THE FERMENTATION OF THE PULP OF WATERMELON (*Citullus lanatus*) IN THE ABSENCE AND PRESENCE OF ADDITIVES WITH A VIEW TO OBTAIN ETHANOL FOR COMMERCIAL USE

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ABSTRACT

The pulp of watermelon matrix was fermented in the absence and presence of additives such as $ZnSO_4$, Promalt, Potassium Phosphate, Yeastex. Fermentation was conducted at a pH of 4.5 at room temperature for 72 hours. In the absence of additives, an average alcoholic strength of 4.23 v/v was obtained. In the presence of additives: $ZnSO_4$, Promalt, Potassium phosphate, Yeastex, an alcoholic strength of 5.10 v/v, 3.37 v/v, 4.09 v/v, 4.19v/v was obtained respectively. For the Reference molecule, glucose without additives, an average alcoholic strength of 6.14 (v/v) ethanol was obtained. For glucose molecule with additives: potassium phosphate, promalt, $ZnSO_4$ and Yeastex, an average alcoholic strength of 7.52, 4.19, 7.11 and 5.53, v/v was obtained respectively. The additives did had an effect on the alcoholic strength. $ZnSO_4$ increased the alcoholic strength for the fermented watermelon matrix, whereas for the reference molecule glucose, potassium phosphate and Yeastex did increase the alcoholic strength.

Keywords: Pulp, Watermelon, $ZnSO_4$, Promalt, Potassium Phosphate, Yeastex

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INTRODUCTION

With a view to decrease dependence on fossil fuel, as a result of depletion, increasing global fuel price, increasing population and increasing global warming, there has been increased interest in the use of renewable energy sources of which bioethanol is one [1,2,3]. Bioethanol (b.p: 78.5°C) can be used for a variety of purposes, of which blending with gasoline to produce gas alcohol to power automobiles is of current utilisation [1-5]. In addition, ethanol is a clean burning renewable energy source[1-5]. Ethanol is also an important component of alcoholic beverages such as wine, beer, cider, vodka, gin. whisky, brandy etc. It is also an important starting materials for aldehydes, ketones, carboxylic acid, carboxylic acid derivatives and the hydroxyl group is a component of many pharmaceutical drugs[6]. Ethanol can be used in the perfume, disinfectant, tincture, biological and biofuel industries. Ethanol production through Fermentation has been one of the world most significant approaches to aid in the Advancement of Commercial Industry.

Ethanol doesn't have significant environmental impact as fossil fuel combustion [1-5]. It has low air polluting effect and low atmospheric photochemical reactivity, further reducing impact on the ozone layer[1-5]. It contributes little net CO_2 accumulation to the atmosphere and thus should curb global warming[1-5].

Ethanol can be used in three primary ways as biofuel, namely, E10 which is a blend of 10% ethanol and 90% unleaded gasoline, a component of reformulated gasoline both directly and or as ethyl tertiary butyl ether (ETBE) and as E85 which is 85% ethanol and 15% unleaded gasoline. When mixed with unleaded gasoline, ethanol increases octane levels, decreases exhaust emissions and extends the supply of gasoline. Bio-ethanol is made by fermenting almost any material that contain starch or sugar. Grains such as corn and sorghum are good sources, but fruits that are high in sugar concentration are excellent sources as well, since they contain ready to ferment sugars [1-5]

To solve the above problem, emanating from fossil fuel, one alternative is to produce bioethanol from fruits, other grown organic matter or waste[7-24, 26-35]. Bioethanol can be obtained via the fermentation of glucose, fructose or sucrose under the influence of *Saccharomyces cerevisiae* at room temperature, [7-35]. Also, acid hydrolysis of lignocellulose material followed by subsequent fermentation [7-9] . Sugar rich sources include ripe fruits [10-23, 26-35] etc. Other sources include biodegradable fraction of products, waste and residues from agriculture like vegetables and animal origin [13-14, 19, 24, 26] etc. The percentage yield of ethanol, ranging from 4.0 to 10.0 v/v) has been reported [7-35]. Fruits that are high in sugar concentration are favourable to the fermentation process, since they can produce high percentage volume of ethanol.

Fermentation is the process of energy production in a cell in an anerobic environment with the lack of an external electron acceptor[28]. Sugars are the common substrate of fermentation and the products include ethanol, lactic acid and hydrogen. In some instances, compounds such as butyric acid and acetone are produced [28].

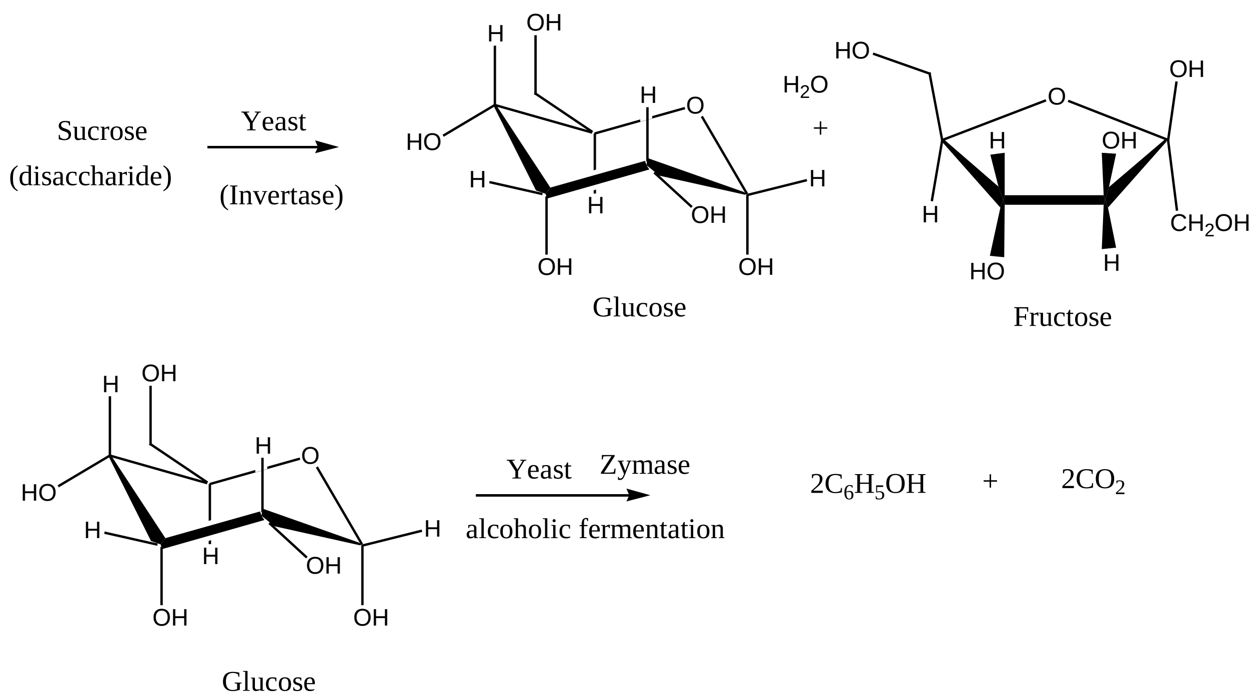


Figure. 1.0. Synthetic Scheme Showing Fermentation of Glucose

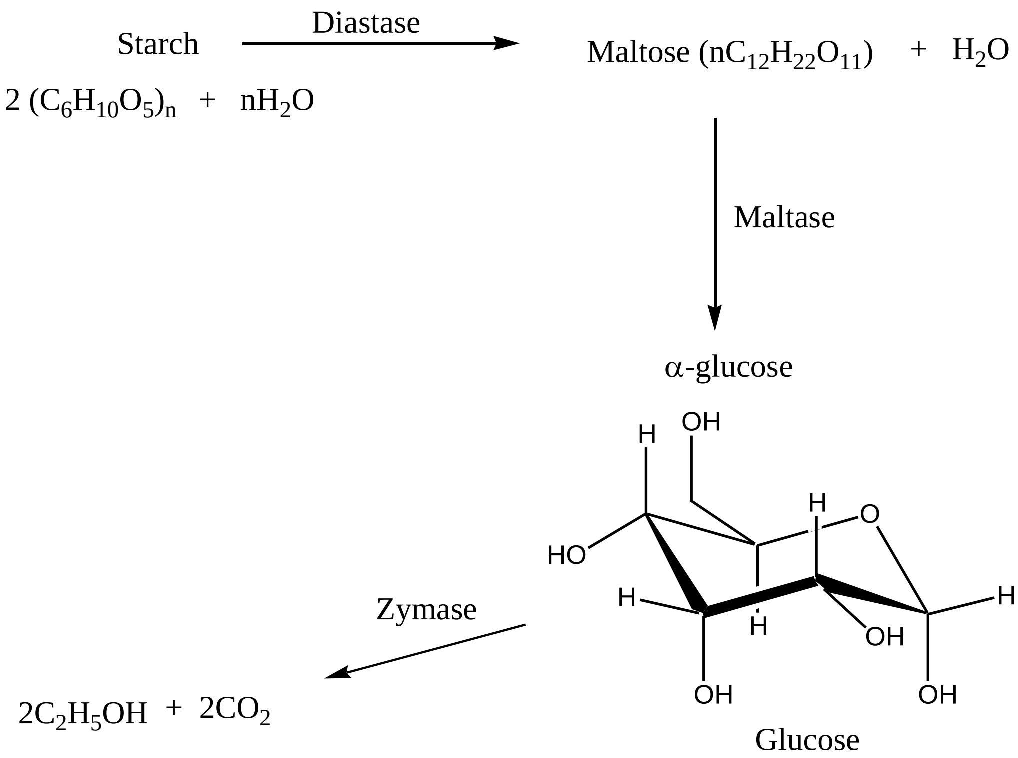


Figure. 2.0. Synthetic Scheme Showing Fermentation of Starch

The fermentation process begins with the yeast breaking down the different forms of sugar in any fermenting matrix. *Saccharomyces cerevisiae* contains two enzymes that is very important for the yeast enzyme activity in the fermentation process. These two enzymes are called Invertase and Zymase and they functions are similar but somewhat prerequisite to each other. Invertase aids in converting any sucrose sugar that is present in any biomass that is used in fermentation to glucose and fructose while zymase aids in the conversion of glucose to ethanol [28]., Fig. 1.0.

During Fermentation, starch is first hydrolysed to maltose by the action of the enzyme diastase. This enzyme is obtained from germinating barley seeds or malt. Maltose is converted to glucose by the enzyme maltase. Glucose is then fermented to ethanol via the enzyme zymase [28], Fig. 2.0. Once the sugars are broken down into monosaccharides, the yeast can now use them. *Saccharomyces cerevisiae* is able to perform both aerobic and anaerobic respiration.

One fruit that can be investigated for its ethanolic production via fermentation is water melon, *Cirullus lanatus*. *Cirullus lanatus (cucurbitaceae)* commonly known as watermelon is cultivated in all parts of the world and is locally found in Guyana in region 4 and region 6. Watermelon contains 7-10 %(w/v) ready to ferment sugars. The pulp of the watermelon contains three types of fermentable sugars (7-10%): sucrose, fructose and glucose while the peel contains cellulose; cellulose which can be can be converted to glucose by enzymatic or acid hydrolysis of the peel [27]

This paper investigate the fermentation efficacy of watermelon (*Citrullus lanatus*) pulp in the absence and presence of additives such as $ZnSO_4$, Promalt, Potassium phosphate, Yeastex with a view to obtain an ethanol percentage yield higher than 15% (v/v), the highest reported using *Saccharomyces cerevisiae* at room temperature (35 ºC). Zinc is an important element necessary for the function of the enzyme carbonic anhydrase whereas phosphate is necessary for nuclei acid formation and hence growth of yeast[28]. Yeastex is usually added when there is limited vitamins, essential salts and amino acids for yeast. This results in slow or incomplete fermentation. The key benefits include maintainance of yeast viability and vigour, optimises fermentation. It can be used in yeast propagation. It compensates for low nitrogen in high adjunct brewing. Promalt usually improves extract yield and fermentability.

The fermentation of water melon juice, a promising feedstock supplement, diluent, and nitrogen supplement for ethanol biofuel production has been reported[27]. Utilising watermelon juices as diluent, supplemental feedstock and nitrogen sources for fermentation of processed sugar or molasses allowed complete fermentation of up to 25% (w/v) sugar concentration at pH 3 (0.41 to 0.46 g ethanol per g sugar) or up to 35% (w/v) sugar concentration at pH 5 with a conversion to 0.36 to 0.41 g ethanol per g sugar. Three types of fermentation processes: batch, fed batch and continuous processes were employed in the fermentation of sugar cane juice. The production of Bio-ethanol from Gurma Watermelon Wastes have been reported[29]. Watermelon juice was concentrated to 10° Brix then fermented by *Saccharomyces cerevisiae* on two levels of pH (~ 3 and 5) at temperature (30 and 35°C) for 48 hrs. The highest rate of ethanol production was 0.42 g ethanol /g fermentable sugar on pH 5 at 35°C. The expected yield of ethanol (approximately 56 thousand tons) can be produced from the total amount of Gurma watermelon wastes. This indicates that Gurma watermelon residue is a potential new source of bioethanol and can be integrated with other more concentrated feedstocks as diluent or, supplemental feedstock. However, further research is necessary to maximize the utilization of Gurma watermelon wastes[29]. Bio-ethanol production from fermentable sugar cane juice has been noted [30].

The use of fruits as fermentable feedstock for bio ethanol production has been reported in the literature. A few are noted. For example, fermentation studies and nutritional analyses of drinks made from water extract of Hibiscus sabdariffa Calyx (Sobo~ Juices of Citrus sinensis (Orange) and *Ananas comosus* (Pineapple) has been reported[31]. Ethanol production by fermentation of the pulp of the "BOKO" mango has been investigated[32]. Accordingly, the yield of transformation of the extract in ethanol, the productivity and the production of ethanol vary according to the indication of maturation.

Laboratory experiments were conducted to evaluate the chemical composition of fruit wastes (pulp and peels) of Banana and Mango in order to explore their potential application in bio-ethanol production. The banana fruit peels yielded a maximum reducing sugar content of 36.67% whereas the lowest of 31.29% was observed in mango fruit peels. The fermentation of the DAP hydrolysate of mixed fruit pulps showed maximum ethanol production of 35.86% corresponding to a fermentation efficiency of 70.31% at 48 hr of incubation. Similarly, the hydrolysates obtained from the dilute H_2SO_4 pretreated banana fruit peels yielded a maximum of 13.84% ethanol with a fermentation efficiency of 27.13% at 42 h of incubation. The present study revealed that the fermentation of hydrolysates obtained from the dilute acid pretreatment followed by enzymatic saccharification of mixed fruit pulps (banana and mango) and the banana fruit peels were found to be for higher ethanol production at optimized conditions [33].

The scope for producing ethanol from the surplus and non-attractive mango (*Mangifera indica*) fruits was investigated. Six varieties of mango that are abundantly occurring in the region were selected for the study and the physio-chemical properties of the mangoes evaluated. It was found that at a pH of 5.0, 30°C temperature, 3% (v/v) inoculum density and 3 days incubation were good for maximal ethanol production [6].

MATERIALS AND METHOD

The watermelons were obtained from the local market at Stabroek, Georgetown, Guyana. These fruits were purchased on the day they were required to be used for the experiment. The fruits were transported to the Banks DIH Brewery laboratory.

<u>Preparation of Samples</u>

The water melons were washed thoroughly with hot distilled water. A sterilised knife was used to take the peel off and the pulp was taken out and 400 grams of the pulp was weighed in a beaker on an electrical scale. 400 grams of pulp was blended with 100 ml of distilled water in a sterilised juice blender. The watermelon matrix was poured into three fermenting vessels so that the experiment could be carried out in triplicates. The initial pH of the fermenting matrix was checked. Citric acid was added to lower the pH to 4.5, the best for the fermentation process. The initial and final sugar concentration of the watermelon matrix was checked using the Pycnometer, density meter.

Yeast

The yeast required (*Saccharomyces cerevisiae*) was obtained from the brewing Department at Banks DIH. The yeast species, *Saccharomyces cerevisiae* was already propagated by that department. Here 100g of propagated *Saccharomyces cerevisiae* was weighed in a sterilised beaker on an electrical scale and was added to the water melon matrix in the three fermenting vessels (Jar1, Jar 2, and Jar 3) and stirred with a sterilised stirrer for a few minutes. The fermenting vessels were sealed and left for approximately three days.

Filtration:

The fermented matrix for each sample was filtered into a conical flask using Whatman filter paper (22 cm). A sample of the filtrate was measured to determine Brix and the final sugar concentration.

Distillation:

100ml of the filtrate was poured into a distillation round bottom flask. The heating flask was then attached to the distillation apparatus so that the distillation process can be carried out.

(v/v) % of ethanol measured:

10 ml of the distillate was collected using a syringe and its alcoholic content determine using a pycnometer or density meter.

Watermelon matrix with additives:

The watermelons were obtained as previously mentioned above and the matrix prepared as mentioned above:

Addition of the additive:

Additives used were potassium phosphate, promalt, zinc sulphate, Yeastex etc. A typical addition is described below: Consider potassium phosphate.

0.1g of potassium phosphate was weighed on an electrical scale and placed into a 100ml volumetric flask and made up to the 100ml mark using distilled water. It was shaken thoroughly and left for 15 minutes. After 15 minutes, 5ml of the additive solution was added to the watermelon matrix in the three fermenting vessels, Jar 1, Jar 2, Jar 3 (triplicates). A sterilised stirrer was used to stir the mixture for a few minutes. Fermentation was done as mentioned above and the (w/v) % of ethanol measured as mentioned above.

Glucose (Controlled)

Glucose matrix without additives:

Preparation of the sample

100 grams of glucose was weighed in a beaker on an electrical scale and then added to 1000ml of water in a sterilised beaker. This glucose matrix was equivalent to 8.3% brix. The glucose matrix was stirred so that all the glucose particles could dissolve. 500ml of the glucose matrix was measured and placed into Jar 1, Jar 2 and Jar 3. The yeast obtained was used as mentioned above. Fermentation was done as mentioned previously.

Filtration:

The fermented matrix for each sample were filtered into a conical flask using Whatman filter paper (22 cm). A sample of the filtrate was subjected to Brix analyses to determine the final sugar concentration.

Distillation:

100 ml of the filtrate was poured into the distillation round bottom flask. The heating flask was then attached to the distillation apparatus so that the distillation process can be carried out.

Glucose matrix with additives:

Additives used were potassium phosphate, promalt, zinc sulphate, yeastex etc. A typical addition is described below: Consider potassium phosphate.

Preparation of the sample

100 grams of glucose was weighed in a beaker on an electrical scale and then added to 1000ml of water in a sterilised beaker. This glucose matrix was equivalent to 8.3% brix. The glucose matrix was stirred until all the glucose particles were dissolved. 500 ml of the glucose matrix was placed into Jar 1, Jar 2 and Jar 3. The yeast obtained was used as mentioned above. Fermentation was also done as mentioned previously.

Addition of the metal additive:

Additives used were potassium phosphate, promalt, zinc sulphate, yeastex etc. A typical addition is described below: Consider potassium phosphate.

0.1g of potassium phosphate was weighed on an electrical scale and each additive was placed into a volumetric flask and made up to the 100ml mark using distilled water. It was shaken thoroughly and left for 15 minutes. After 15 minutes, 5ml of the additive solution was added to the watermelon matrix in the three fermenting vessels, Jar 1, Jar 2, Jar 3 (triplicates). A sterilised stirrer was used to stir the mixture for a few minutes. Fermentation was done as mentioned above and the (w/v) % of ethanol measured as mentioned above.

Filtration:

The fermented matrix for each sample was filtered into a conical flask using Whatman filter paper (22cm). A sample of the filtrate was subjected to Brix analysis to determine the final sugar concentration.

Distillation:

Distillation was done as mentioned above and the (v/v) % of ethanol was measured as mentioned above.

RESULTS

Table 1.0. Watermelon (*Citrullus lanatus)* matrix without additives

Parameters	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.33	4.31	4.44	4.36
Final	4.51	4.62	4.51	4.55
Sugar concentration, % Brix				
Initial	7.31	7.41	7.51	7.41
Final	-0.219	-0.092	-0.053	-0.121
Specific gravity	0.99	0.99	0.99	0.99
Alcohol (% v/v)	4.17	4.17	4.35	4.23
Temperature (°C)	20	20	20	20

Table 2.0. Watermelon matrix, *Citullus lanatus* with zinc sulphate

Tests ($ZnSO_4$)	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.51	4.4	4.41	4.44
Final	4.60	4.73	4.77	4.7
Sugar Concentration, % brix				
Initial	7.2	7.2	7.2	7.2
Final	-0.21	-0.09	-0.16	-0.15
Specific Gravity	0.992	0.992	0.992	0.993
	295	473	6	8
Alcohol (% v/v)	5.32	5.20	4.79	5.10
Temperature (°C)	20	20	20	20

Table 3.0. Watermelon matrix, *Citullus lanatus* with promalt

Tests (Promalt)	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.48	4.53	4.53	4.51
Final	4.87	4.59	4.63	4.69
Sugar concentration, % brix				
Initial	6.52	6.52	6.52	6.52
Final	-0.11	-0.01	-0.051	-0.05
Specific Gravity	0.99	0.99	0.99	0.99
	3	2	0	1
Alcohol (% v/v)	3.61	3.23	3.27	3.37
Temperature (°C)	20	20	20	20

Table 4.0. Watermelon matrix *Citullus lanatus* with potassium phosphate additives

Test done	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.5	4.5	4.5	4.5
Final	4.05	4.02	4.28	4.11
Sugar Concentration, % brix				
Initial	7.5	7.5	7.5	7.5
Final	-0.21	-0.19	-0.21	-0.20
Specific gravity	0.994	0.993	0.994	0.994
	256	523	3	0
Alcohol (% v/v)	3.91	4.46	3.91	4.09
Temperature (°C)	20	20	20	20

Table 5.0. Watermelon matrix, *Citullus lanatus* with Yeastex additives.

Analyses	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.45	4.5	4.56	4.5
Final	4.54	4.66	4.76	4.65
Sugar Concentration, % Brix				
Initial	7.2	7.2	6.2	6.86
Final	-0.34	-0.54	-0.26	-0.38
Specific gravity	0.99	0.99	0.99	0.99
	7	8	6	3
Alcohol (% v/v)	3.94	4.18	4.46	4.19
Temperature (ºC)	20	20	20	20

Table 6.0 Glucose matrix without additives

Analyses	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.5	4.5	4.5	4.5
Final	3.97	3.49	3.99	3.81
Sugar conc % brix	8.3	8.3	8.3	8.3
Initial	8.3	8.3	8.3	8.3
Final	-1.176	-1.087	-1.161	-1.141
Specific gravity	0.99	0.99	0.99	0.99
Alcohol (% v/v)	5.83	6.53	6.06	6.14
Temperature (ºC)	20	20	20	20

Table 7.0 Glucose matrix with potassium phosphate

Analyses	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.45	4.5	4.56	4.5
Final	4.54	4.66	4.76	4.65
Sugar Concentration, % Brix				
Initial	8.3	8.3	8.3	8.3
Final	-1.18	-1.32	-1.25	-1.25
Specific garvity	0.98	0.98	0.98	0.98
Alcohol (% v/v)	7.39	7.42	7.77	7.52
Temperature(ºC)	20	20	20	20

Table 8.0. Glucose matrix with promalt

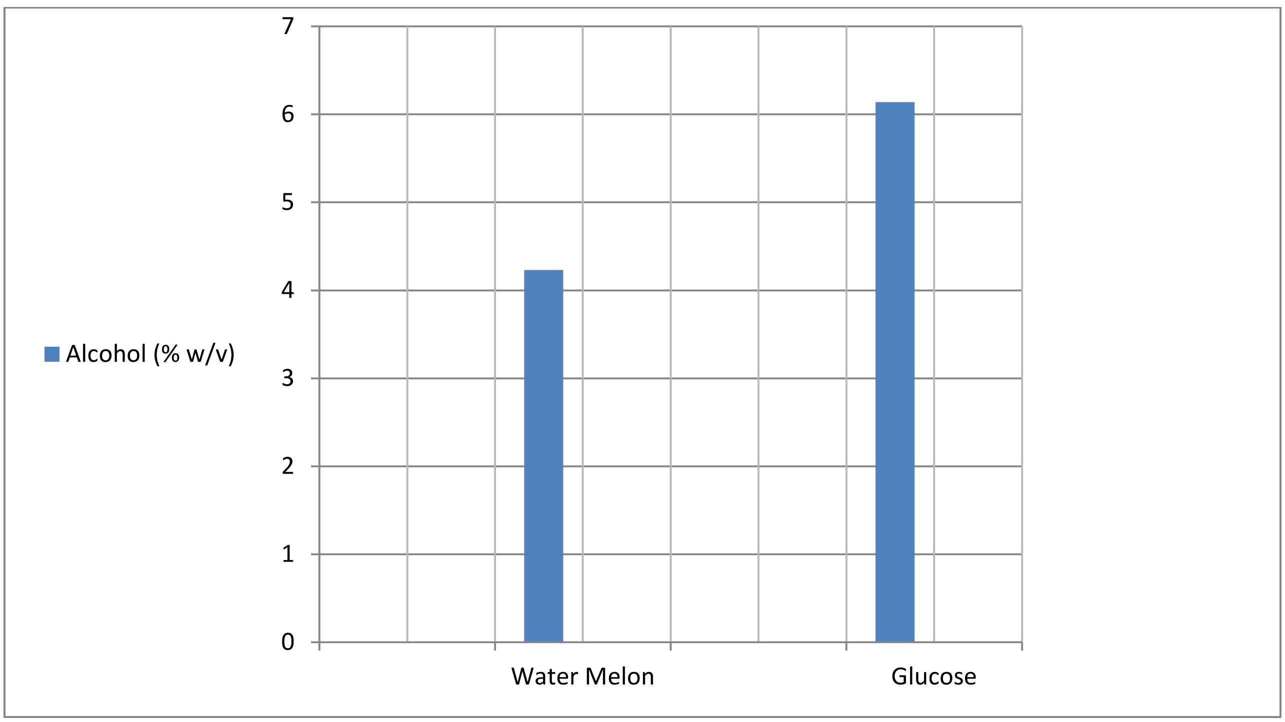
Analyses	Jar 1	Jar 2	Jar 3	Average
Promalt				
Initial	4.45	4.5	4.56	4.5
	4.54	4.66	4.76	4.65
Sugar concentrtation, % brix				
Initial	7.2	7.2	6.2	6.86
Final	-0.34	-0.54	-0.26	-0.38
Specific gravity	0.99	0.99	0.99	0.99
	7	8	6	
Alcohol (% v/v)	3.94	4.18	4.46	4.19
Temperature(ºC)	20	20	20	20

Table 9.0. Glucose matrix with zinc sulphate additives

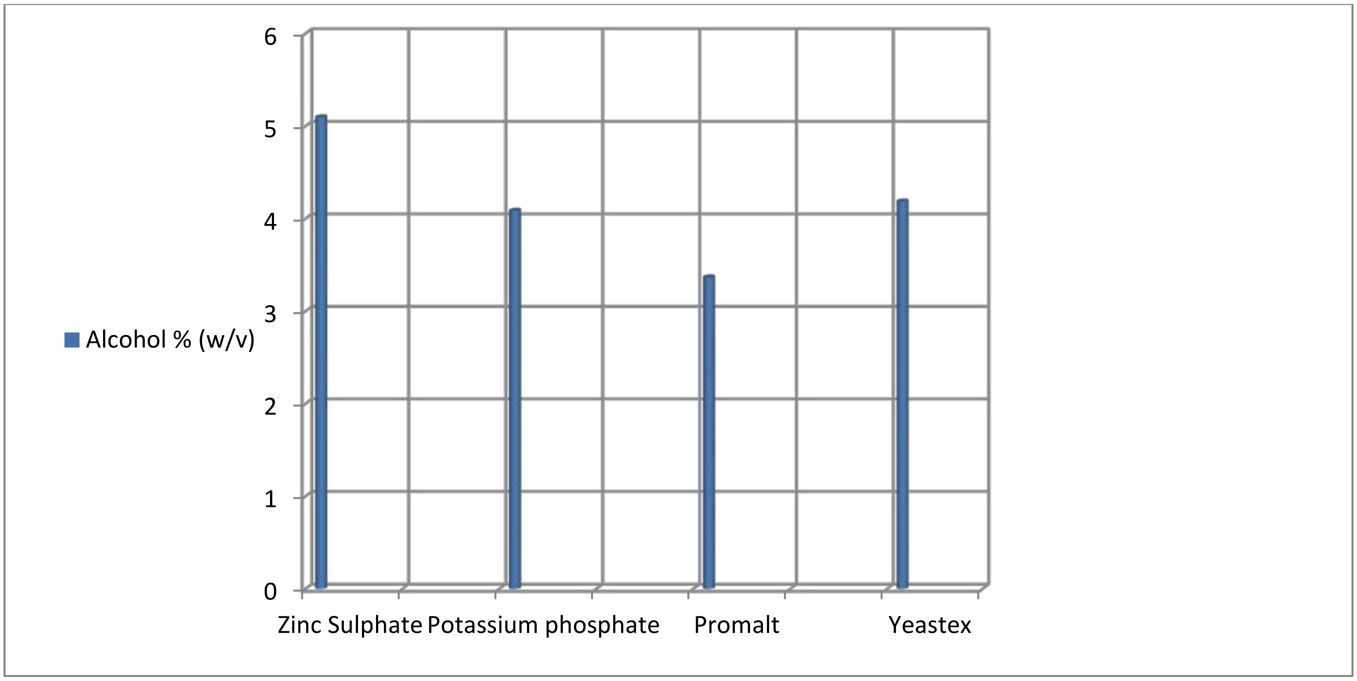
Analyses	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.50	4.50	4.50	4.50
Final	4.91	4.97	4.99	4.95
Sugar concentration % Brix				
Initial	8.3	8.3	8.3	8.3
Final	-1.18	-1.20	-1.10	-1.16
Specific gravity	0.9896	0.9904	0.9898	0.98995
	07	38	27	7
Alcohol (% v/v)	7.37	6.76	7.21	7.11
Temperature(ºC)	20	20	20	20

Table 10.0. Glucose matrix with Yeasttex additives

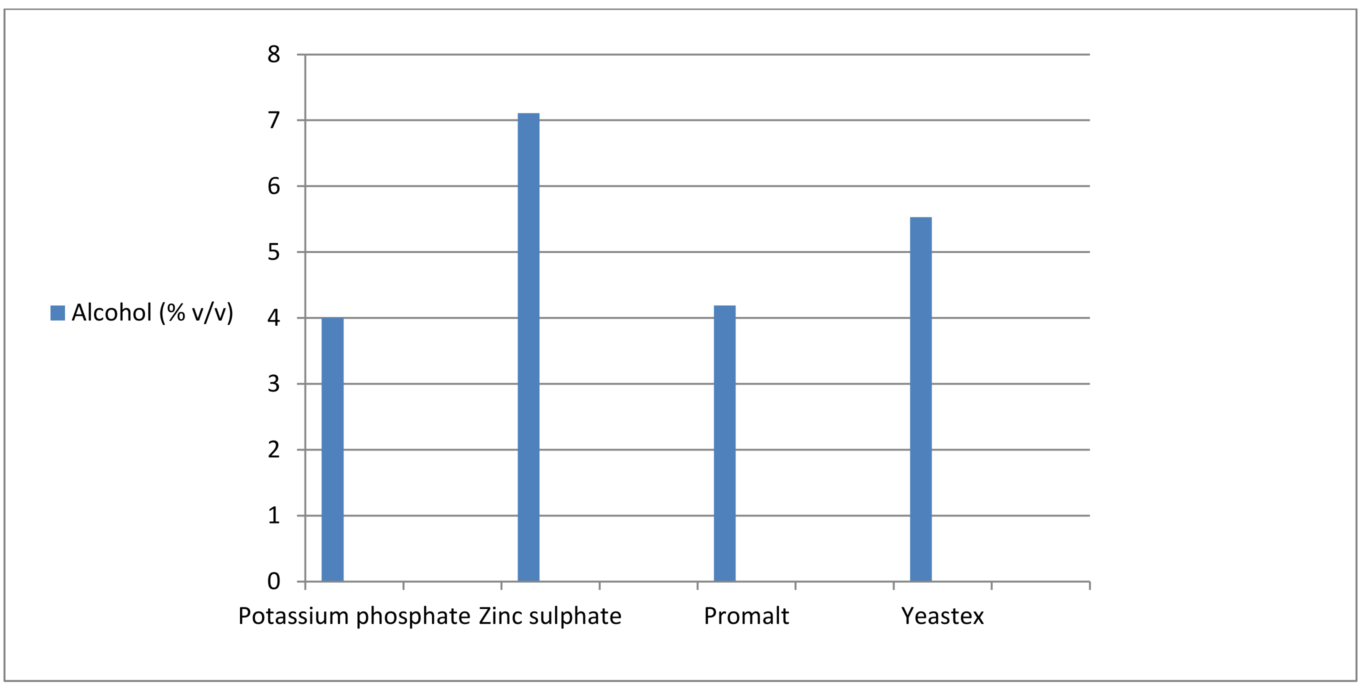
Analyses	Jar 1	Jar 2	Jar 3	Average
pH				
Initial	4.50	4.50	4.50	4.50
Final	3.75	3.67	3.82	3.74
Sugar Concentration, % Brix				
Initial	8.3	8.3	8.3	8.3
Final	-0.75	-0.69	-0.49	-0.64
Specific gravity	0.99	0.988	0.99	0.99
	1	7	4	
Alcohol (% v/v)	5.71	5.31	5.57	5.53
Temperature(ºC)	20	20	20	20



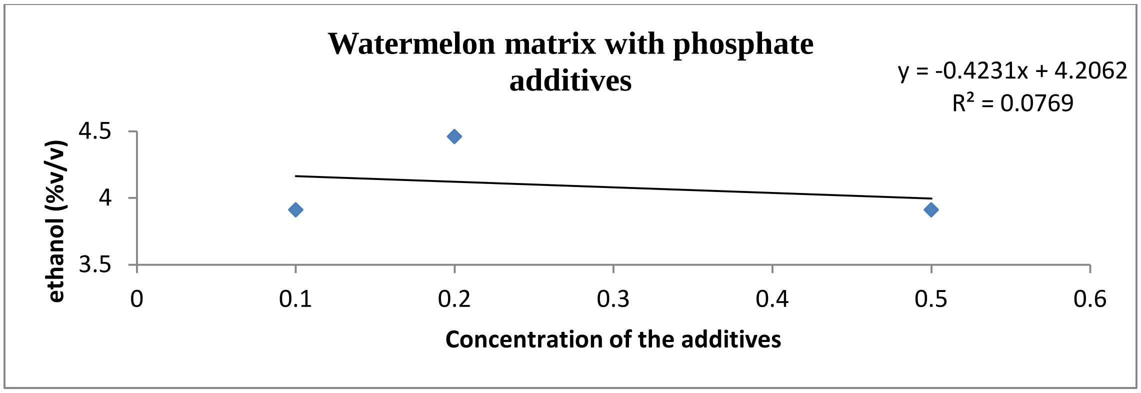
Graph 1: A plot of alcohol content (% w/v) versus substrates type: water melon and glucose after fermentation.



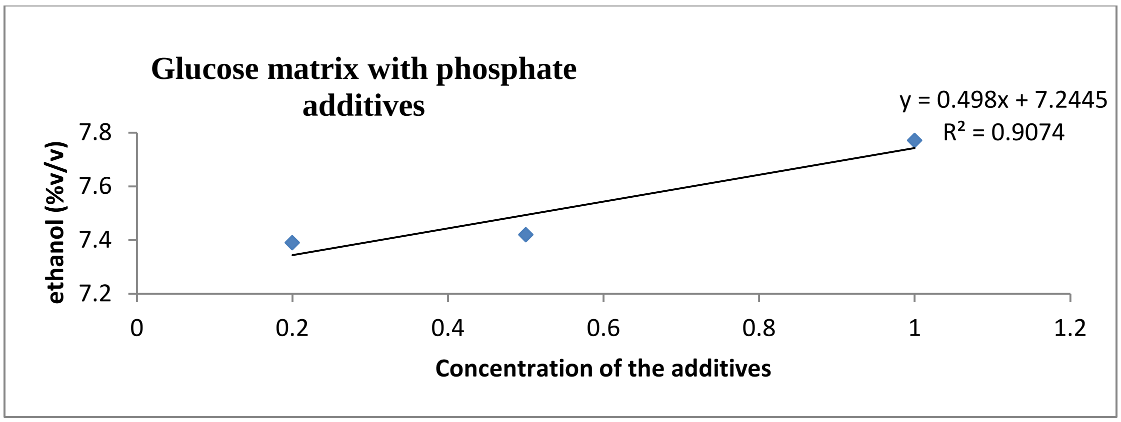
Graph 2: A plot of alcohol content (% w/v) of water melon with selective additives after fermentation.



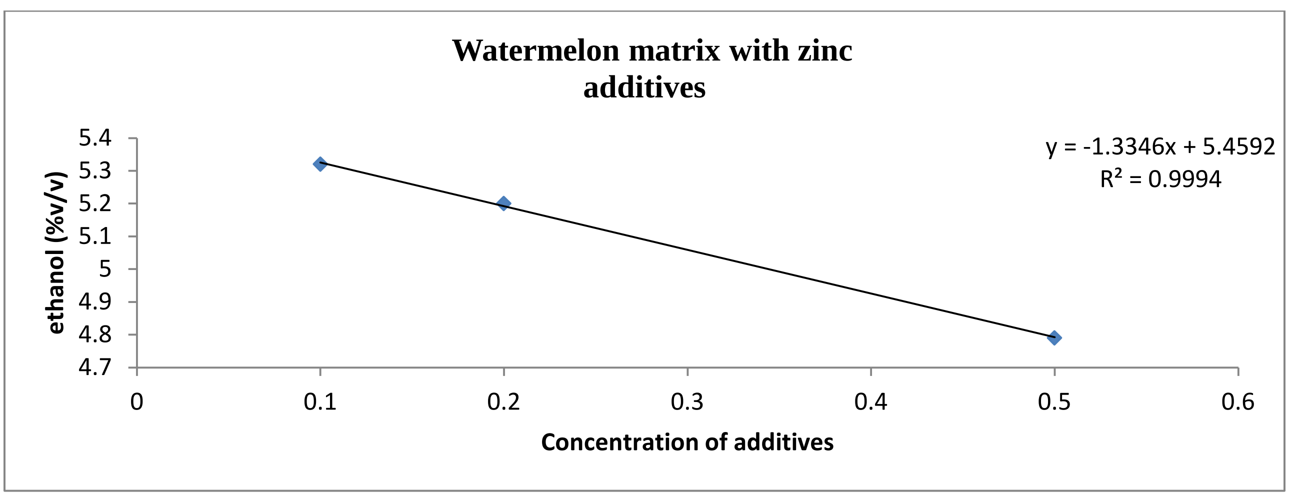
Graph 3: A plot of Alcohol (% w/v) of glucose with various selected additives after fermentation.



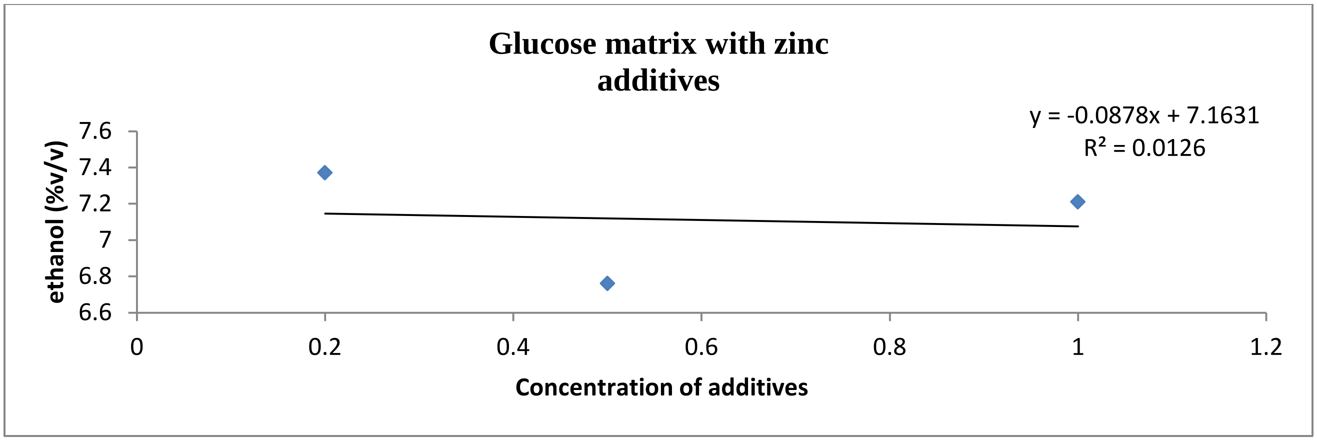
Graph 4. Regression Correlation: Ethanol content (w/v) of water melon, *Citullus lanatus* matrix with phosphate additives.



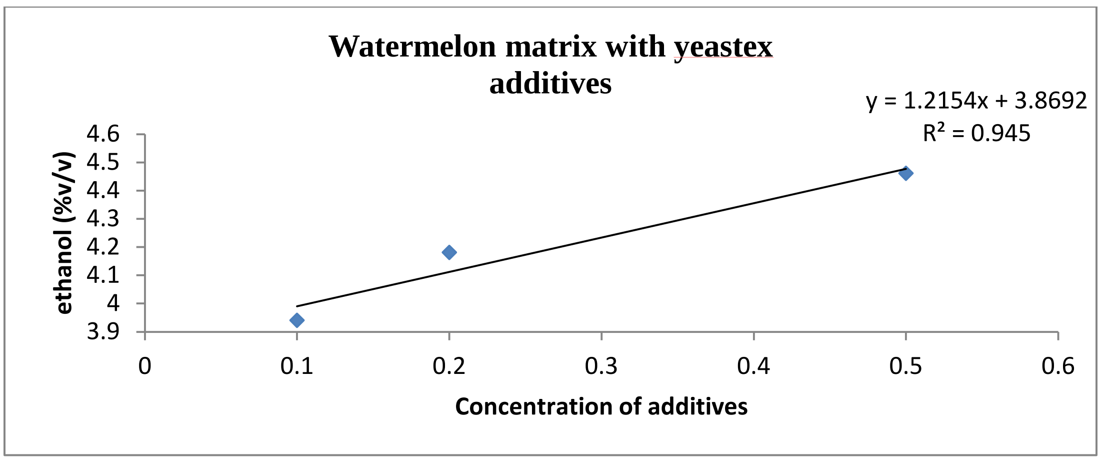
Graph 5: Regression Correlation: Ethanol content (w/v) of glucose matrix versus phosphate additives.



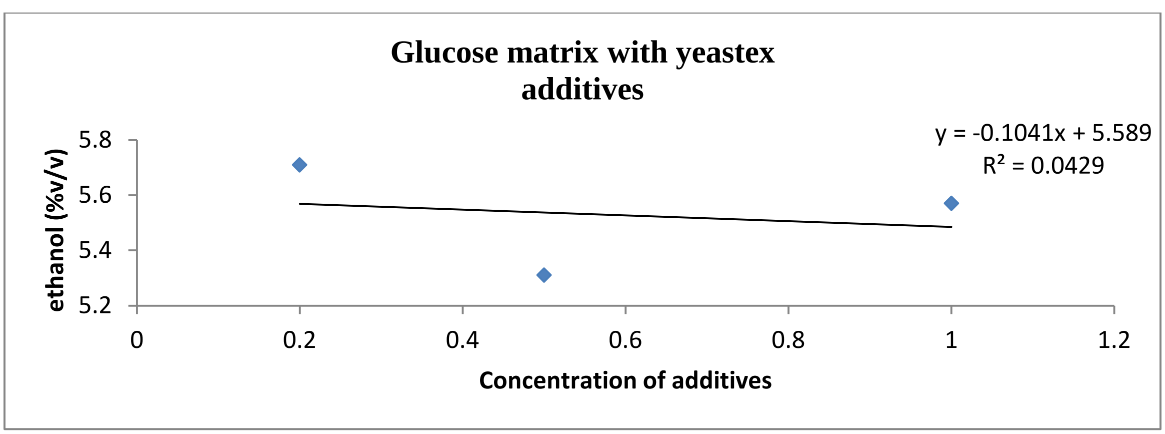
Graph 6: Regression Correlation: Water melon, *Citullus lanatus* matrix versus zinc additives.



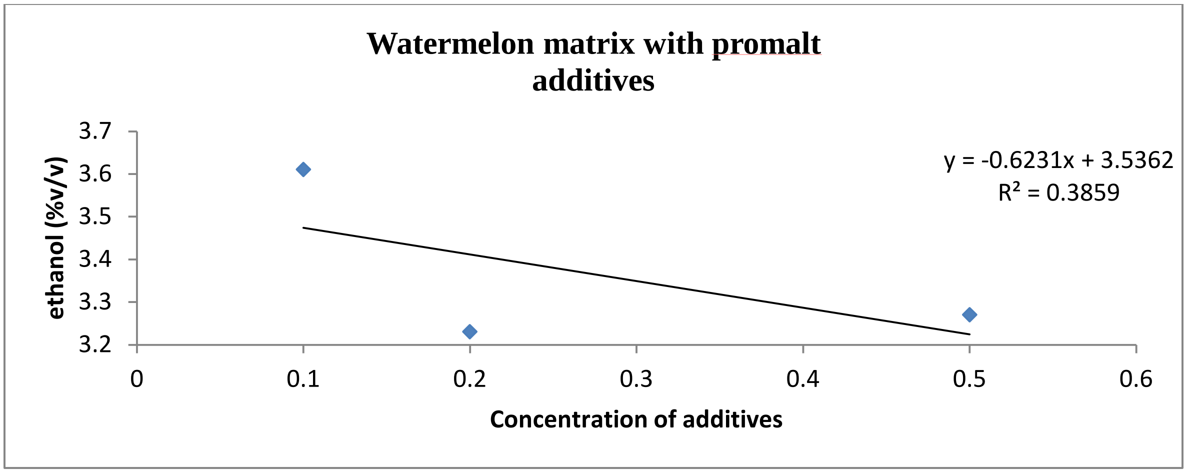
Graph 7: Regression Correlation: Glucose matrix versus zinc additives.



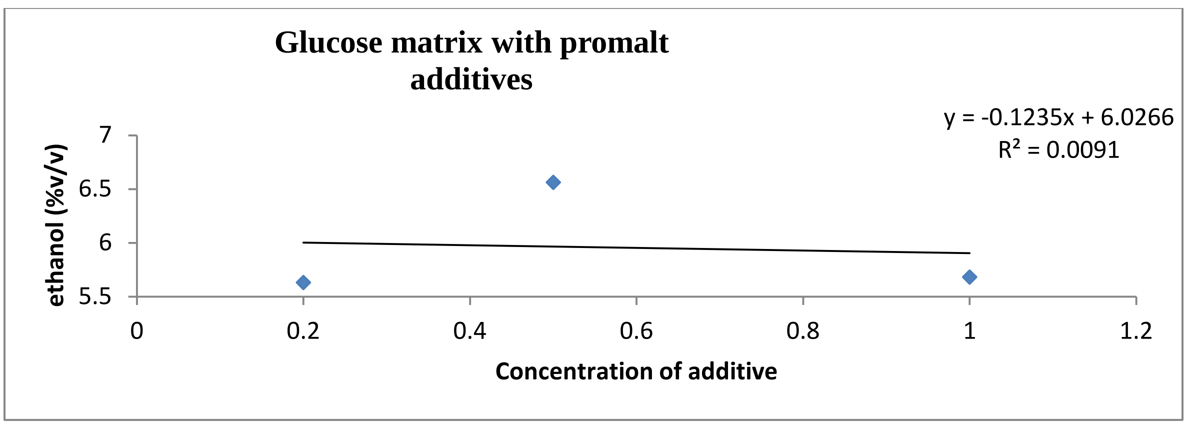
Graph 8.0. Regression Correlation: Water melon, *Citullus lanatus* matrix versus yeastex additives.



Graph 9.0. Regression Correlation: Glucose matrix versus yeastex additives.



Graph 10. Regression Correlation: Watermelon, *Citullus lanatus* matrix versus promalt additives.



Graph 11. Regression Correlation: Glucose matrix versus promalt additives.

DISCUSSION

Results indicate that the water melon (*Citullus lanatus)* matrix without additives induced an average alcoholic strength of 4.23 % v/v with an average in decrease in Brix from 7.41 to -0.121, Table 1.0.

Table 2.0 and Table 3.0 show that in the presence of additives, $ZnSO_4$ and Promalt, the average alcoholic strength was 5.10 and 3.37 w/v respectively i.e there was an increase with $ZnSO_4$ and a decrease with Promalt in comparison to that induced by water melon matrix without additives. Also, the % Brix decrease from (7.2 to -0.15) and (6.52 to -0.05) for $ZnSO_4$ and Yeastex respectively. This indicated that the sugar was used up in the fermentation process.

Table 4.0 and 5.0 shows the effect of the other additives, potassium phosphate and yeastex Potassium phosphate showed an average % ethanol yield of 4.09 w/v, whereas Yeastex showed an average % ethanol yield of 4.19 w/v respectively. Thus, a decrease in the yield was noted with respect to the average value of 4.23 w/v induced with the sample without the additive. The average % brix showed a decrease in value from (7.5 to -0.20). whereas with Yeastex, the average % brix decrease from 6.86 to -0.38 w/v, indicating that fermentation occurred.

The above results are depicted in Graph 1 and Graph 2: Table 6.0 shows results for glucose matrix without additives. The average % yield for ethanol recorded was 6.14% w/v. The % Brix decrease from 8.3 to -1.141, showing that fermentation occurred. As is evident, glucose induced a higher alcohol content (6.14, w/v versus 4.23 w/v induced by water melon.

Table 7.0 and Table 8.0 illustrates the effect of potassium phosphate and promalt on the % yield of ethanol of the glucose matrix. An average % yield of 7.52 and 4.19 was noted for potassium phosphate and promalt respectively. The average % Brix decrease from 8.3 to -1.25 and 6.86 to -0.38 respectively. Table 9.0 and Table 10.0 illustrates the results for glucose matrix with $ZnSO_4$ and yeastex additive respectively. An average % yield for ethanol of 7.11 and 5.53 w/v was recorded for zinc sulphate and yeastex respectively i.e an increase and decrease respectively in comparison to the glucose matrix. The above results are graphically display on Graph 4.0.

The additives did had an effect on the alcoholic strength. $ZnSO_4$ increased the alcoholic strength for the fermented watermelon matrix, whereas for the reference molecule glucose, potassium phosphate and yeastex did increase the alcoholic strength. Thus, alcoholic strength is increased by the additives in the following order: zinc sulphate (5.10 v/v) > potassium phosphate (3.37 v/v) > promalt (3.37 v/v) in comparison to that without (4.23 % v/v). For glucose molecule, the alcoholic strength is increased by the additives in the following order: Potassium phosphate (7.50 % v/v) > zinc sulphate (7.11 % v/v) > yeastex (5.53 % v/v) > promalt (4.19 % v/v) in comparison to the standard value of (6.14 % v/v).

Statistical Analyses using the regression correlation graph to observe the relationship between two variables were done.[36-40]. The two variables are the concentration of the metal additives which is the independent variable and the ethanol (%W/V) which is the dependent variable. These results are shown in Graphs 4-11. (Graph 4 graph is illustrating a weak negative relationship. It shows as the concentration of the metal additives decreases, the percentage of ethanol by volume (% v/v) decreases. Graph 5 is illustrating a strong positive relationship. It shows as the concentration of the metal additives increases, the percentage of ethanol by volume (%v/v)) increases. Graph 6 above is illustrating a strong negative relationship. It shows as the concentration of the metal additives decreases, the percentage of ethanol by volume (% w/v) decreases. Graph 7 is illustrating little to no relationship. It shows as the concentration of the metal additives slightly increases the percentage of ethanol by volume (% v/v) decreases. Graph 8 is illustrating a strong positive relationship. It illustrates as the concentration of the metal additives increases, the percentage of ethanol by volume (%v/v) increases. Graph 9 above is illustrating little to no relationship. Its shows as the concentration of the metal additives slightly increases, the percentage of ethanol by volume (% v/v) decreases. Graph 10 is illustrating a negative relationship. It shows as the concentration of the metal additives increases, the percentage of ethanol by volume (% v/v) decreases. Graph 11 above is illustrating little to no relationship. It shows as the concentration of the metal additives slightly increases, the percentage of ethanol by volume (% v/v) decreases.

CONCLUSION

The pulp of watermelon matrix was fermented in the absence and presence of additives such as $ZnSO_4$, promalt, potassium phosphate, yeastex. Fermentation was conducted at a pH of 4.5 at room temperature for 72 hours. In the absence of additives, an average alcoholic strength of 4.23 v/v was obtained. In the presence of additives: $ZnSO_4$, promalt, potassium phosphate and yeastex, an alcoholic strength of 5.10 v/v, 3.37 v/v, 4.09 v/v, 4.19 w/v was obtained respectively. For the Reference molecule, glucose without additives, an average alcoholic strength of 6.14 (v/v) ethanol was obtained. Fermented glucose molecule in the presence of additives: potassium phosphate, promalt, $ZnSO_4$ and Yeastex, an average alcoholic strength of 7.52, 4.19, 7.11 and 5.53, v/v was obtained respectively. The additives did had an effect on the alcoholic strength. $ZnSO_4$ increased the alcoholic strength for the fermented watermelon matrix, whereas for the reference molecule glucose, potassium phosphate and Yeastex did increase the alcoholic strength.

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