Hydration Kinetics of Blanched and Unblanched Sword Beans

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Abstract— *Sword bean, which belongs to the (Fabaceae) family, is an indigenous legume found in several tropical countries in Africa and Asia. During the processing of legumes including sword bean, hydration is initially carried out to prepare the seeds for further operations such as cooking and milling. The absorption of water is determined by the physical and chemical properties of the crop as well as other extrinsic factors such as blanching, temperature, and soaking time. The physical properties of sword bean were determined using the standard method. Arrhenius equation adequately described the temperature dependency of water absorption of sword bean and showed that high soaking temperature reduced the time required to achieve equilibrium moisture. The activation energy for blanched and unblanched sword beans was discovered to be 14.28 KJ/mol and 13.36 KJ/mol respectively. The initial microbial counts on dry beans were minimized by blanching, thus, there was a reduction in risk posed by microbe proliferation during soaking. The quantitative data that characterize soaking conditions is therefore imperative for designing and optimizing food processing equipment, and also predicting the water uptake of the food as a function of time and temperature. The data of hydration kinetics of sword beans will provide information that could be used in solving problems involved in storability conditions, design problems, predict energy requirements in post-harvesting techniques of the product.*

Keywords— ***Sword beans, blanched, unblanched, absorption kinetics, microbial count.***

I. INTRODUCTION

Food is one of the essentials of life and it constitutes a significant percentage of a typical Nigerian budget. Proteins, which are major constituents of a balanced diet are bodybuilding food agents with basically two sources which are animal and plant protein. A major source of plant protein is legumes. Leguminous seeds comprise a significant nutrition type as a result of their high nutritional value. More so, it has been discovered that they contain a broad spectrum of non-nutritional compounds, which aid in several biological activities.

Legumes, which belong to the family Leguminosae, are the most important food crop after cereals (Uzoechina, 2009). Legume seeds are a rich source of essential minerals, especially iron, zinc, and calcium. (Campos¬ Vega *et al.*, 2010). In comparison with animal products such as meat, fish, and egg, legumes provide low-cost dietary vegetable proteins and minerals (Apata and Ologhobo, 1997). According to Ihekoronye and Ngoddy (1985), indigenous legumes serve as an alternative source of protein to poor people in several tropical countries in Africa and Asia because of its low cost. Sword bean (Canavalia gladiata), which belongs to the legume (Fabaceae) family is a classic example of such indigenous legume. Sword bean is not grown on a commercial scale in both the central and south-central parts of India, however, it is utilized as a vegetable in these regions. This legume is also consumed as a vegetable in major parts of Africa and Asia. Sword bean, which is also utilized for the production of urease, is sold in the international market, however, the exact proportion traded are not known (Bosch, 2004).

During the processing of legumes and cereals, hydration is initially carried out to prepare the crop for further operations such as cooking and milling. Therefore, it is important to understand the absorption of water by the seeds during soaking as it affects not just the subsequent processes but also the quality of the final product. Since the rate of water absorption influences the formulation of foods in the processing industry, it has become imperative to study the penetration of water into these materials. Intrinsic factors, chiefly the physical and chemical properties of the seeds, as well as the extrinsic factors such as temperature, soaking solutions time determines the seed's water absorption. Determining the hydration properties of legumes and cereals is essential in preparing a product from them. Raw products are stored at lower moisture content, to restore the properties of these raw products hydration is very important. (Miano *et al.*, 2017; Miano *et al.*, 2018).

The rehydration process has to be thoroughly understood in various dehydrated foods to conserve energy and still meet quality standards (Miano *et al.*, 2018). The quantitative data that characterize soaking conditions is therefore imperative for designing and optimizing food processing equipment, and also predicting the water uptake of the food as a function of time and temperature (Sobukola and Abayomi 2011; Kaptso *et al.*, 2008; Maskan 2001; Turhan *et al.*, 2002).

Literature search on moisture diffusion data on maize, soybean, cowpea, rice, wheat, sorghum, millet, beans hybrids grown in Nigeria has yielded scanty information no information was found on the water uptake kinetics of sword beans seeds. Moreover, sword bean has higher protein content than cowpea (Borget, 1992). Through empirical models, engineers will proffer optimal solutions that will address the water transfer relationship between various operating conditions and the intrinsic characteristics (physical and chemical property) of the seeds. This necessitates the study of how these parameters influence the rehydration characteristics of sword bean, which is an essential food material in the South West region of Nigeria. Therefore, this study aims to investigate the effects of rehydration temperature on the kinetics of water uptake in sword bean seeds. It also estimates the activation energy for the kinetic constant of the Peleg's Model for sword beans seeds during soaking.

II. MATERIALS AND METHODS

2.1 Material

Sword beans were procured from a neighboring market at Owena in Ondo State Nigeria. The seeds were sorted into samples to remove foreign materials, broken, cracked and damaged grains. The research work experiments were carried out at the Postharvest Engineering laboratory, department of Agricultural and Environmental Engineering, Federal University of Technology, Akure.

2.2 Moisture Content Determination

The standard oven drying method of AOAC (2003) was used in determining the initial moisture content of each variety sample and expressed on a dry basis. 5 grams of each sample was measured using a digital weighing scale to an accuracy of 0.01 g and heated at the temperature of 103+2oC in the oven until a constant weight was achieved (Mahbobeh, *et al.,* (2011); Abodenyi, *et al.,* (2015)). The experiment was carried out in triplicates and the average results were taken and recorded.

The moisture content on dry basis (MC_{db}) was calculated as follows:

$$MC_{db}\% = \frac{W_t - W_d}{W_d} \times 100 \quad (1)$$

Where; W_t = total weight of sample,
$W_t - W_d$ = weight of water in the material, and
W_d = weight of dry matter in the material.

2.3 Blanching

Twenty grams of each sample was put in a screen mesh and placed into a 250 ml beaker. The beaker containing 200 ml of clean water (pH: 7.5 ± 0.2) was heated to 95ºC for 2minutes 30 seconds (Patras *et al*., 2011). Upon boiling, the sample was removed from the water, drained, dried using a towel. It was further allowed to reach equilibrium with the room temperature for some 15 minutes and thereafter weighed.

2.4 Water Absorption

Soaking experiments and modeling techniques were adopted to determine the water absorption capacity of the seeds. The 250 ml beakers contained exactly 200 ml of distilled water, while four different water temperatures (30, 40, 50, and 60ºC) controlled by a thermostatic water bath were used in conducting this experiment on the seeds. A screen mesh containing 5 ± 0.02g of each sample was placed in the beakers immersed in the water bath; this was carried out in triplicates. Uniformity of temperature was ensured by placing the beakers in a constant temperature water bath during tests. 5g of seeds each were randomly selected and placed in a beaker for this experiment. The seeds were intermittently removed during soaking, dried and weighed utilizing the electronic weighing scale and repositioned to the beaker (Seyhan-Gurtas *et al*, 2001).

Once the kernel moisture content reached an equilibrium value, the experiments were ended. Equilibrium value is usually attained when the change in sample mass of the seeds after soaking was less than 0.01g. The operation was conducted at 30 minutes interval until the test was completed and measurements were carried out using digital counting balance (CB-II Series Electronic Balance, Taiwan) (Miano *et al*., 2017). Incremental change in sample moisture content was derived using the incremental change in sample mass during soaking.

2.5 Saturated Moisture Content

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During soaking, initial water absorption was rapid then it became slower in later stages as it approaches a point where no more water or very little water was absorbed. When the resulting increment in weight of soaked grain became less than 0.01 g, the saturation moisture content (M_S) was determined. Thus, M_S of the sword beans legume was recorded for all the soaking temperatures.

2.6 Mathematical Model

2.6.1 Analytical approach

Peleg (1988) proposed a two-parameter empirical equation that was non-exponential, in a bid to dissolve the complexity in describing the water absorption process of food materials. This equation (Peleg) is

$$M_t = M_0 \pm \frac{t}{K_1 + K_2 t} \quad (2)$$

where;M_t = moisture content at a known time (t) (% dry basis);

M_0 = initial moisture content (% dry basis);

t = soaking time (h);

K_1 = Peleg's rate constant ($h\%^{-1}$);

K_2 = Peleg's capacity constant ($\%^{-1}$).

Should the process be absorption or adsorption, the '±' in equation 3 becomes '+', while should it be drying or desorption, the '±' becomes '-'.

Taking the first derivative of Peleg's equation, the rate of sorption (R) becomes;

$$R = \frac{dM}{dt} = \pm \frac{K_1}{(K_1 - K_2 t)^2} \quad (3)$$

K_1 = Peleg rate constant.

This relates to sorption rate at the very beginning (R_0), i.e. R at t = t_0

$$R = \left.\frac{dM}{dt}\right|_{t_0} = \pm \frac{1}{K_1} \quad (4)$$

K_2 = Peleg capacity constant

This relates to maximum (or minimum) attainable moisture content. As t→∞, Equation 4 gives the relation between equilibrium moisture content (M_e) and K_2

$$M|_{t_\infty} = M_e = M_0 \pm \frac{1}{K_2} \quad (5)$$

Where;

M_e = Equilibrium moisture content (% dry basis).

Linearization of Equation 5 gives

$$\frac{t}{M_t - M_0} = K_1 + K_2 t \quad (6)$$

Plotting a graph of $\frac{t}{M_t - M_0}$ on the y-axis and time, t on the x-axis, will result in a straight-line graph, where K_1, K_2, represents the ordinate-intercept and the gradient of the line of the graph. The various properties of Peleg's constants can be determined by the plot on the graph.

Studies in the past have demonstrated the application of Peleg's constants for a wide range of food materials, such as legumes, rice and milk powder (Sopade and Obekpa, 1990; Sopade *et al.*, 1994).

In the study by Sopade and Obekpa (1990), the relationship between K_1 and temperature was discovered to be inverse, while the reciprocal of K_1 defined the initial hydration rate (Equation 6). Sopade *et al.* (1994) also observed the same result in their experiment. They also postulated that K_2 is a characteristic sorption parameter of the food material under investigation.

The reciprocal of K_2 has been proven to be useful in predicting the equilibrium moisture content, while Peleg's equation can be applied to the curvilinear segment of the sorption curve. According to Sopade *et al.* (1992), K_1 could be likened to a diffusion coefficient, while the Arrhenius equation could be utilized in describing the dependence of temperature on the reciprocal of Peleg's constant K_1. This relationship is further described by equation 7 below.

$$\frac{1}{K_1} = K_{ref} exp\left[\frac{-E_a}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right] \quad (7)$$

where;

K_{ref} = reference hydration constant at a reference temperature;

E_a = activation energy (kJ/mol);

R = universal gas constant (= 8.314 kJ/mol/K);

T *and* T_{ref} are the soaking and reference temperatures (K), respectively.

For determining the average experimental soaking temperature, 45^0C was selected for T_{ref}, so as to reduce the co-linearity of K_{ref} and E_a (Gowen *et al.*, 2007a).

Linearization of Equation 7 therefore becomes;

$$ln\left(\frac{1}{K_1}\right) = lnK_{ref} + \left(\frac{E_a}{R}\right)\left(\frac{1}{T_{ref}} - \frac{1}{T}\right) \quad (8)$$

A plot of $ln\left(\frac{1}{K_1}\right)$ against$\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)$, will result in a straight line having $\left(\frac{E_a}{R}\right)$ as the slope. Through this plot, the activation energy is calculated, while the sensitivity of the constant can be evaluated.

2.6.2 Thermodynamic consideration

In the expression below, thermodynamic parameters such as the entropy (ΔS), enthalpy (ΔH) and the free energy (ΔG) of activation can be determined by the E_a value (Jideani *et al.*, 2002; Sanchez *et al.*, 1992)

$$\Delta H = E_a - RT \quad (9)$$

$$\Delta S = R\left(\ln A - \ln\frac{k_B}{h_p} - \ln T\right) \quad (10)$$

$$\Delta G = \Delta H - T\Delta S \quad (11)$$

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2.7 Initial Microflora Determination

To determine the initial microflora, 20g of dried sword beans (dried and undried) samples were added to 20 *ml* Ringers solution in a 0.2*l* bottle. This solution was shaken adequately to make a neat washing. Aseptic dilution of volumes of the solution into 10^{-1}*ml*, 10^{-2}*ml* and 10^{-3}*ml*, were carried out on both the blanched and unblanched samples.

Agar solutions were prepared in triplicate based on the instruction provided by the manufacturer. Sabouraud Dextrose Agar (SDA), Nutrient Agar (NA), Violet Red Bile Agar (VRBA), Baird Parker Medium (BPM) in plates were prepared for each of the samples. Yeast and Mould Count (YMC) was determined on SDA, while Total Viable Count (TVC) was determined on NA. *Staphylococcus aureus* (*S. aureus*) Count was carried out on BPM, and Coliform Count was carried out on VRBA.

The standard spread plate and pour plate method were adopted in determining *S. aureus* counts and (TVC, YMC and Coliform Count) respectively. This was achieved using 0.1 ml aquilots for spread plate and 1 ml aquilots pour plate. Mesophilic counts were determined after the plates were incubated (TVC, Coliforms and *S. aureus* at 37 ^{0}C, YMC at 30 ^{0}C) for 48 hours.

A colony counter was utilized in counting the colonies remaining on the plates after incubation, after which the number of colony forming units per gram (cfu/g) was calculated. The experiment was further carried out thrice.

2.8 Statistical Analysis

The statistical packages used for statistical analysis such as regression and generalized linear model include Microsoft Excel 2007 (Microsoft Corporation) and Minitab 17.0 (Minitab incorporated)

III. RESULTS AND DISCUSSIONS

3.1 Hydration kinetics of selected samples

Figures 1 and 2 showed that water absorption increased as rehydration time increased, but this rate was faster in the initial period of rehydration, while it decreased up till saturation level was reached. High water absorption in the initial period was due to the rapid filling up of capillaries and cavities near the surface as described by García-Pascual *et al*., (2006) and Cunningham *et al.*, (2008). Increased extraction rates of soluble materials ultimately cause the rate of rehydration to reduce as water absorption continues according to Abu-Ghannam and McKenna, (1997). Planinić, (2005), Jambrak *et al*., (2007), Deng and Zhao, (2008) have also reported similar trends in their experiments. Figure 3 shows the direct relationship between solute loss and rehydration time. Thus, it was observed that increasing rehydration time resulted in an increased solute loss. The rate of increment was observed to be faster at the onset of dehydration and decreased up to the saturation level.

As a result of a high rate of mass transfer (solid gradient), there was an initial steep decrease in solid content. This phenomenon explains the variation in dry matter of solid with time. The rate of change of solid dry matter was greatly reduced as the solute concentration attained equilibrium with the environment (Nayak *et al.*, 2006; Rastogi, 2004).

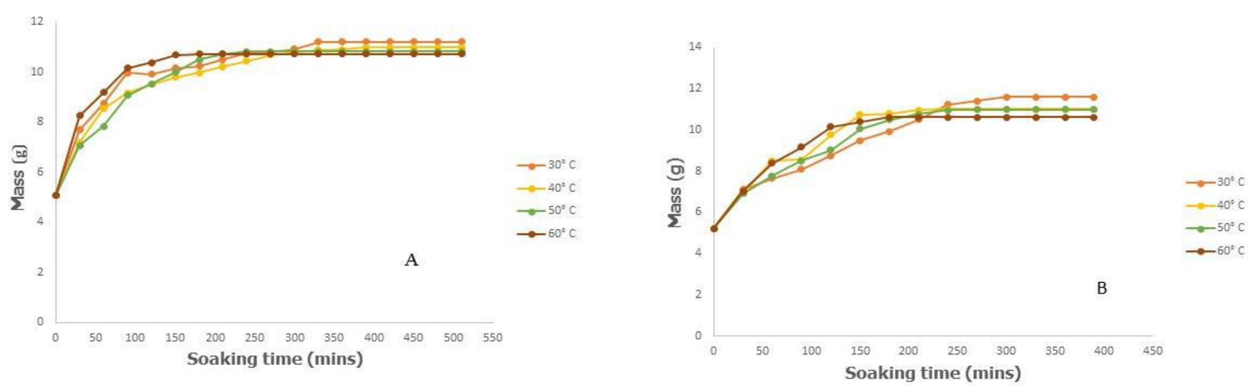

Fig.1: Variation in mass with time during rehydration of blanched (A) and unblanched (B) sword beans at varying temperature

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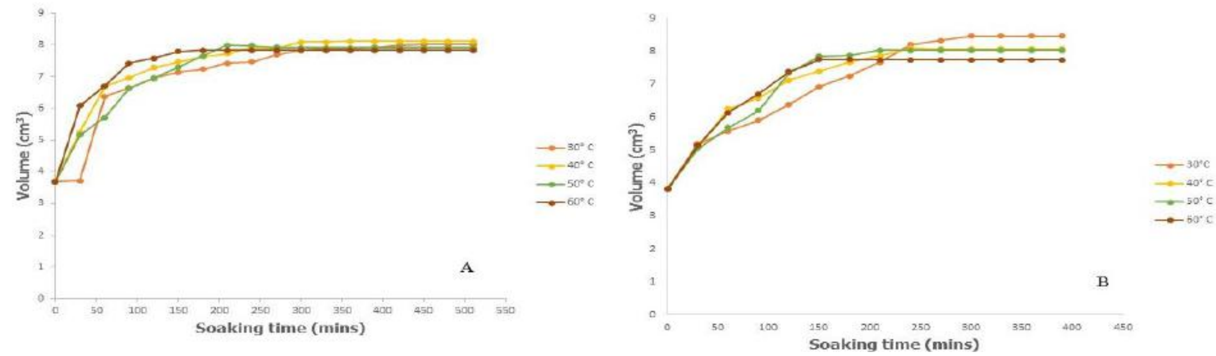

Fig.2: Variation in volume with time during rehydration of blanched (A) and Unblanched (B) sword beans at varying temperature.

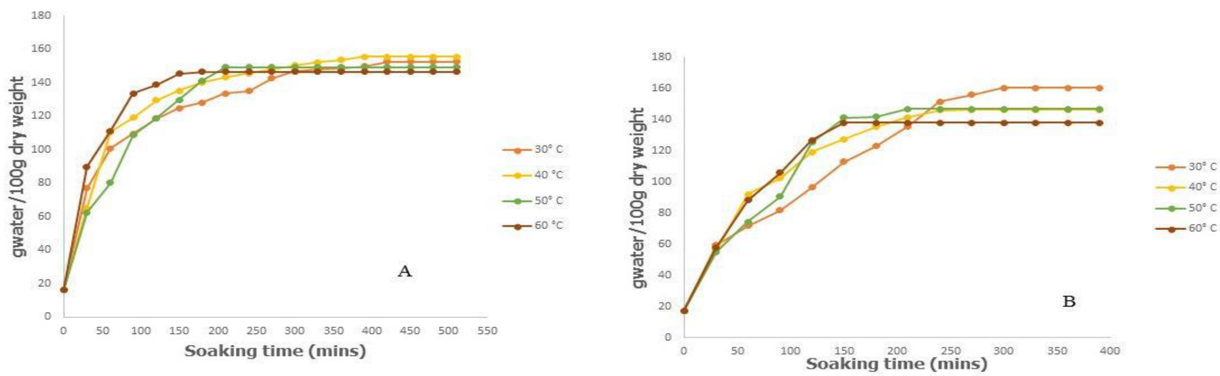

Fig.3: Variation in dry matter with time during rehydration of blanched(A) and unblanched (B) sword beans at varying temperature.

3.2

Effect of Soaking Time on Water Absorption

Figure 4 shows the amount of water present in blanched sword beans seeds at four different soaking temperatures during soaking. It was observed that as temperature increased from 30- 60ºC, there was also a corresponding increase in water absorption. This is due to the linkage between high temperature and high rate of water diffusion. Studies of Sopade and Obekpa, (1990), Pan and Tangra-tanavalee, (2003) resonates with this finding.

Figure 4 shows that the rate of water absorption was fast at the onset of the reaction but slowed down as the reaction approached equilibrium. The asymptomatic behavior observed here is not unconnected to the reduction of impulse for water transfer as hydration progresses and the system approaches equilibrium. Bello *et al.*,(2004) and Solomon, (2007) have also observed similar effect during water soaking of rice and lupin respectively.

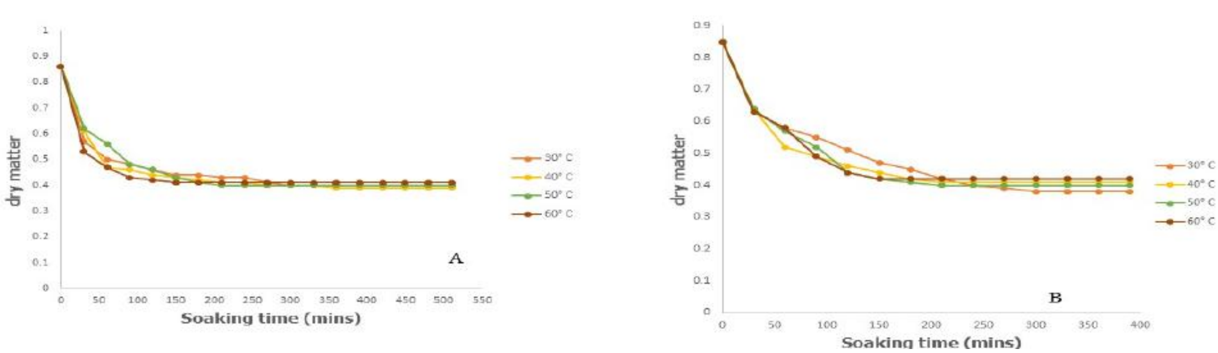

Fig.4: Water absorption characteristics blanched(A) and unblanched (B) sword beans.

3.3 Fitting of Model

It has been shown that grains subjected to varying soaking conditions possess varying water absorption capacity and water absorption rate. Furthermore, several models have expressed the relationship between time and moisture content of seeds in soaking. Thorough knowledge of the water absorption process of seeds during soaking is imperative for researchers and food processors as it determines other processes and overall quality of the final product. Peleg model is not only sufficiently useful in describing the absorption characteristic of various materials during soaking but also for predicting the equilibrium moisture content of grains.

Equation (12) below shows Peleg model:

$$M_t = M_0 + \frac{t}{k_1 - K_2 t} \qquad (12)$$

Where M_t = moisture content at time t (%), M_0 = initial moisture content (%), t = time (h), K_1 and K_2 = the peleg rate ($h\%^{-1}$) and peleg capacity constant ($\%^{-1}$) respectively.

Equation 12 was further re arranged as shown in equation (13):

$$M_t - M_0 = \frac{t}{k_1 - K_2 t} \qquad (13)$$

All the values in this equation is known except the two constant k_1 and k_2, and to get the value of these two constants, the equation (13) was rearranged that a graph of $\frac{t}{[M_t - M_0]}$ against t [time] was plotted for to get the two constant k_1 [the intercept obtained from the graphs] and k_2 [the slope obtained from the graphs].

3.3.1 Peleg model's performance in moisture content estimation

Figure 4 shows the water absorption curves of blanched and unbalanced sword beans at four soaking temperatures. It was shown that there was a significant interaction between soaking time and temperature. The curves obtained are in resonance with those obtained from the water absorption in legumes as observed by Sopade *et al.* (1994), Abu-Ghannam and McKenna, (1997), Seyhan-Gürtas *et al.*,(2001). Peleg's equation fitted to the experimental data within the curvilinear segments of figure 4 and away from the equilibrium conditions is indicated in figure 5. Table 1 shows the output of the linear regression models fitted to the data at hydration temperatures of 30–60ºC.

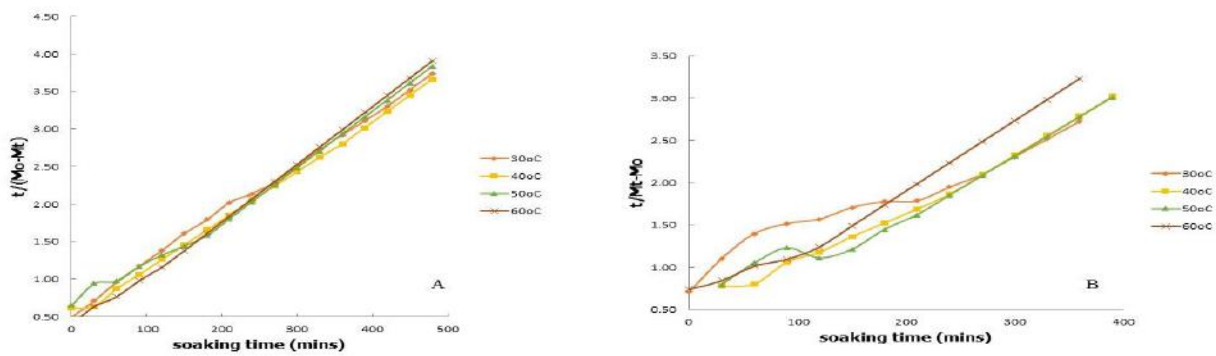

Fig.5: $\frac{t}{[M_t - M_0]}$ *against t for blanched (A) and Unblanched (B) sword beans.*

Table.1: Relationship between Peleg's constant and experiment parameters

Variety	T	K_1	$1/k_1$	K^2	R^2
Blanched sword beans	30	0.946	1.06	0.004	0.9082
Blanched sword beans	40	0.441	2.27	0.006	0.9801
Blanched sword beans	50	0.505	1.98	0.006	0.9274
Blanched sword beans	60	0.541	1.85	0.007	0.9683
Un-Blanched sword beans	30	0.561	1.78	0.006	0.996
Un-Blanched sword beans	40	0.493	2.03	0.006	0.996
Un-Blanched sword beans	50	0.543	1.84	0.006	0.982
Un-Blanched sword beans	60	0.326	3.07	0.007	0.996

The value of crop, K_1, K_2, and co-efficient of determination were tabulated to show the relations between the Peleg's constant and the experimental results in Table 1.

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3.4 Effect of Temperature on Peleg's Rate Constant

In this study, the relationship between temperature and the inverse of K_1 was investigated. Table 2 presents the activation energy Ea which was derived by regression, the coefficient of determination (R^2), and the hydration rate constant at reference temperature (K_{ref}). High activation energy values calculated showed that Arrhenius equation could describe the experimental results over the range of temperature studied. Ea value for unblanched sword beans seeds and unblanched sword beans seeds were calculated to be 14.28 kJ/mol and 13.36 kJ/mol respectively. From the result, water absorption for blanched sword beans was relatively faster than that of unblanched sword beans.

Table.2: Parameters of Arrhenius equation for water absorption during hydration of blanched and un-blanched sword beans

Sword beans	**Temperature (°C)**	**E_a (kJ/mol)**	**K_{ref}**	**R^2**
Blanched	30-60	13.36	1.73	0.38
Un-blanched	30-60	14.28	2.14	0.77

3.5 Thermodynamic Considerations

Thermodynamic parameters such as the entropy (ΔS), enthalpy (ΔH) and the free energy (ΔG) of activation can be determined by the E_a value according to the equation 14. (Jideani *et al.*, 2002; Sanchez *et al.*, 1992):

$$\Delta H = E_a - RT \quad (14)$$

$$\Delta S = R\left(lnA - ln\frac{k_B}{h_p} - lnT\right) \quad (15)$$

$$\Delta G = \Delta H - T\Delta S \quad (16)$$

Where; R = universal gas constant,

ln A = the ordinate intersection when regression analysis is applied to the plot obtained in calculation of E_a,

k_B = Boltzmann constant (1.38×10^{-23} J K^{-1}),

h_p = Planck constant (6.626×10^{-34} J S) and

T = absolute temperature.

Negative results obtained for enthalpy (ΔH*) in Table 3 indicates that the reaction between the soaking water and the seeds is exothermic. An increase in system order i.e a less degree of disorderliness occurs as a result of the negative (ΔS) obtained which indicated a decrease in entropy as the reaction proceeded. Dannenberg and Kessler (1988) explained that a negative entropy of activation is derived for the activated complex when the degrees of freedom of rotation is lost during the formation of the complex. It can also be deduced that the transitional state was in a higher state of order than the reactant particles. ΔG is positive as the reaction is endothermic and indicates that a sufficient amount of energy is required from the surroundings (Reusch, 2007). Furthermore, it can be deduced that the seeds were more thermally stable since there was a relatively low value of Ea and negative values were obtained for entropy of activation for both blanched and unblanched sword beans. Changes in hydration were also less influenced by temperature.

Table.3: Thermodynamic parameters for hydration of blanched and un-blanched Sword beans

Variety	Temp. (°C)	ΔH (cal/mol)	ΔS (cal/Kmol)	ΔG (Kcal/mol)	Ea (kJ/mol)
Blanched sword beans	30	-2505.78	-240.48	70358.51	13.36
Blanched sword beans	40	-2588.92	-240.75	72764.65	13.36
Blanched sword beans	50	-2672.06	-241.01	75173.41	13.36
Blanched sword beans	60	-2755.2	-241.26	77584.76	13.36
Un-Blanched sword beans	30	-2504.87	-238.73	69830.41	14.28
Un-Blanched sword beans	40	-2588.01	-239.00	72219.07	14.28
Un-Blanched sword beans	50	-2671.15	-239.26	74610.39	14.28
Un-Blanched sword beans	60	-2754.29	-239.52	77004.28	14.28

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3.6 Effect of Time–Temperature Combination on Hydration of sword beans Seeds

Equation 17 which represents a generalized model was proposed to describe the kinetics of water intake of sword bean seeds. The equation was considered in a bid to adopt the Arrhenius temperature dependence of K_1.

$$Mt = M_o + \frac{t}{\left[K_{ref}exp\left(\frac{-E_a}{RT}\right)\right]^{-1} + K_2 t} \qquad (17)$$

Equation (17) was utilized in predicting the absorbed water with respect to temperature (T) and time (t) by estimating the values of K_{ref}, K_2 and Ea. Figure 6 shows the time-temperature relationship of water absorption for both blanched and unblanched sword beans. Peleg's and Arrhenius equation were used in predicting the water absorption of the legume varieties as shown by the three-dimensional representations. The geometrical representation provided detailed information on the water absorption behavior within the experimental design.

It was observed that for the first thirty minutes of soaking, water was absorbed quickly for all varieties, after which there was progressive attainment of equilibrium moisture content. Water intake was minimal after this stage. Previous studies by Heil *et al.*, (1992) and (Marconi et al. (1993) showed that these processes are vital in controlling the water entry into dry seeds. The steepness of the temperature curve explains the intensity of the effect of temperature on absorbed water. An increase in the initial slope of the water intake curve results from the increases in the soak-water temperature, while the time required to attain equilibrium moisture content therefore decreased. Prolonged seed soaking increased seed moisture content but remained unaffected as soak time increased.

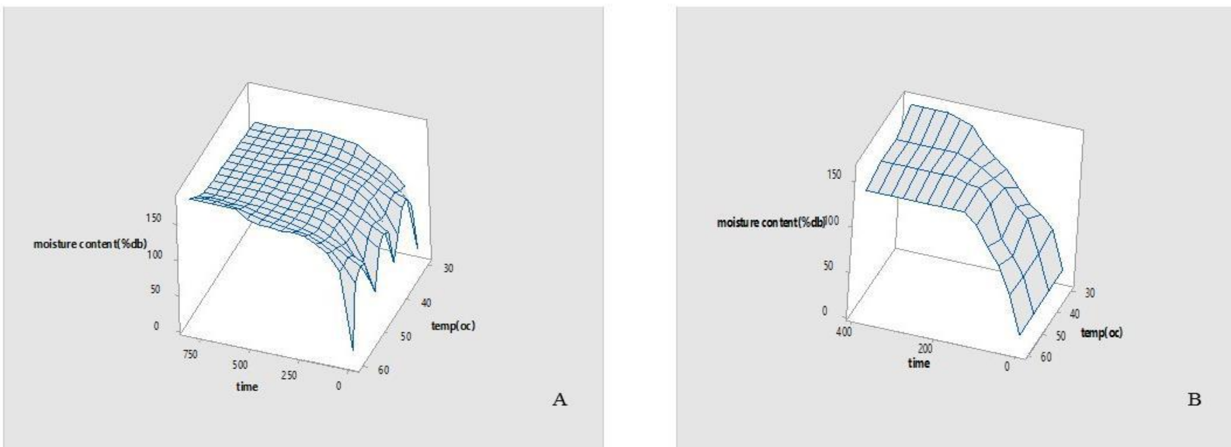

Fig.6: Response surface pattern for moisture absorption of blanched (A) and Unblanched (B) sword beans.

3.7 Effect of Blanching on Time Taken to Reach Equilibrium Moisture

Table 4 shows the period for which equilibrium moisture was attained for both unblanched and blanched sword beans. The blanching effect was observed to be greatest at 40ºC, as the pre-blanching step decreased the required soaking time by some 120 minutes. More so, the time required to reach equilibrium for blanched and unblanched at 50ºC had the same value. This explains why pre-blanching had zero effect at 50ºC for sword beans.

Table.4: Time taken to reach equilibrium texture level for un-blanched and blanched sword beans

Temperature (°C)	Blanched Sword beans	Un-blanched Sword beans
30	390	450
40	270	390
50	210	210
60	150	180

3.8 Microbiological Evaluation

Microbial counts and average microbial profile for dry sword beans before and after blanching respectively are displayed in Figure 7. YMC, AVC, and TVC for dry sword beans were observed to be within satisfactory microbial levels for dry foods (Gilbert et al., 2000). While TVC, S. aureus, and YMC were significantly reduced by blanching ($p < 0.05$), the Coliform Count showed a little increase for sword beans after blanching. The average coliform count was slightly below the acceptable microbial level for dry foods (Acceptable level <100 cfu/g, Gilbert *et al.*,2000).

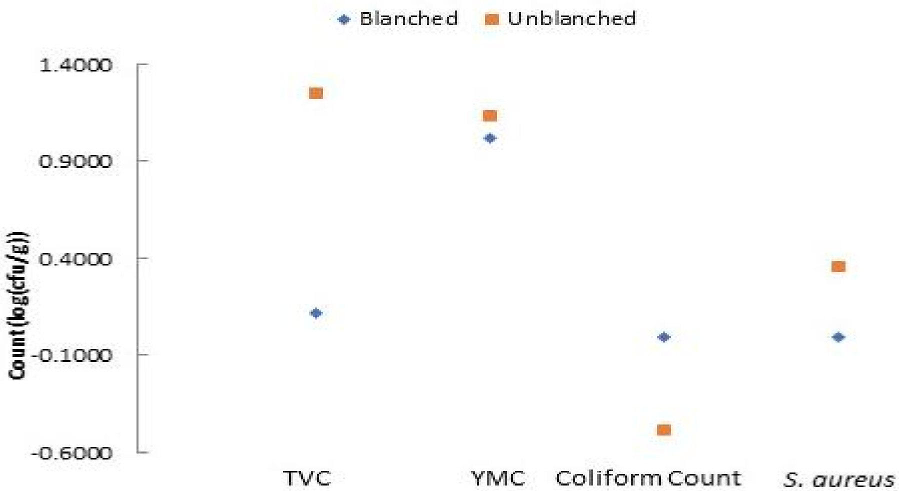

Fig.7: Average profiles of microbial counts for unblanched and blanched sword beans.

IV. CONCLUSIONS

Most of the water intake of all selected crops occur at the first soaking time of 30 minutes and takes up little it could at the rest of the soaking time. Prolonged seed soaking increased seed moisture content but remained unaffected as soak time increased. An increment in soaking temperature resulted in the decreased time taken to achieve equilibrium moisture. The blanching effect was observed to be greatest at 40ºC, as the pre-blanching step decreased the required soaking time by some 120 minutes. Increment in water absorption rate between the final and initial soaking temperatures was not the same for each variety and this could be attributed to the difference in the nutrient and physicochemical composition of the varieties. Arrhenius equation adequately described the temperature dependency of water absorption of sword bean and showed that high soaking temperature reduced the time required to achieve equilibrium moisture. The activation energy for blanched and unblanched sword beans was discovered to be 14.28 KJ/mol and 13.36 KJ/mol respectively. The initial microbial counts on dry beans were minimized by blanching, thus, there was a reduction in risk posed by microbe proliferation during soaking. The result of water kinetics of sword beans will provide information that can be used in solving problems involved in predicting storability conditions, design problems, predict energy requirements in post-harvesting techniques of the product.

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