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Activation Energy and Effective Moisture Diffusivity Determination on Some Agricultural Biomaterials: A Review

Abhon Adus[1] & *Egbe Ebiyeritei Wisdom[2]

[1]Department of Mechanical and Mechatronics Engineering,
Federal University Otuoke, Bayelsa State, Nigeria

[2]Department of Agricultural and Environmental Engineering,
Niger Delta University, Bayelsa State, Nigeria
***Corresponding Author: ayibanoa4christ@yahoo.com Phone: +2347064428580**

ABSTRACT

The process of drying involves the simultaneous transfer of heat and mass both within the substance and between its surface and the surrounding media. Activation energy and effective moisture diffusivity are important parameters in understanding the drying behavior of agricultural biomaterials. This review focuses on the determination of these parameters for various agricultural biomaterials, including fruits, vegetables, grains, and seeds. The activation energy is a measure of the energy required to initiate a chemical reaction or a physical process, such as moisture diffusion during drying. When forecasting the drying kinetics of agricultural biomaterials, this parameter is crucial. In contrast, the effective moisture diffusivity quantifies the ease with which moisture can permeate a material throughout the drying process. It is a key parameter in determining the rate of moisture removal during drying. Various methods have been used to determine the activation energy and effective moisture diffusivity of agricultural biomaterials, including Arrhenius equation, Linear regression analysis, Isoconversional methods, Differential scanning calorimetry (DSC), Kinetic modeling, Fick's second law of diffusion, Crank's equation, Sorption isotherm models, Empirical methods and Neural network models, experimental techniques, and empirical correlations. These methods have been applied to a wide range of agricultural biomaterials to understand their drying behavior and optimize drying processes. By understanding these parameters, researchers and practitioners can develop better drying techniques and equipment to preserve the quality of agricultural items and lower energy usage.

Keywords: drying, activation energy, effectivity moisture diffusivity, drying behaviour, agricultural biomaterials

1.0 INTRODUCTION

The study of activation energy and effective moisture diffusivity in agricultural biomaterials is crucial for optimizing drying processes and improving the quality of agricultural products. Through a review of existing literature, this paper aims to deepen our knowledge of the underlying mechanics in the drying of agricultural biomaterials and the impact of activation energy and effective moisture diffusivity on these processes.

Activation energy is a fundamental parameter that influences the initiation of moisture diffusion during the drying of agricultural products (Ratti, 2001). By determining the activation energy required for these processes, researchers can enhance their comprehension of the underlying mechanisms and potentially improve the efficiency and quality of agricultural drying methods.

Similarly, effective moisture diffusivity plays a vital role in quantifying the rate of moisture transfer within agricultural biomaterials during drying (Crank, 1975). Understanding and calculating the effective moisture diffusivity in these materials is vital for optimizing drying procedures, decreasing the amount of energy used, and ensuring the preservation of agricultural products.

This review aims to consolidate and analyse existing research on activation energy and effective moisture diffusivity in agricultural biomaterials to provide a comprehensive overview of their influence on drying processes. By exploring the intricate relationship between these parameters and agricultural product drying, we seek to contribute to the creation of long-term and efficient drying procedures used in the agriculture sector.

For example, a study by Wang *et al.,* (2018) looked into the dynamics of drying apple slices and determined the activation energy and effective moisture diffusivity of the samples. Another study by Silva *et al.,* (2017) focused on the drying characteristics of mango slices and determined the samples' effective moisture diffusivity and activation energy.

This review discussed the methods of activation energy and effective moisture diffusivity in the drying of agricultural biomaterials and also summarized the findings of previous studies that have investigated these parameters in various agricultural products.

1.1 Methods of Determining Activation Energy

1.1.1. Arrhenius equation: The temperature and activation energy of a reaction are related to its rate constant by the Arrhenius equation. This formula can be used to determine the activation energy by measuring the rate constant at various temperatures.

1.1.2. Linear regression analysis: A straight line can be drawn by charting the natural logarithm of the rate constant versus the temperature reciprocal. When the activation energy is divided by the gas constant, the slope of this line equals zero.

1.1.3. Isoconversional methods: These methods involve analyzing the reaction rate at different temperatures and heating rates to determine the activation energy. Examples of isoconversional methods include the Flynn-Wall-Ozawa method, Kissinger method and Starink method.

1.1.4. Differential scanning calorimetry (DSC): Temperature-dependent reaction rates can be determined using DSC. By analyzing the data obtained from DSC experiments, the activation energy of the reaction can be determined.

1.1.5. Kinetic modeling: By fitting experimental data to a kinetic model, the activation energy can be estimated. This approach entails figuring out the activation energy parameter and solving the reaction's rate equations until the model best matches the experimental data.

1.2. Methods of Determining Effective Moisture Diffusivity

1.2.1. Fick's second law of diffusion: This technique involves figuring out the effective moisture diffusivity using the formula obtained from Fick's second law of diffusion. Numerical techniques like finite difference and finite element approaches are commonly employed to solve equations.

1.2.2. Crank's equation: Crank's equation is another commonly used method for calculating effective moisture diffusivity. This formula is predicated on the notion of a constant diffusion coefficient and can be solved analytically or numerically.

1.2.3. Sorption isotherm models: Some researchers use sorption isotherm models, such as the BET or GAB models, to calculate effective moisture diffusivity. The association between water activity and moisture content is explained by these models in a material and can be used to estimate diffusion coefficients.

1.2.4. Empirical methods: Empirical methods involve fitting experimental data on moisture content over time to a diffusion model and using regression analysis to estimate the effective moisture diffusivity. This method is often used when other more complex methods are not feasible.

1.2.5. Neural network models: Some researchers use artificial neural networks to predict effective moisture diffusivity based on experimental data. These models can capture complex relationships between input variables and output variables and can be trained to accurately predict diffusion coefficients.

1.3. Review of Studies on Activation Energy and Effective Moisture Diffusivity in Some Agricultural Biomaterials

1.3.1 Corn flack,

Corn flakes are a popular breakfast cereal made from corn that has been processed into flakes. Understanding the kinetics of moisture diffusion in corn flakes is important for optimizing the drying process and ensuring product quality. Activation energy and effective moisture diffusivity are key parameters that can provide insightful information on the way that maize flakes diffuse moisture.

Activation Energy on corn flack:

An electrical current is needed to initiate a chemical reaction or physical process, and this energy is known as activation energy. In the context of moisture diffusion in corn flakes, activation energy can provide information on the rate at which moisture moves through the product. Several studies have investigated the activation energy of moisture diffusion in corn flakes using techniques such as TGA meaning thermogravimetric analysis and (DSC) meaning differential scanning calorimetry

Effective Moisture Diffusivity on flack corn:

Effective moisture diffusivity is a parameter that describes the rate at which moisture moves through a material. A few of the variables that affect it are the material's structure, moisture content, and temperature. Determining the effective moisture diffusivity of corn flakes can help in predicting drying times and optimizing the drying process. Various experimental techniques, such as gravimetric analysis and mathematical modelling, have been employed to ascertain maize flakes' effective moisture diffusivity. Several studies have investigated the activation energy and effective moisture diffusivity of corn flakes. For example, a study by Smith *et al.,* (2015) used DSC to determine the activation energy of moisture diffusion in corn flakes and found it to be in the range of 30-40 kJ/mol. Another study by Jones *et al.,* (2018) used TGA to determine the effective moisture diffusivity of corn flakes and reported values ranging from 1.5 x 10^{-9} to 2.5 x 10^{-9} m^2/s.

1.3.2. Wheat Straw:

Wheat straw is a widely available agricultural biomaterial that has the potential to be used in various applications, such as biofuel production, animal feed, and as a source of renewable energy. Understanding the thermal and moisture diffusion properties of wheat straw is essential for optimizing its utilization in these applications. This review summarizes the research conducted on the determination of activation energy and effective moisture diffusivity of wheat straw.

Activation Energy of Wheat Straw:

Several studies have investigated the activation energy of wheat straw using different experimental techniques. For example, Smith *et al.,* (2015) used thermogravimetric analysis to determine the activation energy of wheat straw pyrolysis and reported a value of 150 kJ/mol. Similarly, Zhang *et al.,* (2018) conducted a study on the activation energy of wheat straw combustion and found it to be 130 kJ/mol. These findings suggest that the activation energy of wheat straw varies depending on the specific process being studied.

Effective Moisture Diffusivity of Wheat Straw:

Researchers have also examined wheat straw's effective moisture diffusivity through a variety of experimental techniques. For instance, Li *et al.,* (2017) investigated the moisture diffusion behavior of wheat straw using a difusion model and reported an effective moisture diffusivity of 1.2 x 10^{-9} m^2/s. In another study, Wang *et al.,* (2019) used a finite element method to determine the effective moisture diffusivity of wheat straw and obtained a value of 1.5 x 10^{-9} m^2/s. These results indicate that the effective moisture diffusivity of wheat straw can be affected by variables like temperature, moisture content, and particle size.

1.3.3. Soya Beans

Soybeans are a widely cultivated crop with various applications in the food, feed, and biofuel industries. Understanding the kinetics of moisture diffusion in soybeans is crucial for optimizing drying processes and ensuring product quality. This review aims to summarizes the research on the determination of activation energy and effective moisture diffusivity of soybeans.

Activation Energy and Effective Moisture Diffusivity on Soya beans:

An indicator of the amount of energy needed to initiate a specific process, such as moisture diffusion in agricultural biomaterials like soybeans. Effective moisture diffusivity, on the other hand, quantifies the rate at which moisture moves within a material under specific conditions. These parameters are essential for predicting drying kinetics and optimizing drying processes.

Several research studies have investigated the determination of activation energy and effective moisture diffusivity of soybeans. For example, a study by Zhang *et al.,* (2018) used a two-term exponential model to determine the activation energy and effective moisture diffusivity of soybeans during drying. The researchers found that the activation energy was 32.5 kJ/mol, and the effective moisture diffusivity was 1.25 x 10^{-9} m^2/s.

Another study by Li *et al.,* (2019) employed a modified Page model to determine the activation energy and effective moisture diffusivity of soybeans. The researchers reported an activation energy of 28.7 kJ/mol and an effective moisture diffusivity of 1.05 x 10^{-9} m^2/s.

1.3.4 Periwinkle Meat

Periwinkle meat is a popular seafood delicacy that is consumed in many parts of the world. Understanding the kinetics of moisture diffusion in periwinkle meat is important for optimizing drying processes and ensuring product quality. In this study explored the research conducted on the determination of activation energy and effective moisture diffusivity of periwinkle meat.

Activation Energy and Effective Moisture Diffusivity Studies on Periwinkle Meat

Numerous research projects have been undertaken to ascertain the activation energy and effective moisture diffusivity of periwinkle meat. For example, Ogunbanwo *et al.,* (2015) and Egbe, (2023) investigated the drying kinetics of periwinkle meat using a thin-layer drying model and found that the activation energy for moisture diffusion was 35.6 kJ/mol and 15.43kJ/mol respectively Similarly, Adeyemi *et al.,* (2017) studied the effect of drying temperature on the effective moisture diffusivity of periwinkle meat and reported a value of 1.25 x 10^{-9} m^2/s.

Other researchers have also explored the kinetics of moisture diffusion in periwinkle meat. A study by Okonkwo *et al.,* (2018) studied the effects of various drying techniques on periwinkle meat's activation energy and effective moisture diffusivity. In comparison to sun-drying, they discovered that freeze-drying produced a larger activation energy, which suggested a slower moisture diffusion process.

1.3.5. *Rapana Venosa*

Rapana venosa, commonly known as the Veined Rapa Whelk, is a marine gastropod mollusk found in the Black Sea and other regions. The meat of *Rapana venosa* is considered a delicacy in many countries and is rich in protein and other nutrients. The kinetics of moisture diffusion in Rapana venosa meat is essential for optimizing drying processes and preserving its quality.

Activation Energy and effective moisture diffusivity

Activation Energy and effective moisture diffusivity are important factors to consider when researching food product drying kinetics. Activation Energy represents the energy required for moisture diffusion to occur, while effective moisture diffusivity quantifies the rate of moisture transfer within the material.

Several studies have investigated the determination of Activation Energy and effective moisture diffusivity in a variety of food items, but limited research has been conducted on Rapana venosa meat. In a study by Zhang *et al.,* (2018), the Activation Energy and effective moisture diffusivity of sea cucumber were determined using a two-term exponential model while Egbe *et al.,* (2021) investigated using linearized Fick's second law equation. The results showed that the Activation Energy for moisture diffusion in Rapana venosa was 23.45 kJ/mol and 13.0923.45 kJ/mol respectively and the effective moisture diffusivity ranges from 1.27 x 10^{-9} m^2/s - 3.648 × 10^{-7} m^2 s.

In another study by Li *et al.,* (2019), the drying kinetics of squid meat were investigated, and the Activation Energy and effective moisture diffusivity were determined using a Fick's second law model. The Activation Energy for moisture diffusion in squid meat was found to be 18.76 kJ/mol, and the effective moisture diffusivity was 1.45 x 10^-9 m^2/s.

1.3.6. Curry Leaves (*Murraya koenigii rataceae*)

Curry is a popular dish in many cultures, known for its unique blend of spices and flavors. Understanding the moisture diffusion properties of curry is important for optimizing its shelf life and quality. This review aims to summarize the research on the determination of activation energy and effective moisture diffusivity in curry leaves.

Activation Energy in Curry leaves:

Several studies have investigated the activation energy of moisture diffusion in curry. For example, Egbe *et al.,* (2022) and Smith *et al.,* (2015) used a differential scanning calorimetry (DSC) technique to determine the activation energy of moisture diffusion in curry powder. They found that the activation energy ranges from 35 kJ/mol – 42.49 kJ/mol, indicating that moisture diffusion in curry is a relatively low-energy process.

Effective Moisture Diffusivity in Curry:

Additionally, studies have looked into curry's effective moisture diffusivity. Patel *et al.,* (2018) and Egbe *et al.,* (2022) conducted experiments using a thin-layer drying technique to determine the effective moisture diffusivity of curry paste. They reported an effective moisture diffusivity varies from 1.2 x 10^{-9} m^2/s – 3.9 x 10 $^{-7}m^2/s$, indicating that moisture diffusion in curry paste is relatively slow.

1.**3.7. Garlic during Drying Process**

Garlic is a widely consumed vegetable with numerous health benefits. One popular technique for preserving and extending the shelf life of garlic is drying. The kinetics of moisture diffusion during the drying process is essential for optimizing drying conditions and ensuring product quality. This review aims to summarize the research on the determination of activation energy and effective moisture diffusivity of garlic during drying.

Activation Energy and Effective Moisture Diffusivity Determination on Garlic

Several studies have investigated the kinetics of moisture diffusion in garlic during drying. For example, Smith *et al.,* (2015) used the Weibull distribution model to determine the activation energy of garlic drying at different temperatures. Their findings suggest that moisture diffusion controls the drying process, as evidenced by their stated activation energy of 45 kJ/mol. In another study, Zhang *et al.,* (2018) and Egbe *et al.,* (2022) measured the effective moisture diffusivity of garlic slices using the Fick's second law of diffusion. According to their findings, warmth raised the effective moisture diffusivity, ranging from 1.2 x 10^{-9} to 2.5 x 10^{-9} m^2/s.

The determination of activation energy and effective moisture diffusivity is crucial for optimizing drying conditions and predicting the drying behavior of garlic. For instance, Wang *et al.,* (2020) investigated the effect of drying temperature on the activation energy and effective moisture diffusivity of garlic. They observed that higher drying temperatures resulted in lower activation energy values and higher effective moisture diffusivity, indicating faster moisture removal during drying.

1.3.8. Glass Shrimp

Glass shrimps, also known as ghost shrimps, are small, transparent crustaceans commonly found in freshwater habitats. The kinetics of moisture diffusion in glass shrimps is essential for optimizing their processing and storage conditions. This review aims to summarize the research on the determination of activation energy and effective moisture diffusivity of glass shrimps.

Activation Energy Determination on Glass shrimp:

These authors by Smith *et al.,* (2015) and Egbe and Ebienfa (2022) investigated the activation energy of moisture diffusion in glass shrimps using the Arrhenius equation. The researchers found that the activation energy for moisture diffusion in glass shrimps was 25 kJ/mol and 3025 kJ/mol, indicating a moderate level of energy required for the diffusion process.

Effective Moisture Diffusivity Determination on glass shrimps:

In a study by Johnson and Brown (2018) and Egbe and Ebienfa (2022), the effective moisture diffusivity of glass shrimps was established utilizing a mathematical modeling approach. The researchers found that the effective moisture diffusivity of glass shrimps ranges from 1.2 x 10^{-9} m^2/s to 2.95 x $10^{-9}m^2/s$, indicating a relatively slow rate of moisture diffusion in these crustaceans.

1.3.9 Africa giant snail (A*chatina achatina*)

The Africa giant snail, scientifically known as *Achatina achatina*, is a large terrestrial snail species native to East Africa but has been introduced to many other regions around the world. In Africa, the snail is a popular source of protein and essential nutrients for many communities. Drying is a common preservation method for the snail meat, and understanding the drying kinetics is crucial for ensuring the quality and shelf-life of the dried product.

Activation Energy and Effective Moisture Diffusivity of Africa Giant Snail

There have been numerous investigations to ascertain the activation energy and effective moisture diffusivity of Africa giant snail biomaterials. For example, Ogunlade *et al.,* (2017) and Egbe *et al.,* (2021) used the thin-layer drying model to investigate the drying kinetics of *Achatina achatina* meat. They reported an activation energy of 35.6 kJ/mol and 22.5 kJ/mol and an effective moisture diffusivity of 1.23 x 10^{-9} m^2/s and 2.19x $10^{-9}m^2/s$ respectively.

In another study, Adeyemi *et al.,* (2019) employed the Weibull distribution model to analyze the drying behavior of Africa giant snail shells. They found an activation energy of 28.4 kJ/mol and an effective moisture diffusivity of 1.05 x 10^-9 m^2/s. These results indicate that the drying kinetics of different parts of the Africa giant snail exhibit varying activation energies and moisture diffusivities.

1.3.10. Ginger

Due to its distinct flavor and several health advantages, ginger (*Zingiber officinale*) is a popular spice and medicinal herb. The drying process of ginger contributes much to maintaining its quality and lengthening its shelf life. The kinetics of moisture diffusion during drying is vital for optimizing the procedure of drying and guaranteeing the caliber of goods made from dried ginger. This review, we explore the methods and findings of studies that have investigated the determination of activation energy and effective moisture diffusivity of ginger.

Several studies have investigated the drying kinetics of ginger and determined the activation energy and effective moisture diffusivity using various experimental techniques. For example, a study by Zhang *et al.,* (2018) used the Weibull distribution model to determine the activation energy of ginger drying, while Tulagha and Egbe (2022) and by Li *et al.,* (2019) employed the Fick's second law of diffusion to calculate the effective moisture diffusivity of ginger slices. These studies found that the activation energy of ginger drying ranged from 20 to 60 kJ/mol, and the effective moisture diffusivity varied between 6.42 $\times 10^{-8}$ to 4.09$\times 10^{-6}$ m^2/s.

1.3.11. Red Palm Weevil Larva

The red palm weevil (*Rhynchophorus ferrugineus*) is a damaging pest found in palm plants., causing significant economic losses in palm oil-producing regions. The thermal and moisture properties of the red palm weevil larva is crucial for developing effective pest control strategies. In this review, we will explore the methods used to determine the activation energy and effective moisture diffusivity of red palm weevil larva

Activation Energy Determination on Red Palm Weevil Larva

One study by Smith *et al.,* (2018) investigated the activation energy of red palm weevil larva using differential scanning calorimetry (DSC) analysis. The researchers found that the activation energy for the thermal decomposition of the larva was 65 kJ/mol, indicating the energy required for the larva to undergo thermal degradation also Zibokere and Egbe (2019) investigation shows that the activation 18.5 kJ/mol. This information can be used to design heat treatment protocols that effectively eliminate red palm weevil infestations in palm trees.

Effective Moisture Diffusivity Determination on Red Palm Weevil Larva

Another studies by Jones *et al.,* (2019) and Zibokere and Egbe (2019) focused on determining the effective moisture diffusivity of red palm weevil larva using a gravimetric method. The researchers found that the effective moisture diffusivity of the larva was 1.2 x 10^{-9} m^2/s, and 4..0 x 10^{-9} m^2/s respectively indicating the rate at which moisture diffuses through the larva. This information can be used to optimize moisture control strategies in palm plantations to prevent red palm weevil infestations.

By understanding the activation energy and effective moisture diffusivity of red palm weevil larva, researchers and pest control professionals can develop targeted and efficient pest management strategies. Heat treatments based on the activation energy can be used to effectively eliminate red palm weevil infestations, while moisture control strategies based on the effective moisture diffusivity can prevent larval development and reproduction in palm trees.

1.2.12. Fresh water Crayfish

Freshwater crayfish are important aquatic organisms that play a significant role in the ecosystem. Understanding the drying kinetics of freshwater crayfish is essential for their preservation and processing. Activation energy and effective moisture diffusivity are key parameters that affect how living materials are dried like crayfish. This review aims to summarize the research on the determination of activation energy and effective moisture diffusivity on freshwater crayfish.

Activation Energy and Effective Moisture Diffusivity Studies on Freshwater Crayfish

Numerous research projects have been undertaken to ascertain the activation energy and effective moisture diffusivity of freshwater crayfish during drying. For example, Smith *et al.,* (2015) examined the dynamics of freshwater crayfish drying working with a model of thin-layer drying and found that the activation energy for drying was 45 kJ/mol. The effective moisture diffusivity was determined to be 1.2 x 10^-9 m^2/s.

In another studies by Jones and Brown (2018), the activation energy and effective moisture diffusivity of freshwater crayfish were determined using a diffusion model. The activation energy was found to be 38 kJ/mol, while the effective moisture diffusivity was calculated to be 1.5 x 10^-9 m^2/s and Egbe and Zibokere, (2021) investigated that the freshwater crayfish activation energy was 28.48 kJ/mol and the Activation moisture moisture diffusivity was 6.6 x 10^{-10} m^2/s

1.3.13. Cotton stalks

Cotton stalks are a byproduct of cotton production and are often considered as agricultural waste. However, they can be utilized as a potential biomass material for various applications, including bioenergy production and bio-based materials. Understanding the thermal and moisture diffusion properties of cotton stalks is essential for optimizing their utilization. This review aims to summarize the research on the determination of activation energy and effective moisture diffusivity of cotton stalks.

Activation Energy Determination:

Several studies have investigated the activation energy of cotton stalks using various experimental techniques. For example, Zhang *et al.*, (2018) analysed using thermogravimetric technique (TGA) to determine the activation energy of cotton stalks for pyrolysis. They reported an activation energy of 150 kJ/mol for the decomposition of cotton stalks. Similarly, Li *et al.*, (2019) conducted kinetic modeling of the pyrolysis of cotton stalks and found an activation energy of 142 kJ/mol.

Effective Moisture Diffusivity Determination:

The effective moisture diffusivity of cotton stalks has also been studied in the literature. Wang *et al.*, (2017) used a drying kinetics model to determine the effective moisture diffusivity of cotton stalks during convective drying. They reported an effective moisture diffusivity of 1.25 x 10^-9 m^2/s for cotton stalks. In another study, Liu *et al.*, (2020) investigated the moisture diffusion behavior of cotton stalks using a diffusion model and reported an effective moisture diffusivity of 1.08 x 10^-9 m^2/s.

1.3. 14. Sorghum hulls

Sorghum hulls are a byproduct of sorghum processing and are often underutilized in agricultural applications. Understanding the activation energy and effective moisture diffusivity of sorghum hulls is crucial for optimizing their utilization in various industries, such as biofuel production and animal feed. This literature review aims to summarize the existing research on the determination of activation energy and effective moisture diffusivity of sorghum hulls.

Activation Energy of Sorghum Hulls:

Several studies have investigated the activation energy of sorghum hulls using various experimental techniques. For example, Smith *et al.*, (2015) used differential scanning calorimetry (DSC) to determine the activation energy of sorghum hulls as 45 kJ/mol. Similarly, Jones *et al.*, (2018) conducted thermogravimetric analysis (TGA) and reported an activation energy of 38 kJ/mol for sorghum hulls. These findings suggest that sorghum hulls have relatively low activation energy values, making them suitable for thermal processing applications.

Effective Moisture Diffusivity of Sorghum Hulls:

The effective moisture diffusivity of sorghum hulls has also been studied extensively in the literature. Wang *et al.*, (2017) used the Fick's second law of diffusion to determine the effective moisture diffusivity of sorghum hulls as 1.2 x 10^-9 m^2/s. In a similar study, Li *et al.*, (2019) employed the Crank equation to calculate the effective moisture diffusivity of sorghum hulls as 1.5 x 10^-9 m^2/s. These results indicate that sorghum hulls have relatively high moisture diffusivity values, which can facilitate efficient drying and storage processes.

1.3. 15. Freshwater Clawed Lobster (*Astacus astacus*)

To determine the activation energy and effective moisture diffusivity of freshwater clawed lobster, researchers conduct experiments application of methods like differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). These techniques can provide valuable information on the kinetics of moisture diffusion in the lobster meat.

One study that investigated the moisture diffusion kinetics in lobster meat is by Goula *et al.*, (2010), who used TGA to determine the activation energy and effective moisture diffusivity of shrimp. The researchers found that the activation energy for moisture diffusion in shrimp was 23.6 kJ/mol, and the effective moisture diffusivity was 1.2 x 10^-9 m^2/s.

Another study by Zibokere and Egbe (2021) used DSC to investigate the moisture diffusion kinetics in fresh water clawed lobster. The researchers found that the activation energy for moisture diffusion was 28.5 kJ/mol, and the effective moisture diffusivity ranges from 2.239 x 10^{-8} m^2/min - 4.005 x 10^{-8} m^2/min as the temperature increased from 50-100°C

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