COMPARISON OF CATALYTIC RATES OF REACTION OF BUCCHLOZIA CORIACEA FRUIT BY COOKING

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1.0 ABSTRACT

In this work, four catalyst, iron (II) oxide, papain, fiber and potash were used in the cooking process and the result shows that potash was the best catalyst for the tenderization of wonderful cola. Comparing fig. 7 to that of activation energy diagram (fig. 1), it took 470mins for potash to overcome the activation energy, while uncatalyzed, cola, papain, fibre and iron (II) oxide use 1075,920,780 and 680mins respectively to overcome their activation energies. Also, it took 430mins for the potash catalyzed reaction to register the first positive enthalpy change while it took 780,580,560 and 480mins for the uncatalyzed, cola papain, fiber and iron (II) oxide (nail) respectively ie decreasing times or increasing reaction rates.

The times to overcome their activation energies all occurred at the particle size of 2.15g while the minimum times for catalysts (or heat of overall reaction) were 4g (Fig. 7).

Keywords: *Bucchlozia coriacea, catalyst, activation, reaction rates.*

2.0 INTRODUCTION

Wonderful cola is a highly productive plant of West Africa, belonging to the group of economic edible food whose seed contain about 60% carbohydrate content [1]. It is highly medicinal but takes a very long time to properly cook. This limits its economic importance and use as human food, and so, scarce in the market[1].

Bucchlozia coriacea seed has a hard seed-coat that makes it very difficult for easy penetration of water, and heat, while cooking. In our experiment we intend to introduce the idea of simple technique of particle size distribution (breaking the seed into different size[2]) and comparing the catalytic rates in their cooking. Biologically, the plants belong to the family of Nigerian plant called "Sterculiacea" and a related family of Tiliaceae. Previous work by Ajaiyeoba, et. al[3],(2000) done on the fraction prepared from the methanol extract of this plant stem bark, exhibited a high concentration of antibiotic ampicillin and tioconazole[4].

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2.1 The Arrhenius Energy Level

In the Arrhenius equation:

$$K = Ae^{-E/RT} \quad \text{.....................(1)}$$

The value of K rests substantially on the accuracy with which it represents experimental rate-temperature data (Fig. 1). When measured rates do not agree with the theory it is usually found that the reaction is not an elementary step or that physical resistances are affecting the measurements. In other words, equation (1) correlates remarkably well the rate measurements for single reactions free of diffusion and thermal resistances. The Arrhenius equation provides no basis for discerning the value of E. However, Fig. 1 indicates that the activation energy must be greater than the heat of the overall reaction, ?H, for an endothermic case[5,6]

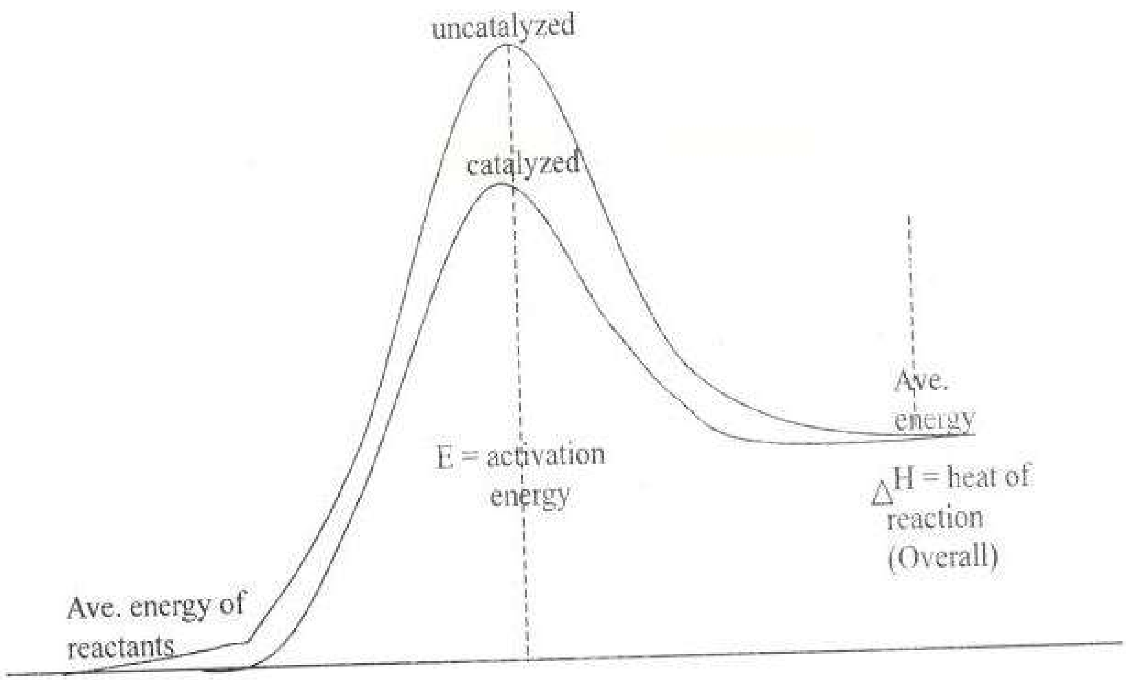

Figure1: Energy levels of initial, activated and final states

In view of the success of the Arrhenius equation, there have been many attempts to develop theoretical interpretations for the frequency factor A and the activation energy E. The logarithmic form of Arrhenius equation is

$$\ln K = \ln A - \frac{E}{R}\frac{1}{T} \quad \ldots\ldots\ldots (2)$$

This is a linear relation between K and T with a slope of - E/R. If (Ti, Ki) T represents one of n data points, the values of A and E/R which describe the least-mean-spare fit are

$$\frac{E}{R} = \frac{n\sum_{i=1}(\ln K_i)(1/T_i) - \sum_{i=1} 1/T_i \quad \sum_{i=1} \ln K_i}{n\sum_{i=1}^{n}(1/T_i)^2 \quad - \left(\sum_{i=1}^{n} 1/T_i^{\,2}\right)} \quad \ldots R\,(3)$$

$$\ln A = \frac{n\sum \ln K_i \sum (1/T_i)^2 - \sum 1/T_i \sum(1T_i \ln K_i}{N\sum(1/T_i)^2 - (\sum 1/T_i)^2} \quad \ldots\ldots (4)$$

But the Van't Hoff equation has it as

$$\frac{d(\ln K_2)}{dT} \cdot \frac{d(\ln K_1)}{dT} = \frac{\Delta H^0}{RT^2} \quad \ldots\ldots (5)$$

which may be split into forward and reverse reactions with $\Delta H = \Delta H_2 - \Delta H_1$..... (6)

The major objective of this work is to compare the catalytically rates of chemical reaction in cooking the seed of this plant for edibility (in terms of activation and reaction heat) i.e. using different catalysts to speed up the cooking while their individual effects are monitored by carefully noting the time duration and volume of water consumed for the seed to be done[7]. Here the un-catalyzed reaction serves as the control experiment.

3.0 METHODOLOGY

3.1 Processing

A particular group of the fruit collected for the experiment was kept in a cool environment, covered with palm leaves or plantain leaves for two weeks. This helps to soften the first greenish hard coat that covered the seeds. When the greenish hard coat became yellowish in color and softer, the seeds were then extracted by peeling and washing.

The bucchlozia coriacea seed is extracted from its pod, washed and weighed on a weighing balance to get the weight for the different particle sizes used for the experiments i.e. fractions of 1(29.55g), $^1/_2$ (14.53g), $^1/_3$(9.20g), $^1/_4$(7.20g), $^1/_5$(4.52g) and $^1/_6$(3.74g). The catalyst to be used for the catalyzed reaction was divided into two equal halves and weighed to get the same weight for each. Pot A and B, which are vessels of same size and make, each containing two of the particles sizes to be cooked at the same time, from which the average value of the volume of water is taken at the end of each experiment.

A cooking gas with two burners was used for pots A and B in order to achieve constant heating through out the experiment. (500 x 4)cm^3 of water was put into each pot, allowed to boil, before the catalyst, if it is catalyzed reaction, was to be introduced. Boiling water was quickly added to the pot as the volume of water in the pot reduces. The addition of boiled water, which was constantly provided by a very big pot heated on a stove, positioned very close to the cooking gas, was to make sure that there was negligible reduction of temperature of the volume of water already in the pots for the experiment before addition.

Once the fruit was done and removed from the pots, the remaining water in the pot was measured and subtracted from the total volume added. The actual volume consumed was gotten by calculating the average volume, since two same particles sizes, of the seed was added and considered at the same time in each pot.

Cooking was terminated when the seed became tender, and, at this time, the color changes to light black with the release of the specific aromatic smell. The time of cooking was also noted also noted (in minutes). The same procedure was carried out for all the different particle sizes considered in both catalyzed and uncatalyzed (control) experiments.

The following precautions were taken to obtain accurate results.

(1) Same vessels were used for all the experiments.

(2) Same quantity of the different catalyst was used in all the catalyzed reaction.

(3) Boiled water was provided very close to the pot and added to avoid noticeable drop in the temperature of the water during the experiment.

(4) Windows and doors were closed to avoid air current.

Results

The results of the experiments are as tabulated below:

Table 1: Control experiment (Uncatalyzed reaction)

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Particle size (g)	Volume of water consumed (cm^3)	Time spent (mins)
1(29.55)	13897.5	1032
$^1/_2$(14.53)	10339	900
$^1/_3$(9.2)	8166	744
¼(7.15)	7951	730
$^1/_5$(4.52)	6972.5	640
$^1/_6$(3.73)	6635	620

Table 2: Papain Catalyzed Reaction (Catalyst A)

Particle size (g)	Volume of water consumed (cm^3)	Time spent (mins)
1(29.55)	8925	720
$^1/_2$(14.53)	7800	630
$^1/_3$(9.2)	7100	600
¼(7.15)	6950	542
$^1/_5$(4.52)	5672	455
$^1/_6$(3.73)	4962.5	445

Table 3 : Potash (KOH) Catalyzed Reaction (Catalyst B)

Particle size (g)	Volume of water consumed (cm^3)	Time spent (mins)
1(29.55)	7800	630
$^1/_2$(14.53)	6700	490
$^1/_3$(9.2)	6275	475
¼(7.15)	5450	445
$^1/_5$(4.52)	4600	325
$^1/_6$(3.73)	3975	305

Table 4 : Nail Fe_2O2) Catalyzed Reaction (Catalyst C)

Particle size (g)	Volume of water consumed (cm^3)	Time spent (mins)
1(29.55)	8745	660
$^1/_2$(14.53)	7425	540
$^1/_3$(9.2)	6945	490
¼(7.15)	6492.5	470
$^1/_5$(4.52)	5450	425
$^1/_6$(3.73)	4842	415

Table 5: Fiber Catalyzed Reaction (Catalyst D)

Particle size (g)	Volume of water consumed (cm^3)	Time spent (mins)
1(29.55)	8475	710
$^1/_2$(14.53)	7245	560
$^1/_3$(9.2)	6925	510
$^1/_4$(7.15)	6350	490
$^1/_5$(4.52)	5245	435
$^1/_6$(3.73)	4485	425

Table 6: Volume of Water Consumed for both Catalyzed and Uncatalyzed Reaction

Particle Size (g)	Exp. 1 Uncatalyzed (cm^3)	Exp. 2 Papain Catalyzed (cm^3)	Exp. 3 H (KOH) Catalyzed (cm^3)	Exp. 4 Nail (Fe_2O_3) Catalyzed (cm^3)	Exp. 5 Fiber Catalyzed (cm^3)
1(29.55)	13897.5	8925	7800	8745	8475
$^1/_2$(14.53)	10339	7800	6700	7425	7245
$^1/_3$(9.2)	8166	7100	6275	6945	6925
$^1/_4$(7.15)	7951	6950	5450	6492.5	6350
$^1/_5$(4.52)	6972.5	5672	4600	5450	5245
$^1/_6$(3.73)	6635	4962.5	3975	4842	4485

Table 7: Time Taken for both Catalyzed and Uncatalyzed.

Particle Size (G)	Exp. 1 Uncatalyzed (mins)	Exp. 2 Papain Catalyzed (Mins)	Exp. 3 Potash (KOH) Catalyzed (mins)	Exp.4 Nail (Fe_2O_3) (mins)	Exp. 5 Fiber Catalyzed (mins)
1(29.55)	1032	720	630	660	710
$^1/_2$(14.53)	900	630	490	540	560
$^1/_3$(9.2)	744	600	475	490	510
$^1/_4$(7.15)	730	542	445	470	490
$^1/_5$(4.52)	640	455	325	425	435
$^1/_6$(3.73)	620	445	305	415	425

4.0 DISCUSSION

From the result tables 1-7 and figures 2-9 one can observe that the uncatalyzed experiment 1 had the longest time and largest volume of water consumed. Also, for the catalyzed reactions, a trend was observed, except that a slight deviation was found in nail and fiber catalyzed reactions from the fact that, as the time spent increased, the volume of water consumed, also, increased. This is true, that, the rate of evaporation increases with the rate of heating as the contents boils[8,4].

A slight deviation of this fact is seen in the nail and fiber catalyzed reactions: it was expected that fiber catalyzed reaction, having a longer time of reaction (cooking) than that of nail catalyzed reaction, will also have a larger volume of water consumed but the reverse was the case. The palm fruit fiber as one of the catalyst used, contains some little amount of oil, which serves as an impurity in the water used for the experiment and so increases its boiling point[4]. Also, the presence of oil on top of the boiling water surface acts as a coating material and reduces the rate of evaporation of water[9].

Generally, comparison of catalyzed and uncatalyzed reactions show that the reaction time and volume consumed in each case of the catalyzed reactions is shorter than that of uncatalyzed (control experiment) (Fig. 7).

For the catalyzed, though the difference of one from another was not much, it was obvious that some reached to completion in the reaction of same particle size more than others[5].

It was observed that the reaction time and volume of water used up in each case, decreases as the particle size decreases. By breaking the seed into many parts leads to exposure of more surface area of the solid and thus facilitates greater contact and reaction, between reacting particles, and, hence quickens the rate of cooking[10,11].

In comparing the rate of cooking of the particle size fraction of 1 and $^1/_2$ in each case, it was noted that particle size fraction of $^1/_2$ consumed water faster than that of 1, before it got done. But due to lengthy time of cooking of one lump, the total volume of water consumed was greater than that of $^1/_2$.

From the tables 1-7 and Figs. 2-9, the most effective catalyst in catalyzing reaction considered in this experiment, in descending reactivity, is potash (KOH), nail (Fe_2O_3), Fiber and Papain catalyst (found in unripe pawpaw). It was observed from literature that bucchlozia cariacea an energy giving food, contains 60% carbohydrates with the rest of 40% mixed up with protein and other classes of food[12]. Papain being the list effective, as biological catalyst, are enzymes which are protein, and, characteristically are specific in reactions they catalyzed. It has been found that papain catalyst will catalyze only protein or fruits with little or no effect in carbohydrates.

Thus, the rate of a catalyst, catalyzing a particular reaction differs from one catalyst to another and can be compared if all conditions

Are kept constant in all. And the rate of catalyzing any reaction is usually based on the kind of catalyst and reaction they catalyzed. Generally, however, the presence of any catalyst brings reactions to completion than when uncatalyzed[13]. Comparison of fig. 7 with that of the activation energy diagram (fig. 1) shows that it took 1075mins for the uncatalyzed reaction to overcome activation energy, and 650mins to register a positive enthalpy change. While it took 470mins for the Potash catalyzed reaction to overcome the activation energy and 420mins to register a positive change of enthalpy. The difference in reaction time between the two, shows a better effective reaction for that of potash. In fig. 8, the sluggish movement as seen between 4000 to 8000cm^3 on Y-axis shows that the main reaction took place at that point, after which the reaction sped up to completion as seen between 6070 to 14000 on the Y-axis.

Finally from the results, it has been found that all the catalyzed reactions reached completion faster than that of uncatalyzed, but the most effective catalyst for tenderization of wonderful cola compared with papain, fiber and iron (II) oxide is potash (KOH).

5.0 CONCLUSION

The use of non-poisonous catalyst especially potash (KOH) is commercially and economically feasible in preparation of Bucchlozia coriacea which is one of the most energy giving food of Africa. It is highly medicinal but not commonly taken by the people of the land or sold in the market because of the limitation that, it takes a very long time (about 21/2 days) to be well cooked.

This work shows that the limitation can be solved or reduced with the use of unpoisonous catalysts like potash, fiber, papain, Fe_2O_3 etc. in the cooking of the fruit. With catalyst, the process can be started and finished in less than half a day, and, if particle size distribution (i.e. particulate reduction) is employed, the cooking process completes in less than the stipulated time above. Finally, the rate of catalyzing a particular reaction can be compared more meaningfully when based on the kind of reaction they catalyze.

5.1 Recommendation

- For further research in this work, it will be necessary to find the chemical constituent of this bucchlozia coriacea (which was not covered).
- The bleaching foamy-like bubbles that normally surface once heat is applied in water-potash-bucchlozia coriacea contents should be further studied.

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