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Extraction and Characterization of Ethanol Obtained from Potato in Tepi Town Local Market.

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ABSTRACT

Potato crop is mainly comprises two bodies one which is found above the ground known to be the plant and the other which is found in the underground stems (or stolons) known as the tuber This student project aims at utilizing potato for the production of ethanol by using the yeast Saccharomyces cerevisiae, thus, producing a valuable product from potato. Potatoes were crushed for easy drying and grinding. Sample drying was carried out in oven (250 ^{o} C for 24 hr) to obtain easily crushable material. After drying, each of the samples was milled separately. The maximum particle sizes of the ground mixed sample were 2 mm. The mill samples of different gram from each sample were taken and then passed through fermentation and distillation process to produce ethanol. The effects of potato concentration and time were investigated. From the study, effective amounts of ethanol were obtained from each classes of potato. For concentration 2, 4, 6 & 8 g of samples were used and the result obtained were 23, 27, 32 & 35 ml for red potato & 25, 28, 35, 39 ml for white. Among these 8 g of potato gave highest yield for both. For incubation period 1, 2, 3, 4, 5 & 6 days with the same amount of 4 g of potato sample the result obtained were 33.4, 45, 35, 35, 36, & 35 ml for white potato & 35.3, 45, 37, 35, 36 & 35 ml for red potato. Among these highest result obtained in 2 days for both potato. So it is advisable to use, 2 days for incubation period to get effective amount of ethanol.

Keywords: *Potato, Ethanol, Yeast, Simple distillation, Fermentation.*

INTRODUCTION

Potato

Potato crop is mainly comprises two bodies one which is found above the ground known to be the plant and the other which is found in the underground stems (or stolons) known as the tuber.

The Plant

The potato (*Solanum tuberosum*) is a herbaceous annual that grows up to 100 cm tall and produces a tuber – also called potato – so rich in starch that it ranks as the world's fourth most important food crop, after maize, wheat and rice as it is indicated below in figure 1.1. The potato belongs to the Solanaceae – or "nightshade"– family of flowering plants, and shares the genus *Solanum* with at least 1000 other species, including tomato and egg plant. Recent research indicates that *S. tuberosum* is divided into two, only slightly different, cultivar groups: Andigenum, which is adapted to short day conditions and is mainly grown in the Andes, and Chilotanum, the potato now cultivated around the world. Also known as the "European" potato, the Chilotanum group is believed to have developed from Andean cultivars introduced first into Chile and from there, during the 19th century, into Europe *(IYP, 2008 and FAOStat, 2012)*.

The Tuber

As the potato plant grows, its compound leaves manufacture starch that is transferred to the ends of its underground stems (or stolons). The stems thicken to form a few or as many as 20 tubers close to the soil surface. The number of tubers that actually reach maturity depends on available moisture and soil nutrients. Tubers may vary in shape and size, and normally weigh up to 300 g each. At the end of the growing season, the plant's leaves and stems die down to the soil level and its new tubers detach from their stolons. The tubers then serve as a nutrient store that allows the plant to survive the cold, and later regrow and reproduce. Each tuber has from two to as many as 10 buds (or "eyes"), arranged in a spiral pattern around its surface. The buds generate shoots which grow into new plants when conditions become favorable once more.

A raw potato tuber is rich in micronutrients – the vitamins and minerals that are essential to health. A medium-size potato contains high levels of potassium and nearly half the daily adult requirement of vitamin C. It is also a good source of B vitamins, and minerals such as phosphorus and magnesium *(IYP, 2008.and.FAOStat, 2012).*

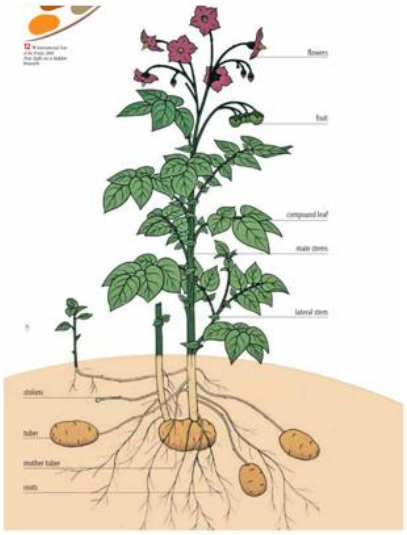

Fig1.1. *Parts of potato plant (Adapted from: IYP, 2008).*

History of Potato

Potatoes were first cultivated around 200 B.C. by the Inca Indians in Peru. At that time, potatoes served a wide variety of uses, such as healing broken bones and measuring time. Nearly 4,000 varieties can be found in the Andes. The Spanish brought potatoes to Europe in the 16th century. European consumers were reluctant to adopt the potato. However, due to the sheer practicality of the potato—adaptability, generally plentiful crops and relatively long shelf life, combined with the nutritional value—it was soon widely accepted and consumed. Potatoes were introduced to North America in 1691, and they are thought to have been first planted in New Hampshire in 1719. The first French fries were served some 80 years later at the White House during the presidency of Thomas Jefferson and distributed worldwide *(FAOStat, 2012)*.

Potato Production in the World

Since the early 1960s, the growth in potato production area has rapidly overtaken all other food crops in developing countries. It is a fundamental element in the food security for millions of people across South America, Africa, and Asia, including Central Asia. Presently, more than half of global potato production now comes from developing countries *(http://www. fao.org /potato-2008 /en /world/ africa. html, June, 2015)*.

Table1.1. *The Top five Potato Producing Countries in the world.*

Rank	Country	Potato Production 2012(metric tons)	% of World Total
1	China	85,860,000 m/t	23.3%
2	India	45,000,000 m/t	12.2%
3	Russian Federation	29,532,530 m/t	8.0%
4	Ukraine	23,250,200m/t	6.3%
5	United States	19,165,865 m/t	5.2%

Sources: *FAOSTAT data, 2014 (last accessed by Top 5 of anything: January 2014).*

Potato Production in Africa

Potato arrived late in Africa, around the turn of the 20th century. In recent decades, production has been in continual expansion, rising from 2 million tons in 1960 to a record 16.7 million tons in 2007.

Potatoes are grown under a wide range of conditions - from irrigated commercial farms in Egypt and South Africa to intensively cultivated tropical highland zones of Eastern and Central Africa, where it is mainly a small farmer's crop*(http://www.fao.org/potato-2008 /en/world /africa.html,June, 2015)*.

Potato Production in Ethiopia

A German immigrant is credited with introducing the potato to Ethiopia in 1858. Over

the following decades, farmers in Ethiopia's highlands began cultivating the new tuber - known as denech-as an "insurance policy" against cereal crop failures. Among African countries, Ethiopia has possibly the greatest potential for potato production: 70 percent of its arable land - mainly in highland areas above 1 500 m - is believed suitable for potato. Since the highlands are also home to almost 90 percent of Ethiopia's population, the potato could play a key role in ensuring national food security. At present, potatoes are still widely regarded as a secondary crop, and annual per capita consumption is estimated at just 5 kg. However, potato growing is expanding steadily: FAO estimates that production has increased from 280 000 tones in 1993 to around 525 000 tones in 2007*(http://www.fao.org/potato-2008/en/world /africa.html, June 2015)*.

Table 1.2. *Top Potato Producing Countries in Africa*

Rank	Country	Potato Production [tones]
1	Egypt	4,500,000
2	Algeria	4,219,476
3	Malawi	3,255,780
4	Kenya	2,915,067
5	Morocco	1.56 million
6	Rewanda	1.3 million
7	Nigeria	843 000
8	Kenya	800 000
9	Uganda	650 000
10	Angola	615 000
11	Ethiopia	525 000

Source: *FAOSTAT, 2014*

Potato Varieties

There are literally thousands of different varieties of potatoes grown around the world depending on different criteria. In Ethiopia there is no clear data about the varieties of potatoes.

For the purpose of the study researchers of this study select two common types of potato which are widely used in Tepi local Market. The appearance and other properties of these potatoes are given below.

Red Potatoes

Fig1.2. *Appearance of red potato.*

When we see the properties of white potato; Its Appearance ranges from small to medium; round or slightly oblong; smooth, thin red skin; white flesh. Its Texture is waxy, moist and smooth; creamy. Its Flavor is subtly sweet; mild medium sugar content. Its preferred uses are Roasting, mashing, salads, soups/stews.

Because of their waxy texture, the flesh of red potatoes stays firm throughout the cooking process, whether they are being roasted or cooked in a stew. Their thin yet vibrant red skin adds appealing color and texture to side dishes and salads. Reds are frequently used to make tender yet firm potato salad or add pizza to soups and stews, as well as being served baked or mashed. Round reds are often referred to as “new potatoes,” but the term “new” technically refers to any type of potato that is harvested before reaching maturity.

White Potatoes

Fig1.3. *Appearance of white potato.*

When we see the properties of Red potato; it’s **Appearance**: small to medium; round to long shape; white or tan skin; white flesh. Its Texture is medium starch; slightly creamy, slightly dense; thin, delicate skin Its Flavor is subtly sweet; mild; low sugar content. Its preferred

uses are mashing, salads, steaming/boiling, frying.

White potatoes hold their shape well after cooking. Their delicate, thin skins add just the right amount of texture to a velvety mashed potato dish without the need for peeling. Grilling whites brings out a more full-bodied flavor. Create signature potato salads–just toss cooked white potatoes with dressings and ingredients "borrowed" from other salads, e.g., Caesar dressing and grated Parmesan; or ranch dressing, chopped egg and bacon crumbles.

Chemical Composition of the Potato Tuber

Potato tuber (or simply potato) is composed of different nutrients (compounds) and elements. The basic chemical components of the tuber are described in Figure 1.4 below.

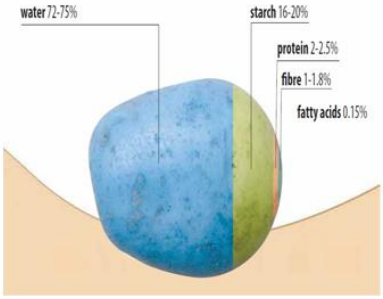

Fig1.4. *Chemical composition of potato tuber (Adapted from: IYP, 2008)*

As we can see above Potato is a rich source of starch. It has 16-20% more starch. This high starch content is being judiciously utilized for the production of ethanol. The demand for ethanol is being rising day by day due to its potential of being used as a substitute for gasoline. To meet this demand there are different researches around the world that investigate alternative energy sources from different food staffs one is extraction of ethanol from potato (*Rani P.,etal,2010, A.Meenakshi and R. Kumaresan,2014, Afifi, A.etal,2011).* In the case of our country researches were done to extract ethanol from different food staffs like fruit peel waste (orange, mango and banana) *(W. Mekonnen, 2012).* But in the case of potato there is no or little work in extraction and characterization of ethanol from it. Researchers of this study were aimed to investigate the extraction and characterization of ethanol from potato.

Objectives of the Research

Potato-based ethanol production utilizes potatoes as a raw material. Potatoes are produced as in potato cultivation and we use for dietary purpose. In addition to dietary purpose solid potato mash is also formed which can be considered as raw material in ethanol production *(Kilpimaa 2008, Liimatainen 2004).*

General Objective

The main objective of the study is to extract ethanol from Potato by simple distillation method and characterize the ethanol produced.

Specific objectives are:

- To develop a technique to extract the ethanol from available Potato.
- To analyze and characterize chemically the ethanol obtained from Potato.
- To determine the amount of ethanol produced by the process.

MATERIALS AND METHODS

Materials and Instrumentation

- Plastic bag: To collect and transport samples to the laboratory.
- Knife: For cutting the potato samples.
- Bath, water boiling bath: For cooking the pieces of the sample.
- Oven: To dry the sample.
- Crusher: To crush the dried sample.
- Sieves: To sieve the crushed sample to the particle size of 2mm.
- Balance: To weigh the samples and yeast.
- Vessels: To hold the samples for distillation.
- Graduated cylinders: For volume measurement.
- Distillation set ups: To distill.
- Conical flask: For preparing solution.

Chemicals and Reagents

- Yeast or Saccharomyces cerevisiae.
- Water: For washing the samples, materials and for preparing the solution.

Experimentation and Working Procedure

The general experimentation procedure was followed as follows in the figure 2.2. Basic steps for production of ethanol from potato

Sample Collection

Potato sample and baking yeast were collected from the local market of Tepi town.

Sample Preparation

The samples that were acquired had to be prepared and conditioned for pre treatment and distillation. The sample preparation process includes: Manual size reduction (knife cutting), drying, grinding and sieving after the samples were collected. Peel of red and white potato each one kilogram was used for sample preparation.

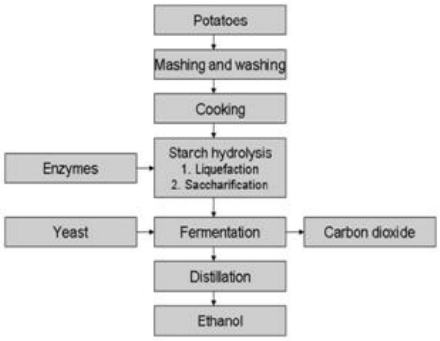

Fig3.1. *Potato based ethanol production process (modified from Vahtola et al. 1999)*

Fig2.1. *Steps for preparation of potato mash.*

Fig2.2. *Potato slurry before extraction*

Sample drying was carried out in an oven at 250 degree centigrade to obtain easily crushable material. Each of the samples was milled separately.

The maximum particle size of the ground mixed sample was two millimeter. The sample of larger particle size than 2mm was ground over again until all particle size became 2mm. The sample was kept at low temperature until the next stage of the experiment.

Fermentation

The aim of experiment was to measure the ethanol production by *Saccharomyces cerevisiae* using potato peel. The clean solution then goes to fermentation. The fermentation was carried out under anaerobic condition.

Component of Distillation Experimental Set Up

- Distillation vessel.
- Condenser.
- Beaker.
- Thermostat supporting flat metal bar.
- Heating mantle.

Fig2.3. *Distillation set up*

Simple Distillation Process

Distillation was the last step in the production of ethanol from potato peel experiment. It is the purification step. Distillation is the method used to separate two miscible liquid based on their different boiling point. In this experiment separations were used by simple distillation method at temperature of 80 degree centigrade.

RESULT AND DISCUSSION

White potato		Red potato	
Period (days)	**Ethanol in ml**	**Period(days)**	**Ethanol in ml**
1	33.4	1	35.3
2	45.0	2	45.0
3	35.0	3	37.0
4	35.0	4	35.0
5	36.0	5	36.0
6	35.0	6	35.0

For incubation period as the table above shows that, the amount of ethanol produced increase as incubation period increase and for some cases decrease as day increase.

Real Sample Analysis on Different Parameters

Effect of Concentration

In order to study the effect of concentration four solutions of different potato flour concentrations of both the white and red potato were prepared as follows: In the first trial 2 g of sample in 200ml conical flask with 2 mg of yeast and then distilled water was added up to the mark. For the second trial 4 g of sample in 200ml conical flask with 2 mg of yeast and then distilled water was added up to the mark. For the third trial 6 g of sample in 200ml of conical flask with 2mg of yeast and then distilled water was added up to the mark and for the fourth trial 8g of sample in 200ml of conical flask with 2mg of yeast and then distilled water was added up to the mark and the solution was kept for five days.

Amount of ethanol produced from each sample after incubating five days was summarized in Table 3.1 below.

Table3.1. *Extracted ethanol from different amounts of white and red potato slurry.*

Red potato	Ethanol obtained	White potato	Ethanol obtained
2 g	23 ml	2 g	25 ml
4 g	27 ml	4 g	28 ml
6 g	32 ml	6 g	35 ml
8 g	35 ml	8 g	39 ml

From Table 3.1 above and figure 3.1A and B below as the amount of sample in grams used increase the yield of alcohol increase. When we compare white and red potato the yield of alcohol is high in the case of white potato. Concentration of 2, 4, 6 & 8 g of samples were used for the production of ethanol, out of which 8 g gave the highest yield for both samples.

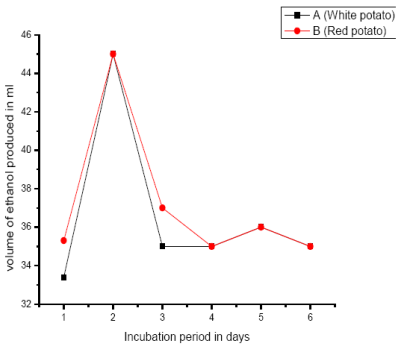

Fig.3.1. *Ethanol concentration versus amount of red potato (A) and white potato (B) slurry*

In both cases the graph is ploted as volume of ethanol produced in ml versus amount of potato mash flour used in grams. And from the graphs the relation ship between volume of ehanol obtained and amount of potato slurry is directly proportional which means as the amount of potato flour increase the volume of ethanol production increases.

Effect Incubation Period

Six solutions were prepared using the same amount of yeast with 200 ml conical flask and then the flask were filled with distilled water .The amount of sample used was 4g from each sample and 2 mg of yeast then each solutions prepared were shake well and made ready for simple distillation.

Table 3.2 *Amount Ethanol produced at different incubation period.*

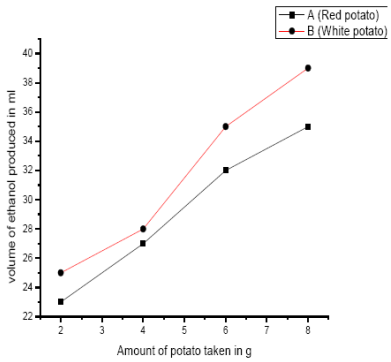

Fig3.2. *Effect of inccubation period on ethanol production for white potato (A) and red potato (B)*

Incubation graph were plotted using time versus yield of ethanol.The two graphs were almost similar due to the closeness of results obtained.

Generally, the result obtained during this experiment showed different values depending on incubation period and concentration effect. For incubation period, the result obtained as listed in the table above, more precise one is 35ml from the same sample amount of 4 g of each type of potatoes means white and red potatoes, this values obtained was after four days (96hr).The result obtained is for each color or type of potatoes .This means from red potato35ml of ethanol is recorded and 35ml of ethanol obtained from white potato.

For concentration effect different amount of sample used from 2 g up to 8 g of potato with range of 2 g and kept for five days for fermentation purpose and by simple distillation,among the results obtained from each amount of samples (2 g,4 g,6 g ,8 g) more accurate for both types of potatos were recorded from 4 g sample, the amount ethanol obtained is 27ml from red potato and 28ml from white potato.

In this study the ethanol from potato was 35ml which is some what nearly similar to ethanol from orange,mango and banana of 38 ml *(W. Mekonnen, 2012).*

Finally, the extracted solution is tested for exactness by physical (odour and flame test) and chemical (using acidified potassium dichromate solution) means in which both are qualitative. Its odour is similar with that of the spirit alcohol and is flammable on fire. When we add acidified potassium dichromate solution the color of the solution is decolorized which indicate the solution is ethanol alcohol.

A **B**

Fig3.3. *Test for ethanol using acidified potassium dichromate solution (A) Colour for acidified Potassium dichromate solution (B) Colur for ethanol and acidified potassium dichromate solution after shaking.*

CONCLUSION

Potato flour prepared by cooking mashing & grinding was used for ethanol fermentation by *saccharomyces cerevisiae*. In this study potato has been carried out on the effect of incubation period and concentration for ethanol extraction we have got a significant amount of ethanol from both types of potato. As we compare the two white potato gave greater amount of ethanol in both cases.

RECOMMENDATION

Further study have to be done to investigate the difference in value for the white potato and to improve the production of high quality of ethanol from potato and other effects like temperature and pH effects should be investigated further. Alternative extration methods of ethanol such as enzymatic extraction have to be done in order to investigate the varaition that could be arise on the quality & quantity of the ethanol yield as result of using different extraction methods.

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