

Technology Development for Roots or Tubers Vinegar Production

Dissertation 1 Report

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CERTIFICATE

This is to certify that **Jay Raju Hemke** (Registration No.11707850) has personally completed M.Tech. Dissertation 1 entitled, “**Technology Development for Roots or Tubers Vinegar Production**” under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of Dissertation has ever been submitted for any other purpose at any University.

The project report is appropriate for the submission and the partial fulfilment of the conditions for the evaluation leading to the award of Master of Food Technology.

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CHAPTER 1.

INTRODUCTION

The genus *Cichorium* (Asteraceae) is categorized in six different type. It is cultivated probably in the region of Europe and Asia. (Bais and Ravishankar 2001).It is commonly in the existing market exposed with a named as chicory, Its structure is like woody pastarium , It having near about 1m long as well as fresh pulpy root of up to 75 cm in length. It having long as well as broad basal leaves. (Bais and Ravishankar 2001 and Gericke et al., 1997).In the ancient times the chicory roots is explored for medicinal purposes, coffee replacer sometimes it is consumed by animals.

In the time of 1970s, it was discovered that chicory roots is containing 40% inulin, which having the minimum impact on blood sugar does not having huge impact on the diabetics .For the industrial scale it is explored due to it is rich in the inulin. The name of chicory is taken from the Latin and Greek (Vergauwen et al., 2012).Chicoricum is word which means intibus is taken from Greek literacy it means “for cutting”, due to leaves it indicates the open stem (Radix, 2013). Chicory plant having the stability to survive in high thermal conditions in both of the genuine stages follows somatic and reproduction growth conditions(Bais and Ravishankar 2001).In the case of all portions of the plant is get worn-out then portions of plant have milk like fluid(Wyk et al., 1997).

C.intibus is cultivated for huge number of purposes chicory plant having different type of portion having different types of characteristics are as follows. 1) Chicory root is most probably used for coffee replacer (adulterant).2) Chicory Brussels are commonly used for the medicinal purpose.3)Leafs of chicory plant is used for preparation of salad dressing as well as use as vegetables for cooking purpose. And 4) “forage” Portion of chicory plant is used in application of pharmacological parameters.

C.intybus having huge number of medicinal and pharmacological applications. As a medicinal purpose it is used generally in the region of Eurasia and southern part of African countries. For covering pharmacological parameters European regions is gave important contribution (European medicinal agency 2010, 2013). Chicory plant having different plant and each of them having different type of medicinal purposes over the world each one of them are used for different application(medicinal and pharmacological).Every portion of plant having numerous phytochemicals as well as nutritional attributes, but roots of chicory is rich in phytochemicals and many other nutritional factor (Akkola et al., 2012).

Vinegar is term which said to be a liquid material produced with incorporation of *saccharomyces* species with production of final material acetic acid undergone fermentation process. It is prepared by numerous raw material black rice, white rice, barley, sweet potato, apple cider, beer, wine and coconut etc. The

production method of vinegar is completed with incorporation of wooden chips and wooden barrels etc. then submerged fermentation method is takes place under acetators (Morales et al., 2001).

Vinegar has mechanism to act as food preservative in food processing chain. In the case of preservation of food material there are two kinds of chances 1st one is added intentionally another one is formation of acetic acid during the fermentation. It having stability to inhibit microbial growth as well as enhance sensorial attributes of food stuff (De Ory et al., 2002). There is numerous amount of product which are existing in market (sauces, salad dressing, ketchup and mayonnaise). Due to presence of predominant acetic acid presence vinegar having flavour enhancing ability, for antimicrobial activity of vinegar presence of acetic acid is plays the important role. From all that review focus on status of vinegar as a food straight food additive also now a days, it is used as food ingredient in food processing sector (Marshal et al., 2000). Currently there are three methods which are existing for the vinegar production in market submerged state fermentation (fermentation is takes place with incorporation of wooden carks, wooden chips etc.). Orleans process (it is known as slow process) It is generally used in ancient times. It take too much time as compare with other existing methods. Generator process (It is said to be fast process).

CHAPTER 2.

PROBLEM BACKGROUD

Chicory roots or sweet potatoes are never ever explored for the vinegar production. It having large amount of polysaccharides or starch which is carbon source which is plays main role in alcoholic fermentation. Chicory roots or sweet potato having huge amount of inulin/dietary fibre, hydroxycinnamates as well as 8-deoxylactucin Glucosite. Now a days peoples are consuming chemically prepared vinegar (synthetic vinegar).Chicory roots having large number of medicinal properties which cures number of diseases. Thus tubers/roots crops have high potential for vinegar production.

CHAPTER 3.

REVIEW OF LITERATURE

3.1 Vinegar:

Vinegar is term which said to be liquid hysteries for consumption by human being produced by differential existing method from the numerous raw material (i.e., apple cider, rice, pineapple barley, sugarcane and beer) and acetous and contain specific range of acetic acid. Vinegar is produced by different type of fermentation method with numerous sources which is rich in carbon source. White wine, red wine as well as untainted alcohol are used as substrates. Vinegar is act as a food preservative in food processing chain. In the case of preservation of food material there are two kinds of chances 1st one is added intentionally another one is formation of acetic acid during the fermentation. It having stability to inhibit microbial growth as well as enhance sensorial attributes of food stuff (De Ory et al., 2002).

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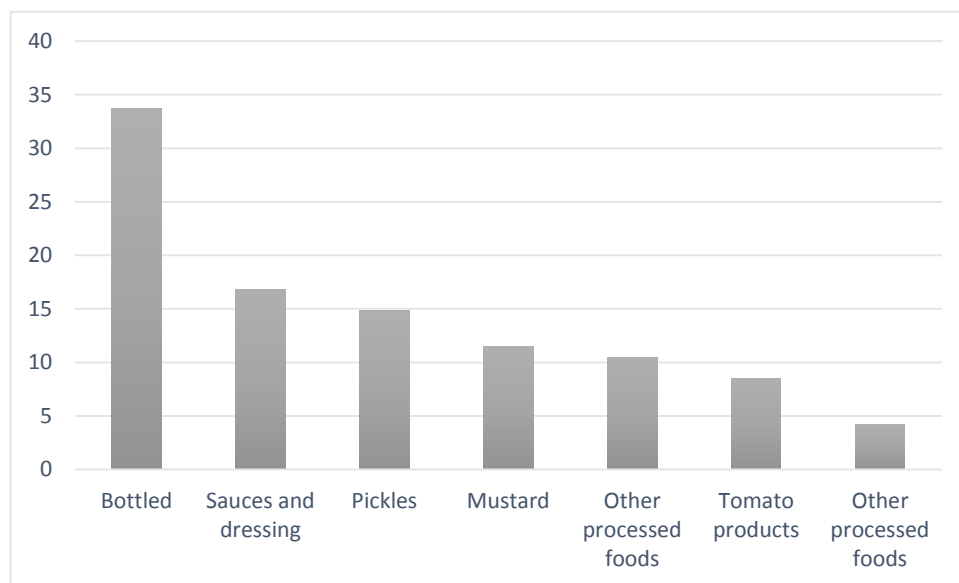
3.2 Vinegar History:

Vinegar is stand for world oldest food preservative as well as ingredient incorporate in the cooking purpose. As per the information provided by vinegar institute production and consumption of vinegar is started BC 10,000 years. After that trend of flavoured vinegar is comes BC 5,000.It having great response in that days then it is commercialized. Now a days lots of vinegar varieties are available in market its not any new thing (Kehner, 1921).

Six century back, Babylonians made selling flavoured vinegar which is made by raw material named as honey, fruit, malt and sugarcane etc. In old days vinegar is made up with incorporation of Hippocrates for taking benefits of medicinal purposes (Conner, 1976).The researcher named as Loewitz, due to implementation of incorporation of charcoal in submerged fermentation would be straighten.

3.3 Production of Vinegar, Market Analysis and Types of Vinegar

Figure 1. Vinegar Institute Production Survey in 1989



Source: (San, 2005)

As per information provided by Vinegar Institute, the rate of peddle is enhance with 15% in the time period of 2000 to 2002. It is very outstanding statistical figures as compare with any other food material in that specific region (i.e., meat, marinades, oriental sources, wine beer etc.). Again, as per AC Nielsen figures in 2003 annual meeting held in headquarter sales of vinegar is enhances with 29% as compare with backwards nine years. In this bottled vinegar production is probably high 33.7% shown in Table (1).

Table 1. Types of Vinegar

Balsamic vinegar	Balsamic vinegar has a dark brown color shade. It comes in both sweet and sour flavor. For Its production it's undergone by aging process in large container of wood (called barrels) of Trebbiano grapes.
Cane vinegar	Cane vinegar is made up by fermentation of sugarcane. After complete fermentation it has minor and sweet flavor comes.
Champagne vinegar	It is made up by substitution of grapes as raw material (two varieties of grapes are preferred Chardonnay or pinot Noir).For quick optimization sometime wine of that grapes are also preferred.

Cider vinegar	It is made up by substitution of apple cider as a raw material. It having huge popularity as compare with the other vinegars. Famous in United States.
Coconut vinegar	It is made up by substitution of coconut as raw material. It is acidic in nature. It is mildewed flavor and distinctive after taste.
Distilled vinegar	It is made with Incorporation of grains as fermentation substitute. It colorless.
Rice wine vinegar	It is made up by three types of raw material black rice, white rice, and Red rice. It takes low time period for aging as compare with other one. It is used for salad dressing and cooking purpose.
Sherry vinegar	It is fermented under very high thermal encapsulation in the wooden containers. It has nutty-sweet taste.
Wine vinegar	It can be used for cooking, cleaning and salad dressing purpose. It is made up of substitution of raw material as roses.

Source: (San, 2005)

There are numerous range of vinegar existing over the world which is used for differential purpose (Table 1).Vinegar is food ingredient which is elaborate of grains strength. The grains has 10 times much amount of acid proportion. Shows in (Table 1) For example 10%acid is given onwards of 100 grains (cruess, 1958). As per the statistical data provided by Crisco Company, Numerous types of vinegar is differ and consumer acceptability is changes from country to country.

3.4 Chicory:

Chicory is also knows as in botanical term *C.intybus* l. It has shaggy herb. It comes under Asteraceae family. Chicory plants having differential portion each of them having different types of characterized in nature as well as chemical composition and medicinal parameters. It is used in following forms leaves, flower and roots. Leaves and flowers are incorporated in salad dressing and vegetable cooking purpose. It has bitter taste so that's why it is not probably consumed in this form (Coney and Whitney 1987). (Barlianto and Marier, 1994) illustrated that roasted form of chicory roots are substitute in coffee replacer in various types of brand over world. In region of southern portion Germany used chicory roots incorporated with malt of barley (Baek and Cadwallader 1998). (Desprez et al., 1999) illustrated that rosted chicory roots are mix with numerous coffee substitute and without substitution of coffee it cannot give a preferable after taste. Some North Eastern area of African countries they are boiled it and consumed. For undertaking Fermentation purpose of some alcoholic beverages chicory roots are

probably preferred (Bais and Ravishankar 2001). Some of commercialized industries are used substitute of chicory roots for inulin fortification in food products (Geel et al., 2005). Chicory roots containing large number of inulin content therefore, there is huge chances of alcohol production in large amount (Wilson et al., 2004).

3.5 Chemical Composition:

Table 2. Approximate chemical composition of chicory plant

Chemical content%	Roots	Leaves
Moisture content	75.63±0.39	83.06±1.55
Crude protein	4.65±0.25	14.70±1.03
Crude ether extract	1.69±0.71	3.68±0.19
Ash	4.25±0.11	10.91±1.86
Total Carbohydrates	89.41±1.07	70.71±3.08
Total soluble sugar	11.06±1.00	7.80±1.45
Inulin	44.69±0.88	10.95±2.6
Crude fibre	5.12±1.55	16.78±2.20
Dietary fibre DF		
Insoluble DF	30.73±0.33	ND**
Soluble DF	0.42±0.07	ND**
Total DF	31.15	ND**

Source: (Mona et al., 2009)

*On dry weight basis

Mean ± 5.0 (every figure represents the average of three determinations ± standard deviation)

ND: Not Determined

As per information provided by (Table 3) chicory leaves contain amount of protein is (14.70%) ash (14.70%), Crude ether (3.68%) and crude fiber (16.78%) and had low amount of carbohydrate (68.50%) as compare with roots. As compare with other side chicory roots having high concentration of inulin (44.69%) is present. (Monti et al., 2005) reported all results we have. The obtained results originate that crude protein and ash content ranges about 8.56% to 15.73% and 9.58% to 13.75% respectively. (Adamoni and Rigon 2001) reported that roots having 15-20% inulin as well as 5-10% oligofructose.

3.6 Medicinal Uses of Vinegar:

3.6.1 Antimicrobial effect:

Vinegar is well known for antimicrobial things; it is useful for spring-cleaning, treating nail fungus, head lice, warts and skin problem in olfactory nose (Rutala et al., 2000). Now a day it is used as a natural preservative method for inhibit the development of the microorganism in food material. Many type of organic acid are present natural form in variety of fruits and other in fermented food, together with acetic lactic, ascorbic, malic, citric, propanic acid etc, and in no excess levels. Not any of these acids are hazardous to individual health (Escudero, 1999). Many of research has said to be vinegar might be used to hinder the microorganisms on garden-fresh fruits and vegetable.

3.6.2 Cardiovascular Effects:

Vinegar ingestion influences other hazard components for cardiac malady in people is not acknowledged. Hu as well as colleagues announced an essentially bring down hazard for lethal ischemic coronary illness among members in the Attendants Wellbeing Study who expended oil-and-vinegar serving of mixed greens dressings as often as possible (5-6 times or more for each week) contrasted and the individuals who seldom devoured them Successive utilization of mayonnaise or other velvety plate of mixed greens dressings was not altogether connected with hazard for ischemic coronary illness in this populace. The review creators fight that since oil and vinegar dressings are a noteworthy dietary wellspring of nutritional alpha-linolenic corrosive, an antiarrhythmic operator, alpha-linolenic corrosive may possibly be the advantageous element of this sustenance. However, velvety, mayonnaise-based serving of mixed greens salad dressing are additionally high amount of alpha-linolenic corrosive and did not demonstrate a similar hazard advantage as the oil and vinegar dressings.

3.6.3 Anti-obesity Effect:

In a review revealed by (Johnston, 2006), humanoid subjects expending 2 tablespoons of reddish raspberry vinegar every day with unreservedly access to sustenance in addition water for 4 week shed pounds though the control bunch devouring a comparable measure of cranberry squeeze day by day for 4 week had a slight weight pick up.

3.6.4 Anti-infective Properties:

The utilization of vinegar for battle contaminations and other intense conditions goes back to Hippocrates (460-377 BC; the father of current prescription), who prescribed a vinegar arrangement for cleaning ulcerations and for the curing of wounds. Oxymel, a well-known antiquated prescription made out of nectar and vinegar, was endorsed for tireless hacks by Hippocrates and his peers, and by doctors up to current day. The definition of oxymel was itemized in the (English Pharmacopeia, 1898) and the German Pharmacopeia (1872), and, as indicated by the (French Codex, 1898), the solution was set up by blending virgin nectar, 4 sections, with white wine vinegar, 1 section, focusing and elucidating with paper mash.

3.6.5 Antioxidant Effect:

In the recent study hydrogen peroxide, superoxide and hydroxyl radical are the reactive oxygen genus that have been reported to affect lipid, protein, and DNA resulting in leading cancer, aging and degenerative disorder (Buonocore et al., 2010). Some of bioactive compounds within food may lead to reduce incidences of degenerative illness by providing the antioxidant effect. Examination of conventional balsamic vinegar indicated an antioxidant activity, which was mostly due to melanoidins, futher investigation report that melanioidins prevent absorption and prooxidant, cytotoxic effect to human in simulated gastric digestion of the meat(Xu et al ., 2004).

3.6.6 Anti diabetic effect:

Insulin affectability has been enhanced through vinegar treatment in 19% of citizens with sort 2 diabetes and 34% of citizens with prediabetes (Johnston et al., 2004). Late reviews in both creatures and people have demonstrated that vinegar may be used for diabetic treatment (Salbe et al., 2009).

4. Vinegar quality characteristics:

4.1 Vinegar aroma:

Vinegar quality is depend upon its double fermentation process, it include rate of fermentation, acetification speed. The frequency of fermentation enhances the sensory properties of the finishing vinegar. The vinegar odour and essence is depending on method of processing, it may be traditional or submerged, aging time, basic row material used for vinegar creation. So vinegar is not containing only acetic acid but also contains other organic acid.

5. Acetator:

In most of Mediterranean countries wine vinegar is produced and widely used as a preservative, condiment, and acidifying agent. Conventional production requires maturation within wood for several years to gain a high acetic degree and the resulting produce is relatively expensive. New technologies are being developed to conquer this complexity with the goal of producing vinegars with an analogous quality and at the similar time less expensive. This method of production of vinegar involve the application of continuous aeration system and submerged bacterial culture which enhancing yield and superiority of the final product. (Tesfaye., et al 2002).

6. Production Methods:

Vinegar is produced by a two phase fermentation method however in first stage the fermentable sugar is converted to ethanol by yeasts, generally *Saccharomyces* species, and in second stage the oxidation of ethanol is done by bacteria, generally *Acetobacter* species. From a technological point of view, there are two well defined methods for vinegar making: traditional (slow) process (Orleans Process) and submerged (quick) process (Generator Process) methods.

6.1 Orleans Process:

This is the slow process of acetifying wine and from 1670 in France this method has been used called as French or Orleans process (Figure 1). In this process, alcohol solutions a smaller amount than 5% in wine cannot be acetified simply. This process of producing vinegar was the only method to produce wholesome wine vinegar, and was reported to be the top method to make fine class table vinegar (Hickey and Vaughn 1954). In this method the wood barrels from (Cruess 1958) are used and filled with alcohol fermenting liquid to approximately $\frac{3}{4}$ full.

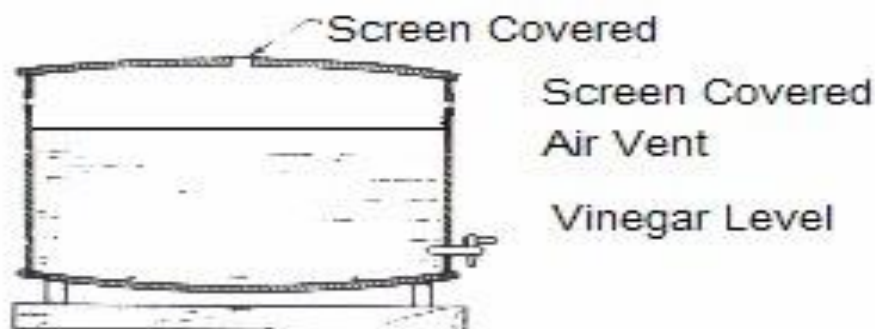


Figure 1: Orleans Process Fermentation Barrel

At First, a few inches above the liquid surface and at the ends of the barrel a few inches above of the liquid surface holes are made. The holes are stayed open and roofed with a fine screen. Secondly, about 20-25% of fresh and clean vinegar is filled in the barrel (Muspratt 1871). The purpose of adding up the

fresh vinegar is acidifying the liquid to the point of finest growth for the vinegar bacteria. The fermentation is run for nearly about 1 to 3 months at 70°F to 85°F. Following this time, 1/4 to 1/3 of the liquid vinegar drained off for bottling purposes and an equal quantity of alcoholic liquid filled. Alcohol sources should continuously be added to the vinegar or the acetic acid may initiate to oxidize (Crues 1958).

6.2 Submerged Fermentation:

Now a days, the most common method is used for the fermentation is submerged culture technique having stability to enhance general fermentation attributes (i.e., aeration, stirring, heating etc.). As we know Generator method is taken large number of time to complete the fermentation process in alternation of that in commercial vinegar production they are prefers submerged fermentation. In this process mash is incorporated then, start continue supply of air (De ory et al., 1999). For appropriable completion of fermentation process main thing is that to maiming temperature during fermentation as well as heat exchanger would be used to unholding of minimal temperature.

The process used for vinegar fermentation over the world for vinegar production is creating connection with antibiotic. Only the change is this in antibiotic bacteria plays the main role, in case of vinegar production vinegar bacteria is intermediate in liquid in case of alcoholic mash. In case of submerged fermentation it can be takes place with any kind of filler component (i.e., wood shaving, beech-wood etc.). It is undercoated in airtight generator with acetic acid bacteria. The acetic acid bacteria is water-logged at the time of fermentation of liquid, due to this condition mash is converted into vinegar with continues multiplication of oxidase (Allgeier et al., 1960; Adams 1985). To takes place the oxidation process continuously, acetic acid bacteria needs a regular supply of oxygen. After successful completion of this condition the final yield of vinegar is outstanding. At the commercial production of vinegar best temperature is utilized is 86°F (30°C). If sometime due to some technical problems temperature is goes above 86°F in that case vinegar bacteria is get damaged also effect on final yield and sensorial attributes (Fregapane et al., 2001).



Figure 2: Submerged Fermentation Process

6.3 Generator Fermentation:

Historically, Vinegar fermentation process I said to be trickle process. Now a days it is called as Generator fermentation process. It is taking low time as compare with other existing method therefore it is called as quick method. This method is reported by German Scientist named as Schutzenbach in 1832, his research area is basically chemical department (Hickey and Vaughn 1954). In this method need of incorporation of wood corks and wood shaving as well as charcoal. For the formation of dense slime layer within (Figure 3) non-compacting substance (Peppler and Beaman 1967). For the appropriate fermentation in low interval of time there is need to packed the non-compacting material into the fermentation barrel (Figure 4) which is made up from wooden material (Cruess, 1958). It having capacity of 2000 cubic feet upper to wooden surface.

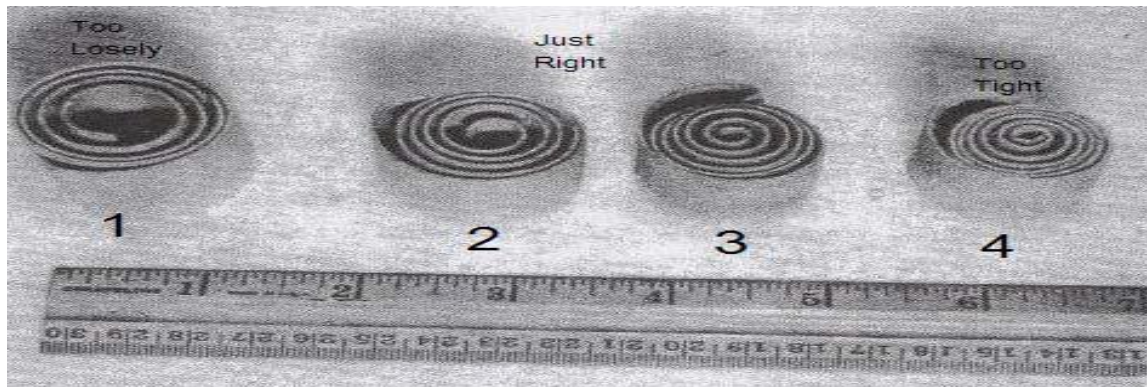


Figure 3: Beech Wood Shaving

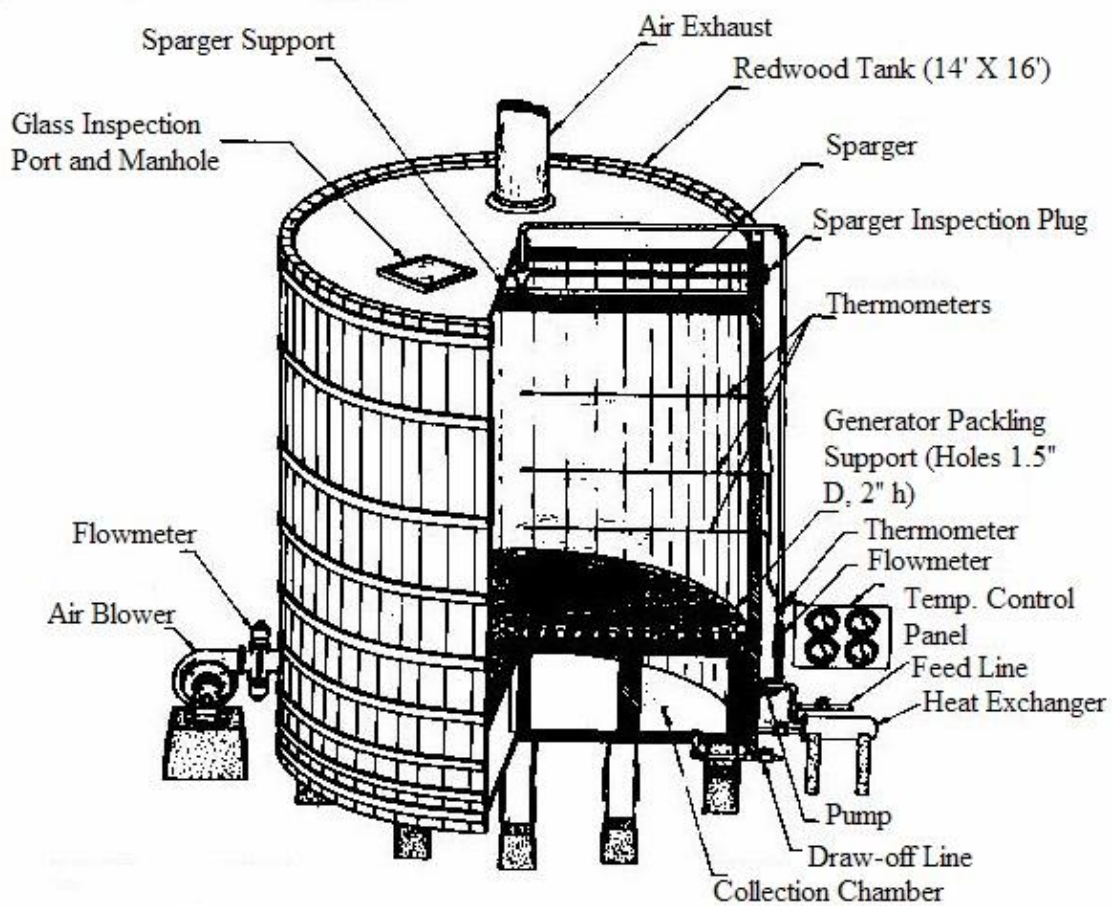


Figure 4: Vinegar Generator

4. PROPOSED RESEARCH OBJECTIVE

1. Preparation of base wine from chicory roots or sweet potato.
2. Preparation of chicory root or sweet potato vinegar from wine.
3. Development of farm based acetator.
4. To develop a process for production of seasoned chicory root or sweet potato vinegar.

Chapter 5: PROPOSED RESEARCH METHODOLOGY

5.1 Detailed plan work

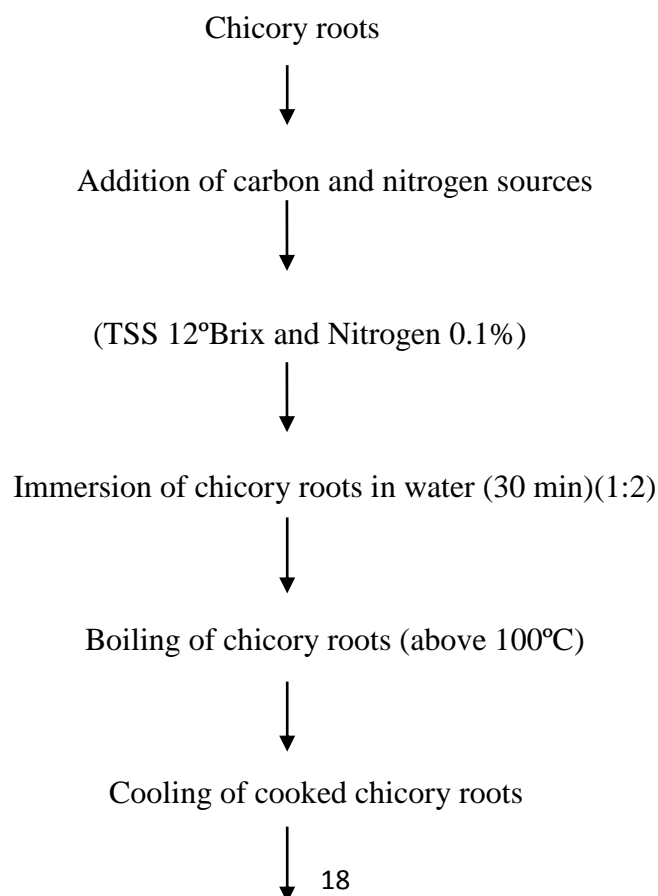
5.1.1 Objective 1: Standardize the process for base wine production from chicory roots

Base wine preparation: The method of vinegar production from chicory roots will be standardized by alcoholic fermentation (wine). Alcoholic fermentation will be done by the *saccharomyces cerevisia* (Brewer's yeast). The wine process will be standardized by ameliorating with low cost carbon (starch and sugars) and nitrogen source (mustered cake and soya cake) comparing with defined carbon and nitrogen source, to ensure the ferment ability of chicory roots.

- Carbon source: The TSS will be maintained at 12° Brix (to get minimum 5% alcohol)
- Nitrogen source: The nitrogen concentration will be maintained at 0.1% (mustered cake and soya)

Chicory roots alcohol fermentation (Nishidai et al., 2000)

Production of chicory roots vinegar starts with the immersion of chicory roots in water followed by heating, cooling and incubation it with yeast for production of ethanol.



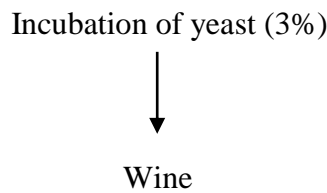


Figure 5. Flow chart of base wine production

The following parameters will be evaluated after production of wine:

- Titratable acidity (San Chiang, 2005)
- Antioxidant activity (Sasmita, 2016)
- pH (San Chiang, 2005)
- Alcohol content (Ranganna, 2012)
- Total phenolic (Sasmita, 2016)
- Sensory evaluation (Tsfaye et al., 2002)

5.1.2 Objective 2: To optimize the process for production of chicory roots vinegar using submerged state fermentation

The term “submerged acetic fermentation” is similar to the common procedures involved in the cultivation of yeasts. In this case, bacteria carry out fermentative work on a solution, which is the alcohol blend. Bacteria are forever dipped in the liquid to ferment, where they build up and oxidize the alcohol blend into vinegar. In submerged state fermentation method, acetic acid bacteria is dipped in the liquid to multiplying, ferment and drawing power from the oxidation of ethanol to acetic acid. To catalyze the reaction that gives them energy, acetic acid bacteria want a sufficient and permanent delivery of oxygen in all parts of the tank. A disturbance in the oxygen delivery, especially in the last stages of fermentation, will influence the performance (Budak et al., 2014)

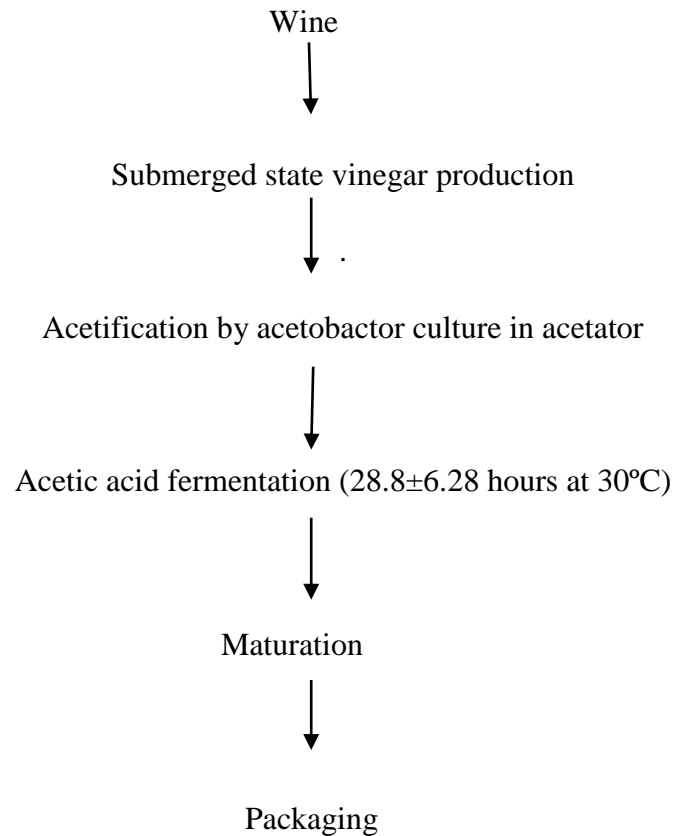


Figure 6. Flow chart of chicory roots vinegar production

The following parameters will be evaluated after production of acetic acid:

- pH (San, 2005)
- Titratable acidity (San, 2005)
- Antioxidant activity (singh et al., 2009)
- Antimicrobial activity (inhibition zone) (Ghalem, 2009)
 - a) Well diffusion method
 - b) Disc diffusion method
- Sensory evaluation (Tesfaye et al., 2002)
- Yield of vinegar.

5.1.3 Objective 3: To Develops a farm based acetator

Material requirement:

- Reaction vessel
- Cooling coils
- Aeration system
- Valves to control loading, unloading
- Cooling coils
- Air compressor
- pH meter
- Air Flow meter
- Centrifugal pump
- Thermocouples

Design parameters: (Wilma et al., 2015)

- The height of acetator 2 times larger than diameter (shown in figure 7)
- Total volume = 8 liters(shown in figure 8)
- Working volume= 6 liters
- The fermentation process set at= 30 ± 03 °C
- Air flow rate= 3 liters/min
- The chicory roots wine (raw material) having pH of 3.0
- The chicory roots used for vinegar making should have an alcohol deliberation of 6.28 g/100 ml, glucose content of 2.8 g/100 mL and the pH was 3.00.
- In the fermentation step Acetobacter sp.Consisting of the natural contaminant alcoholic musts implemented in the existence of air.
- Start through 3.4 litre of wine have alcohol amount 6.28%
- At starting add 1.6 litre of inoculums of Acetobacter sp. Contained 2.7 gram /litre of bacteria analysed with calculating absorbance at 600 nm.

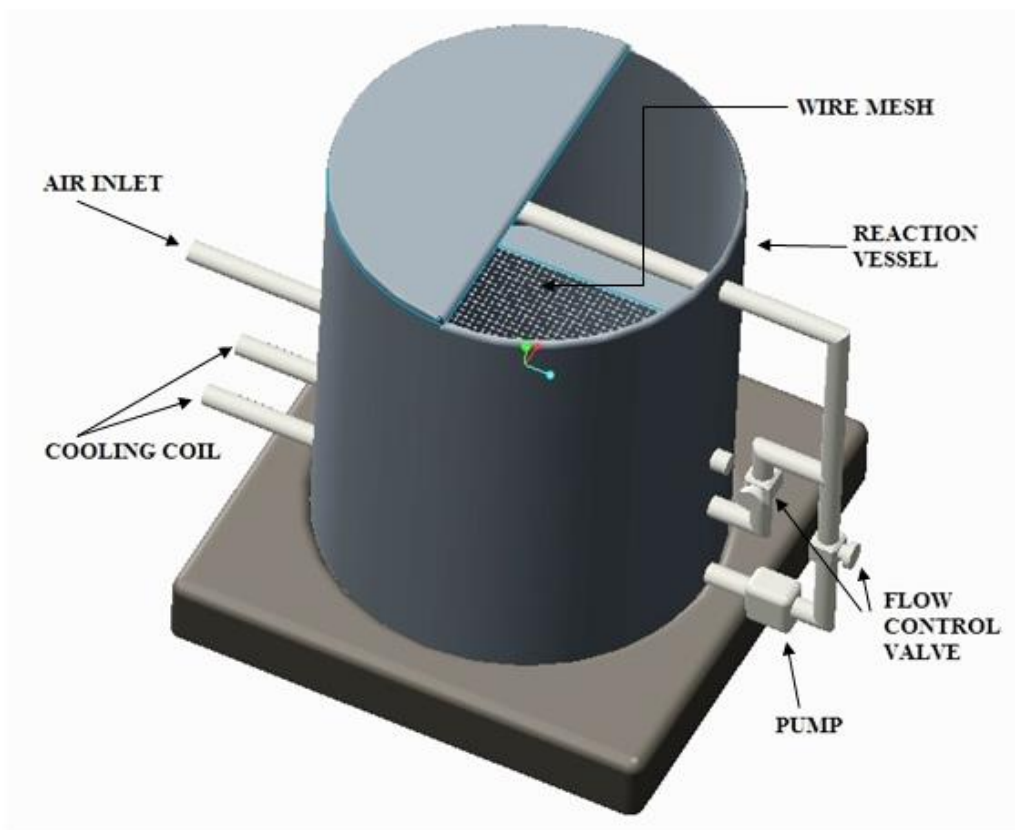


Figure 7: Farm Level Acetator

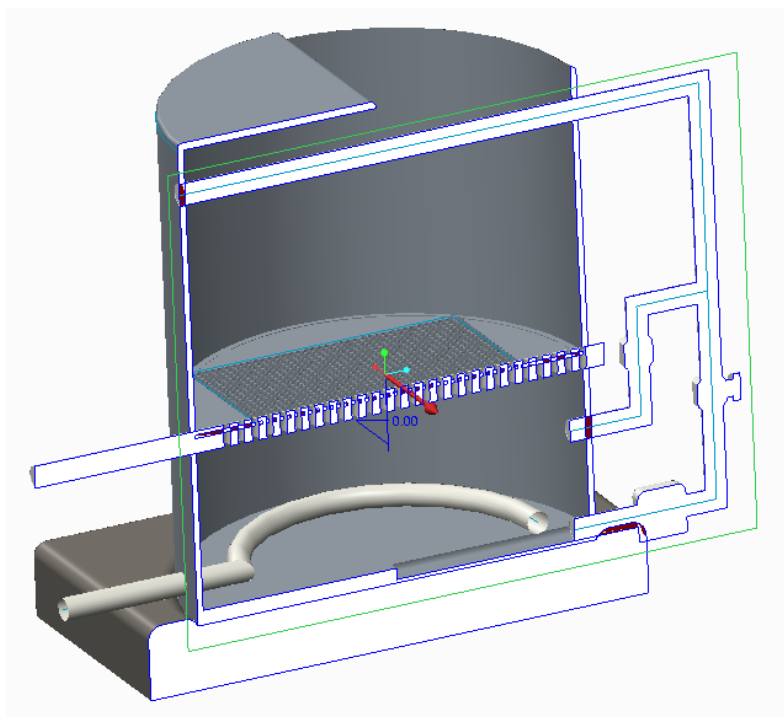


Figure 8: Cut section of Farm Level Acetator

5.1.4 Objective 4: To develop a process for production of seasoned chicory roots vinegar

For the development chicory roots vinegar incorporation of spices is takes place (i.e., common salt, pepper, garlic, clove as well as cinnamon) also with another constituents follows as honey, olive oil, soy oil etc., and obtain vinegar which having a specialized characteristics as well as sensorial attributes.

Following parameter will be estimated:

- Titratable acidity (San, 2005)
- pH (San, 2005)
- Antioxidant content phenolics (Yang et al., 2014)
- Antioxidant activity (singh et al., 2009)
- Antimicrobial activity (inhibition zone) (Ghalem, 2009)
 - a) Well diffusion method
 - b) Disc diffusion method
- Sensory evaluation (Teskaye et al., 2012)

6. EXPECTED RESEARCH OUTCOME

1. Optimized process for the production of Chicory roots or sweet potato based wine will be obtained.
2. Optimized process for the production of chicory roots or sweet potato vinegar will be obtained by submerged state fermentation.
3. Develop a farm level acetator.
4. The obtained final product will be having good sensory characteristics by seasoning of vinegar with different spices.

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