast muscles were kept in the refrigerator at 7^{o} C for 24 hours. Marinated jerky was drained on flat perforated trays, there after spread on the oven rack and dried in the oven at low heat of 93^{o}C; samples were turn at interval of 1hr 30 minutes until the entire products were totally done at 24 hours (23).

2.4 Preparation of oven dried turkey leg

Dried ingredients of 1gm of salt, 1gm red pepper,1gm garlic paste, 1gm ginger paste, 1gm curry powder and 5gms guava leaf powder, were mixed to homogenous mixture in a separate bowl and gradually marinated with 500g of turkey leg. This was set on parchment paper laid on the oven tray, placed in a pre-heated oven at 50 ^{0} C for 16hours. Each sample was flipped at interval of 5 minutes until the sample was totally dried. Dried turkey leg samples were cooled to room temperature and stored prior to analysis (24).

2.5 Procedure for the preparation of fried turkey leg

500g of turkey leg were marinated with dried ingredients of 1gm of salt, 1gm red pepper,1gm garlic paste, 1gm ginger paste, 1gm curry powder and 5gms guava leaf powder in a separate bowl. This was gradually added to the turkey leg, massaged by hand, wrapped with foil paper and chilled for 6 hours prior frying. 150ml of canola oil was placed in a skillet and pre-heated to temperature of 120^{o}C, Samples were fried

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and flipped at every 5 minutes, till golden brown colour to internal temperature of 75^{o}C, drained. This was cooled and weighed.

2.6 Sorption isotherm measurement

Dynamic Thermal Humidity (DTH) controlled chamber method was used to measure the moisture sorption isotherm of the different products from turkey muscles. Advanced Preheating Technology was used in this chamber that maintains unvarying climatic conditions in the interior part of the chamber and secures recovery of relative humidity and temperature subsequent to opening and closing during measurement of sample weight. This chamber allows incremental adjustment of relative humidity and temperature at 0 to 98% and -15 to 100^{0}C apiece. 0.2 g of the different product samples were placed uniformly in a glass dish in triplicates after the initial moisture content of the samples were determined. Dishes containing the samples were incubated in the Dynamic Thermal Humidity Chamber. The chamber was set at 25 °C and 10 % relative humidity and sample weight was recorded after 30 min. The relative humidity was then changed to 20 % and continued to increase up to 90 % with a 10 % change. Equilibrium time was considered as 30 min for all the relative humidities used for this experiment (25).

2.7 Determination of equilibrium moisture content

The equation below was used to estimate the equilibrium moisture content

$$\mathrm{EMC} = \frac{We}{Wi}(\mathrm{Mi} + 1) - 1(26) \quad \text{.....Equation 1}$$

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)

2.8 Water activity and Monolayer moisture determination

GAB equations were used to determine the water activity and monolayer moisture (27)

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

GAB equation was rearranged into second degree polynomial for the determination of water activity and monolayer moisture value.

$$aw/M = Aaw^2 + Baw + C \quad \text{.....Equation 3}$$

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Where aw = water activity

M_m = GAB Monolayer

3. RESULTS AND DISCUSSION

Water activity was 0.185 for vinegar marinated turkey breast jerky with a monolayer moisture of 17.832. The fried turkey leg recorded the highest monolayer moisture while oven dried turkey leg recorded the highest water activity of 0.193. However, lowest water activity was found with soy-sauce marinated turkey breast jerky which had 0.147 while vinegar marinated turkey breast jerky had the lowest monolayer moisture of 17.832 (Table2). This might be due to the presence of salt in soy sauce (28) and this indicates a good shelf-life stability of soy-sauce marinated turkey breast jerky.The fitness ofcurve ranged from 0.833 t0 0.902 across the four turkey meat products assessed in this study.These values represent high goodness of fit which indicates that the observed values are close to expected values of the model used for this study.The results of equilibrium moisture content and water activity of moisture is as shown in Table1. The results of the sorption isotherm of meat products from turkey cuts with their respective equation of line are as shown in Figure1.Considering the sorption isotherm results for assorted turkey meat specimens, vital perspectives on their moisture capturing characteristics were revealed. Through the use of absorption GAB formula, an all-encompassing grasp of how water activity at constant temperature intertwines with the different products investigated was elucidated. This strategy has permitted the scrutiny of adsorption tendencies through diverse processing methods, imperative for upholding consistent quality during storage and packaging intervals.

The water absorption phenomena of vinegar marinated turkey breast jerky are quintessential for deciphering the complex linkage between jerky characteristics and its hydration tendencies (29). Insights garnered from the investigation into moisture absorption tendencies in vinegar-marinated turkey breast jerky, oven dried turkey leg, soy-sauce marinated turkey breast jerky and fried turkey leg through sorption isotherm exploration have shed light on the hydration behavior of this well-liked food items. It was discovered that these products demonstrated a characteristic Type II sorption isotherm, marked by an initial steady climb in moisture levels before reaching a saturation point at elevated water activities (30).

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This observed pattern can be credited to the unique composition and texture of the turkey meat products, which include protein-dense flesh, marinades and additional seasoning components that play roles in water sorption capabilities. Additionally, data from the sorption isotherm analysis pinpointed specifically that the water activity and monolayer moisture of these products are good indicators of stability which offers vital clues for predicting shelf life and configuring storage prerequisites (31). In essence, these research outcomes enhance comprehension regarding how vinegar-marinated turkey breast jerky absorbs moisture, with ramifications touching upon new product creation and health guidelines within the meat processing sector.

The impact of vinegar and soy-sauce marinades on turkey meat products significantly alters the moisture absorption characteristics of the different turkey meat products investigated (Table 2). Soy-sauce marination had the lowest water activity compared to vinegar marinade. However, monolayer moisture of soy-sauce marinated was higher (20.211) than vinegar marinated turkey breast jerky (17.832) which implies that soy-sauce marinated turkey breast jerky may tolerate a relative higher relative humidity vinegar marinated turkey breast jerky in storage. Oven dried turkey leg had a comparatively lower water activity (0.193) to fried turkey leg (0.183) which also suggest that, the oven dried product can be stored effectively at the water activity of fried turkey leg while fried turkey leg will deteriorate if stored at the water activity of oven dried turkey leg.

Generally, the four products investigated cannot easily undergo microbial spoilage as their water activities are far lower than the water activity range (0.565-0.91) required by all types of microorganisms if moisture uptake is prevented. (32,33,34)

The behavior of moisture absorption in these products may have been significantly influenced by several factors that dictate their sorption isotherms. The level of water activity within them was probably affected by a variety of elements, such as temperature, relative humidity levels, and their make-up. It has been revealed through research that the sort of marinade utilized when preparing meat products played a pivotal role in determining its moisture capture tendencies (35). Specifically, using vinegar as a marinade has been shown to increase the capacity for moisture desorption in beef meat (36). This agrees with the outcome of this research as soy-sauce marination retained more water than vinegar marination. This

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improvement in moisture desorption can be attributed to how vinegar's acidic nature modifies the protein configuration within the meat, resulting in an elevation in water loss. Grasping and applying this behavior of moisture adsorption and desorption can play a crucial role in enhancing processing methods and prolonging shelf-life strategies specific to turkey meat products.

Table 1. Equilibrium moisture content of meat products from turkey cuts

a_w	Vinegar Marinated Turkey Breast Jerky		Oven Dried Turkey Leg		Soy-sauce Marinated Turkey Breast Jerky		Fried Turkey Leg	
	EMC	$a_{w/M}$	EMC	$a_{w/M}$	EMC	$a_{w/M}$	EMC	$a_{w/M}$
0.1	14.24	0.0071	15..42	0.0065	17.45	0.0057	19.52	0.0051
0.2	17.72	0.0113	18.93	0.0106	20.55	0.0097	22.65	0.0088
0.3	19.62	0.0153	20.85	0.0144	22.45	0.0134	24.70	0.0121
0.4	21.32	0.0188	22.65	0.0177	24.23	0.0165	26.45	0.0151
0.5	25.90	0.0192	27.25	0.0183	28.90	0.0173	31.15	0.0161
0.6	31.15	0.0193	32.36	0.0185	33.95	0.0177	36.35	0.0165
0.7	40.65	0.0172	41.84	0.0167	43.35	0.0161	55.15	0.0127
0.8	51.95	0.0154	52.12	0.0153	53.66	0.0149	65.45	0.0122
0.9	49.35	0.0182	49.45	0.0182	51.08	0.0176	62.85	0.0143

EMC- Equilibrium moisture content, a_{w-} Water activity, $a_{w/}$M- Water activity of moisture

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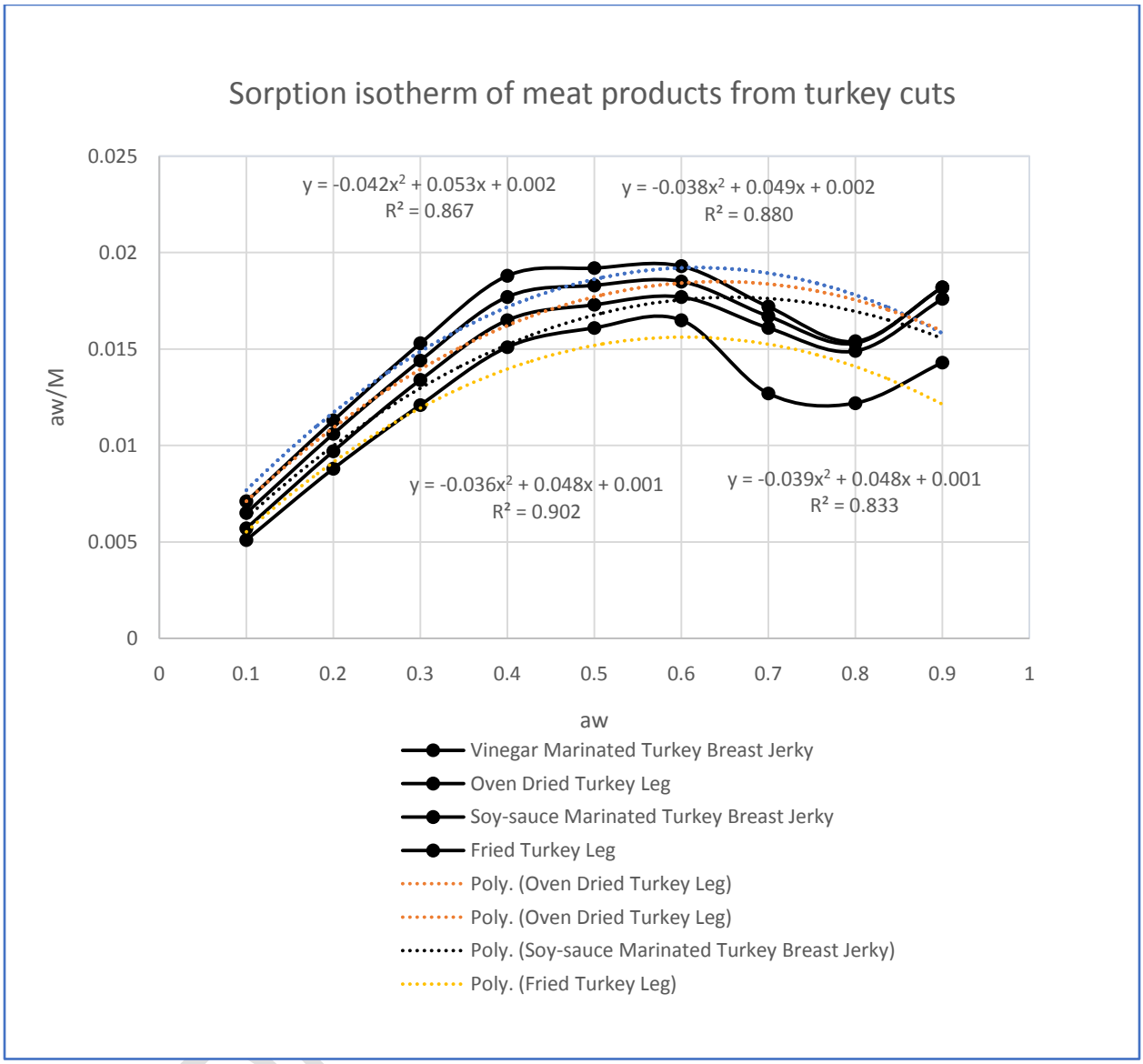

Figure 1: Sorption Isotherm of meat products from Turkey cuts

Table 2. Analysis of sorption data of meat products from turkey muscles according to GAB Model

Product sample	Water activity (a_w)	Monolayer value (Mo)	R^2(Fitness of curve)
1.Vinegar marinated turkey breast jerky	0.185	17.832	0.867
2.Oven dried turkey leg	0.193	19.227	0.880
3.Soy sauce marinated turkey breast jerky	0.147	20.211	0.902
4. Fried turkey leg	0.183	21.577	0.833

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The comparison of sorption isotherms between turkey jerky and leg varieties reveals interesting differences in moisture adsorption properties as they exhibited varied moisture sorption capacity which may be attributed to their texture and water activity levels. Such variations might influence the longevity on the shelf and prerequisites for storing these edible items, underscoring the necessity to grasp their differential absorbing tendencies. Considering the sorption behavior of these products, valuable insights can be gained into their unique characteristics and potential applications in the food industry.

The employment of acidic marinades, specifically those containing vinegar, to improve both the quality and safety aspects of turkey meat products is an area gaining traction in the food processing industry (37, 38). Vinegar is known for its germ-killing capabilities and has the potential to diminish foodborne pathogens that may be found in vinegar marinated turkey breast jerky, thereby alleviating concerns regarding bacterial-induced gastroenteritis (39, 40, 41). With a worldwide increase in poultry consumption, it becomes paramount to adopt natural bactericidal solutions like vinegar-based marinades for enhancing consumer protection and prolonging product freshness. It has been proposed through

studies that merging vinegar with other active entities such as essential oils or phenolic constituents might provide an effective method for turkey meat marination and preservation alike (42).

Considering the fried turkey leg, the primary influences on the sorption isotherm encompass the turkey leg's initial moisture levels, frying time and heat intensity, oil composition used in frying, along with additives incorporation such as natural antioxidants and sodium chloride. However, changes in ingredients or how they are processed may result in variations within processed turkey leg variants and jerky concerning their monolayer moisture alongside water activity values, thus affecting their distinct characteristics plus longevity on shelves.

4. CONCLUSION

To wrap up, the absorption curves of vinegar marinated turkey breast jerky, oven dried turkey leg, soy-sauce marinated turkey breast jerky and fried turkey leg shed light on their water content and balance. The scrutiny of collected experimental observations along with the utilization of diverse mathematical formulas clearly shows that these turkey meat products display distinct absorption properties affected by variations in moisture levels surrounding them. This acquired knowledge can be harnessed to boost longevity on shelves, and uplift the entirety quality of these snacks. Looking ahead, more inquiry could probe into elements swaying the absorption mannerism of these products, including how variations in pore dimensions, different temperatures, marinations, frying and drying methods impact the phenomenon of sorption behaviour. To sum up, the investigation into single-layer moisture and water activity across various turkey jerky and leg products has yielded crucial information regarding the levels of moisture content and water activity in these widely consumed meat items. The data revealed that there were notable disparities in the equilibrium moisture content and water activity figures between the variants of turkey jerky and those of leg products, pointing to differences in processing approaches and ingredients used during their creation.

5. RECOMMENDATION

The findings of this study showed that monolayer moisture of vinegar marinated turkey breast jerky, oven dried turkey leg, soy-sauce marinated turkey breast jerky and fried turkey leg were 17.832, 19.227, 20.211 and 21.577respectively and can therefore be recommended that storage should be at these

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respective monolayer moistures. Also, additional studies on the variation of temperature for sorption analysis of these productsshould be investigated to ascertain the influence of temperature change on sorption parameters.

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