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# Lab 6: Food Preservation by Means of Moisture Control

## I. PURPOSE/OBJECTIVE:

The purpose of this lab is to compare totally dehydrated food with intermediate moisture food in terms of water activity, to plot % moisture versus water activity to determine adsorption or desorption isotherm for potato flakes and dog food, and to estimate the initial water activity of the dog food from a plot of percent moisture change versus water activity.

## II. INTRODUCTION:

For centuries, food consumers and scientists have known that a relationship exists between the water content of foods and food spoilage. Thus, dehydration of foods is often used as a means of preservation. Due to the fact that water content is not a reliable indicator of food spoilage potential, water activity must be measured as a means to evaluate this. Water activity influences the rates of microbial growth, enzyme activity, oxidation, vitamin loss, and non-enzymatic browning. Water activity is most important in it's influence of microbial growth. This is because microbial growth is more related to water activity than it is to the percentage of water in the medium, or moisture content.

Dehydrated foods have water activities below or equal to 0.60, have low moisture contents, and are stable against microbial spoilage. Examples are dried potato flakes, crackers, dried vegetables, nuts, cocoa, chocolate, honey, spices, candy, and dry noodles. Intermediate moisture foods, such as dog food, on the other hand, have water activities between 0.75- 0.85, are semi-moist (20-30% moisture), with water bound by humectants to lower water activity, and are fairly stable against microbial spoilage. Examples of intermediate moisture foods are jams, molasses, dried fruit, syrup, aged cheese, fruit cake, some types of salami, and licorice. Water activity is defined as the ratio of water vapor pressure of the system (p) to the vapor pressure of pure water (po) at the same temperature. Foods with the same water activities do not necessarily have the same water content.

## III. PROCEDURE:

"The procedure followed for the experiment is found in "Principles of Food Composition Laboratory Manual" (2010) Experiment 6, Preservation by Means of Moisture Control.

**IV. DATA/Results:**

Table 1.1: Raw Data for Potato

| **Solute** | **$a_w$** | **Dish Weight (g)** | **Initial Dish + sample (g)** | **Final Dish + sample (g)** | **% Water (initial)** |
|---|---|---|---|---|---|
| **K-acetate** | 0.225 | 1.8 | 4.3 | 4.2 | 0.0 |
| **$Mg(NO_3)_2$** | 0.520 | 1.9 | 4.4 | 4.4 | 0.0 |
| **NaCl** | 0.755 | 1.8 | 4.3 | 4.5 | 0.0 |
| **KCl** | 0.845 | 1.9 | 4.4 | 4.8 | 0.0 |
| **$KNO_3$** | 0.930 | 1.9 | 4.4 | 5.1 | 0.0 |

Table 1.2: Raw Data for Dog Food:

| **Solute** | **$a_w$** | **Dish Weight (g)** | **Initial Dish + sample (g)** | **Final Dish + sample (g)** | **% Water (initial)** |
|---|---|---|---|---|---|
| **K-acetate** | 0.225 | 1.8 | 5.8 | 5.2 | 21.1 |
| **$Mg(NO_3)_2$** | 0.520 | 1.8 | 5.8 | 5.2 | 21.1 |
| **NaCl** | 0.755 | 1.9 | 5.9 | 5.6 | 21.1 |
| **KCl** | 0.845 | 1.8 | 5.8 | 5.6 | 21.1 |
| **$KNO_3$** | 0.930 | 1.8 | 5.8 | 6.1 | 21.1 |

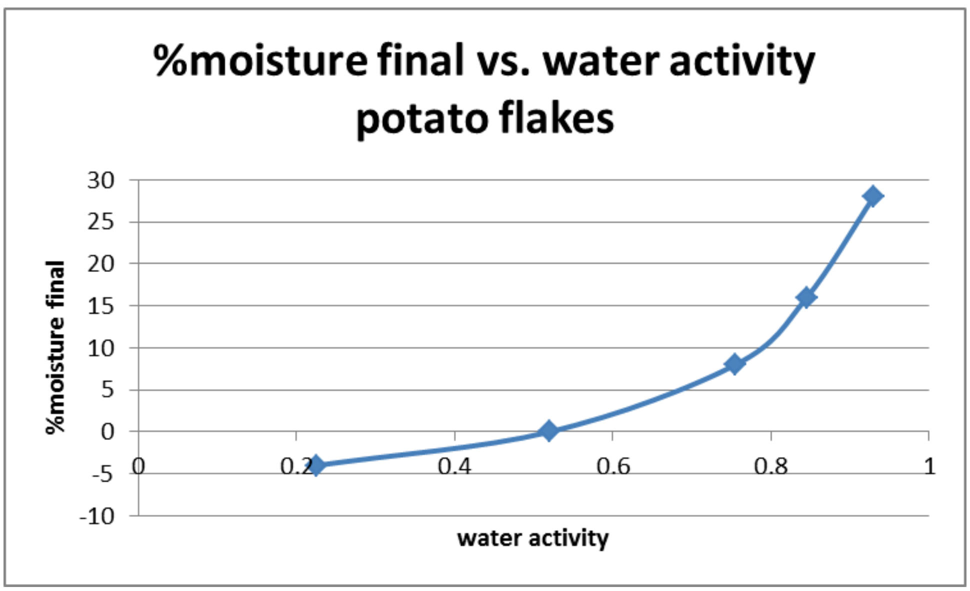
Table 2.1: Calculated data for potato

| Potato | | | | | |
|---|---|---|---|---|---|
| Solute | $a_w$ | $WT_{init}$ (grams) | $WT_{final}$ (grams) | $WT_{dry}$ (grams) | % $moisture_{final}$ |
| K-acetate | 0.225 | 2.5 | 2.4 | 2.5 | -4.0 |
| $Mg(NO_3)_2$ | 0.520 | 2.5 | 2.5 | 2.5 | 0.0 |
| NaCl | 0.755 | 2.5 | 2.7 | 2.5 | 8 |
| KCl | 0.845 | 2.5 | 2.9 | 2.5 | 16 |
| $KNO_3$ | 0.930 | 2.5 | 3.2 | 2.5 | 28 |

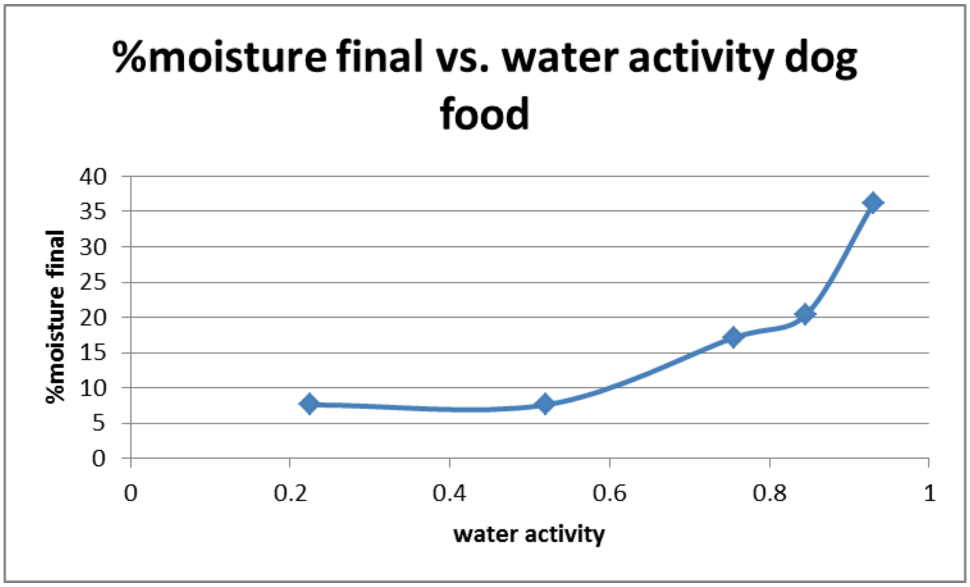
Table 2.2: Calculated data for dog food

| Dog Food | | | | | | |
|---|---|---|---|---|---|---|
| Solute | $a_w$ | $WT_{init}$ (grams) | $WT_{final}$(grams) | $WT_{dry}$ (grams) | % $moisture_{final}$ | %moisture change |
| K-acetate | 0.225 | 4.0 | 3.4 | 3.16 | 7.6 | -19.0 |
| $Mg(NO_3)_2$ | 0.520 | 4.0 | 3.4 | 3.16 | 7.6 | -19.0 |
| NaCl | 0.755 | 4.0 | 3.7 | 3.16 | 17.1 | -9.5 |
| KCl | 0.845 | 4.0 | 3.8 | 3.16 | 20.3 | -6.3 |
| $KNO_3$ | 0.930 | 4.0 | 4.3 | 3.16 | 36.1 | 9.5 |

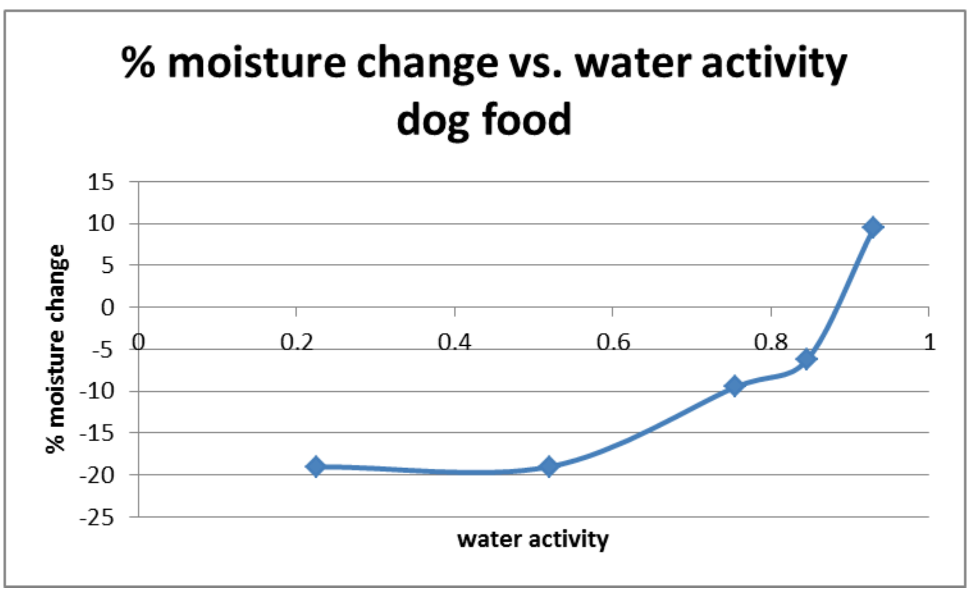
Graph 1



Graph 2:




Graph 3:



**V. CALCULATIONS:**

**Dry sample weight (for Potato with K-acetate)**

$wt_{dry}$= dry sample weight = (1-$X_{water}$) $wt_i$
(the dry sample weight is the appropriate fraction of the initial wet sample weight)

$X_{water}$ = fraction of water in sample

For potato, initial sample weight equals dry sample weight (ie $X_{water}$ = 0)

$wt_{dry}$= dry sample weight (g)= (1-$X_{water}$) $wt_i$

$wt_{dry}$= (1-0) $wt_i$

$wt_i$ for potato with K-acetate = 2.5g

$wt_{dry}$= (1)(2.5g)

**$wt_{dry}$= 2.5g for potato with K-acetate**

**% Moisture final (for potato with NaCl)**

% moisture final, dry weight basis = ($wt_f$-$wt_d$/ $wt_d$ ) x 100

Refer to Table 1.1, Values for potato with NaCl
$wt_f$ = 2.7g
$wt_d$ = 2.5g

% moisture final = ($wt_f$-$wt_d$/ $wt_d$ ) x 100

% moisture final = (2.7g-2.5g/ 2.5g) x 100

**Moisture final = 8% for potato with NaCl**

**% Moisture change (for dog food with K-acetate):**

% moisture change, dry weight basis = ($wt_f$-$wt_i$/ $wt_d$ ) x 100

Refer to Table 1.2, Values for dog food with K-acetate
$wt_f$ = 3.4g
$wt_d$ = 3.16g
$wt_i$= 4.0g

% moisture change = ($wt_f$-$wt_i$/ $wt_d$ ) x 100
% moisture change = (3.4g-4.0g/ 3.16g ) x 100

**Moisture change = -19% for Dog food with K-acetate**

**VI. DISCUSSION:**

As is seen from the results in the tables and the graphs, as the % moisture final increases, the water activity increases as well. This pattern is not linear, however. As is seen in the graphs for both dehydrated potato flakes and for the dog food. Potato has low moisture content and dog food has an intermediate moisture content, however, both foods were completely dehydrated and then rehydrated to achieve the desired water activity. This is shown through the adsorption curves of both graphs.

Five relative humidity chambers for each material were prepared with the five saturated salts used in the lab. In order to get the desired water activity students placed the sample of food in an enclosed chamber with foil and the salt. In order to get the desired water activities and relative humidities for each food, the five different saturated salts were used, one per chamber, for both the dog food and potato samples. Using a set amount of saturated salts, for example for dog food with K-acetate, and potato with K-acetate, enabled students to accurately compare the data of dog food to potato flakes under the same relative humidities for each salt. Each salt had it's own relative humidity because the salts had different water binding properties, and different affinities for water. Therefore, they were able to absorb moisture in different amounts.

While the water activities were the same for each salt added to the different chambers, the % moisture finals were different for the dehydrated potato flakes and the intermediate moisture dog food. Initially, the water activity for the salts K-acetate and $Mg(NO_3)_2$ was similar to that of the dog food, so there was not much of an incline as their was with the potato flakes in the beginning. Thus, for dog food the $\%moisture_{final}$ was 7.6% for both the K-acetate and $Mg(NO_3)_2$ humidity chambers. It then began to show an adsorption curve with the next three saturated salts, and the $\%moisture_{final}$ increased.

The potato flakes, on the other hand, started with a low $\%moisture_{final}$ value, and then increased as it was dehydrated and then rehydrated with the higher relative humidities, as the adsorption curve typically does. From these graphs, it is clear that the water activity increased with a relatively stable moisture for dog food (an intermediate moisture food) which means that dog food is less stable against microbial growth. As water activity increases, specifically past 0.6, microbial growth will occur. On the other hand, potato flakes needed a higher moisture content for higher water activities. This demonstrates that potato flakes, being a dehydrated food with a low moisture content, is more stable against microbial growth. This is because it needs higher relative moisture contents for an increase in water activity. It is important to note that these are relative moisture contents with water activity because, upon looking at the raw data, dog food naturally has higher moisture final moisture percentages, due to the fact that it is an intermediate moisture food. Thus, it naturally had more initial moisture than potato flakes. Intermediate foods typically have 20-30% moisture contents, while dehydrated foods have very low moisture contents.

Although this was a straight-forward experiment, there were some notable major sources of error. Upon moving the tray with the potato flakes, even the slightest movements caused the potato flakes to fly away. This was easy to disregard as unimportant, however, the potato flakes flying off of the tray would inextricably affect the weight of the potato flakes on the tray. Although, our group thought we had very consistent weights for potato flakes, as seen in the data table 1.1, in reality, the initial weights could have been off due to the fact that potato flakes flew off. If the weights were skewed, this would lead to inaccurate calculations for final moisture percentages. For instance, if there was less dried potato flakes in one sample, it would take even more moisture to get to a higher water activity, which would alter the curve on the graph.

Additionally, the chambers were made by the students and it was essential that students cut three triangles in the foil covering the samples. Due to the fact that the chamber were student-made, it was very easy to over-cut the foil, which would lead to air coming in at the top and thus a further addition of moisture to the environment. The chambers, being student made, also were not sealed very well, which would affect the relative humidities of the chambers, and thus the reported water activity in the data. With altered water activities in the data, the graph curve would look either more or less curved like an adsorption curve. Additionally, the data reported for the $\%moisture_{final}$ in table 1.1 for K-acetate with potato flakes was a negative number (-4.0g). This was due to the fact that the final weight in grams of potato flakes was less than that of the initial weight. This could have been due to the potato flakes flying off the sample when weighing it, or an initial error in the recorded initial weight of the potato flakes for K-acetate.

**VII. CONCLUSION:**

This lab enabled students to compare totally dehydrated food with intermediate moisture food in terms of water activity, to plot % moisture versus water activity to determine adsorption or desorption isotherm for potato flakes and dog food, and to estimate the initial water activity of the dog food from a plot of percent moisture change versus water activity. The goals of the lab were achieved through student- made relative humidity chambers with saturated salts K-acetate, $Mg(NO_3)_2$, NaCl, KCl, and $KNO_3$. The different saturated salts enabled students to see first hand which salts had higher affinities for water and were better humectants. Thus, this enabled students to determine final moisture contents and how that affected the water activity of both dig food and potato flakes.

Through the data table and graphs, it was clear how each salt was adjusted to the desired relative humidities, and thus how the relative humidities affected the water activities of both the dog food and potato flakes. This enabled students to see the difference between a totally dehydrated food (potato flakes) and an intermediate moisture food (dog food). As seen through the graphs, both foods were adsorptions, meaning they were dehydrated and then re-hydrated to the desired water activities of the saturated salts. It was clear that as moisture content increased from K-acetate chambers to the $KNO_3$ chamber, water activity decreased as it absorbed more moisture. The graphs were the only way to determine the relationship between the water content of the food and the water activity and it enabled students to see, first-hand, the effects of moisture on water activity.

The potato flakes water activity plataued and then increased as the final moisture percentage increased from -4 to 28%, and the water activity increased as the final moisture percentage increased from 7.6% to 36.1% for the dog food. It was easy this way to see how the dog food started with an intial moisture content, which stayed the same for the first few points, whereas potato flakes started getting rehydrated earlier, due to the fact that they area dehydrated food. Through this, students could infer that potato flakes are generally more stable against microbial spoilage due to the fact that they have a lower overall moisture content.

Although the graphs were essential in understanding the elements of the experiment, the problems with this experiment were the student- created chambers, and the fact that the potato flakes were flying everywhere. Errors in these both could have led to skewed graphs and calculations, thus affecting the overall picture of the experiment. To improve this in the future, labs should have set up chambers, and the dried, dehydrated food should be crushed up crackers for instance, instead of potato flakes. Crushed up crackers could be more contained and easy to work with.

**VIII. QUESTIONS:**

1. The plot of % moisture vs. water activity for the dehydrated food that is shown in graph 1.1 is an example of moisture adsorption, in which a completely dehydrated food is rehydrated to a desired water activity. In order to get desorption, one would need to simply remove the moisture from a food until the desired water activity is reached.

2. The initial water activity from the graph of % moisture change versus water activity, which is also where the % moisture change is zero would be at $a_w$ of 0.9. Because most foods have $a_w$'s between 0.2 – 0.99, foods with a water activity value of 0.9 is considered high. At this water activity, microbial growth can occur, as well as molds and yeasts. Thus, an $a_w$ =0.9 is not very stable against microbial growth. However, it is important to note that a food is usually more stable against microbial spoilage if it's water activity is adjusted by adsorption, as is the case here.

3. The IMF data we obtained corresponds to that of adsorption isotherms. Due to the shape of the plot, which is in the form of an adsorption isotherm, we can see that the dog food must have been de-hydrated and then re-hydrated to achieve the desired water activity. The graph is an adsorption for both the %moisture final vs. water activity and %moisture change vs. water activity.