‘DESIGN AND MANUFACTURING OF STEAMER FOR PRODUCTION OF IDLI ’

Dissertation 1 Report

Submitted by,

SHUBHAM SANJEEV JADHAV

11709262

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School of Agriculture

Lovely Professional University, Phagwara

Under the Guidance of

DR. ANIL PANGHAL

Coordinator

Department of Food Technology and Nutrition

School of Agriculture

Lovely Professional University, Phagwara

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CERTIFICATE

This is to certify that Shubham Sanjeev Jadhav (Registration No.11709262) has personally completed M.Tech. Dissertation 1 entitled, **"DESIGN AND MANUFACTURING OF STEAMER FOR PRODUCTION OF IDLI"** 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 pre-dissertation has ever been submitted for any other purpose at any University.

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

Date: 14 May 2018

Signature of Supervisor
Dr. Anil Panghal
Coordinator
Department of Food Technology
And Nutrition
School of Agriculture
Lovely Professional University
Phagwara, Punjab, India

TABLE OF CONTENTS:

INTRODUCTION:

Fermented foodstuffs are the important part of the diets of many parts of the population since time immemorial. It is because of benefits in providing high nutritive value, better organoleptic characteristics, shorter cooking time, prolonged shelf life and enhancement of flavor and aroma in foods (Reddy and Salunkhe, 1980; Sathe et al., 1986; Das and Deka, 2012). The combinations of cereals and legumes provide good amounts of vitamins and proteins in the intake of the people (Rajalakshmi and Vanaja, 1967; Reddy et al., 1981; Sathe et al., 1986). Of all the fermented foods, idli, a spongy textured steam cooked product is enjoying its popularity in south India because of its superior digestibility, unique surface and sensory characteristics (Steinkraus et al., 1967; Kanchana et al., 2008).

Idli is prepared by fermentation as breakfast food in India. Its demand as a breakfast food because it is having good textural and organoleptic attributes (Steinkraus et al. 1967). It is mostly prepared by using black gram and rice, a cereal. Commonly, black gram dhal is used together with polished rice for idli preparation. Black gram has a most important role in fermentation of idli. It is used as culture of microbs and as fermenting substrate (Radhakrishnamurthy et al. 1961).

It is mostly defined as replacement of human energy by mechanical energy in all degrees of automation in this an age of automation. The degree of mechanization is increased with changing demands on physical input although the operation remains an essential component of the system.

Till recently, the manufacturing of traditional foods was considered more an art than science and the mechanization has been thought of very recently. The effective operation of any equipment depends basically on the kinematics of the equipment. Design is a process of prescribing the sizes, shapes, material composition and arrangement of parts thus the equipment will perform the prescribed task. The role of science in design process is to provide tools, to be used by the designed as they practice their art. However analysis is vital tool, inevitably be used as one of the steps in the design process. This comprises of over-all introduction of idli, an Indian traditional foodstuff and theoretical design of automatic idli steamer machine. Different parameters are necessary for the idli batter preparation such as, soaking time, swelling ratio, moisture content in batter, mixing and fermentation time are discussed.

The key objective of this project work is to automate the time consuming processes in the large scale production. Human work force is eliminated in every possible situation, in the present scenario, leading to an improvement in the efficiency to a large extent.

We are planning to Design and Manufacture an automatic idli making steamer for bulk catering and by considering cost, safety, easy handling and hygiene.

The traditional technique of making idli involves soaking, grinding, fermentation, filling cups/moulds and steaming. The idea is to make it automized filling of cups and steaming of idlis untouched by human elements.

PROBLEM BACKGROUND:

The traditional foodstuffs have been prepared for hundreds of years and the art of preparation has been perfected over years and varied across the country. The tries to change these food habits have not been successful to the extent envisaged. As the value of time is increasing day by day, especially with the working women being the sign of times, the demand for the ready- to- eat traditional foods is also increasing. Though the basic kitchen technology for the production of these foods is known, considerable research and development efforts are required to translate these technologies to the level of large- scale production. This requires a lot of effort from the food engineers and technologists.

REVIEW OF LITERATURE:

IDLI :

Ittali is the first word mention in tamil literature as early as the Meghapuranam of the 17th century AD. TheManasollasa of nearby 1130 AD engraved in Sanskrit defines the Iddarika as prepared of finely grounded urad dhal flour, shaped into small spheres, fried in ghee and then flavored with pepper powder, jeera and asafetida. In Karnataka the idli in1234 AD is described as being light, 'like coins of high value', which is not suggestive of rice base. The steaming receptacle in Kannada is allage, and the daligid. In all these references, three basics of the modern idli are missing. One is the usage of rice grits. The afterward is lengthy process of grinding and the full night fermentation of ground batter. The latter is the steaming of the fermented batter.

In 1485 AD and 1600 AD, the idli is judged against to the moon, which might propose that rice was in use; up till now there are mentions to other moon-like products only made from black gram flour. The Indonesians ferment numerous materials have alike fermented and steamed item called kedli. Steaming is a very earliest form of food preparation in the Chinese ethos, referred to by Xuan Zang saying that in 7th century AD India did not have a steaming bowl. It has been recommended that the chefs who go together with the Hindu kings of Indonesia for the duration of their visits home for the duration of the 8th to 12th centuries AD, conveyed fermentation methods along with them to their homeland. Possibly the usage of rice along with the pulse was essential as a source of mixed natural microflora needed for an effective fermentation. Yeasts have enzymes which break down starch to simple sugar forms and bacteria which lead the idli fermentation convey enzymes for souring and leavening through carbon dioxide formation. Even Czechoslovakia has alike steamed product named the Knedlik. Steaming can of course be accomplished by very simple means, merely by tying up a thin cloth over the opening of a receptacle in which water is boiled and its antiquity would be difficult to establish. It is likely that the name of idli continued even though its appeal changed with time, resulting in differentiated forms of Idly (Achaya, 1994).

Production properties of idli:

During fermentation time of idli, batter increase in non-protein nitrogen and a drop in reducing sugars have been observed. The batters are normally formulated by soaking rice (*Oryza sativum*) and black gram (*Phaseolus mungo*) dhal in water, grinding them separately, mixing and allowing the mixture to ferment overnight. The titrable acidity and the volume has increased because of the fermentation and have been used as standards for assessing the development in the fermenter. Optimal temperature range has been found for fermentation is 25-30˚C. Both bacteria and the yeast are participate in the yeast in the fermentation has been shown using

penicillin G and chlortetracylin as selective inhibitors. Acid and gas production relies on the microbe's growth belonging to the group of bacteria. Desikachar et al., (1993)

Significant increase in the methionine was not found after overnight fermentation of the idli made by fermenting of soaked and grinded parboiled rice and black gram, when idli is generally steamed. The digestibility and PER in rats were similar to the unfermented mixture. Riboflavin content reduces in the fermented batter because of the presence of the *Streptococcus faecalis.* The existence of pharmacological active amines such as tyramin was anticipated but they were not identified. Veen et al., (1993).

To produce a batter of desired consistency parboiled rice and black gram dhal are soaked and wet ground separately with addition of water. A small amount of salt is added and overnight fermentation is allowed, during that time Streptococcus faecalis and Leuconostoc mesenteroides which are naturally present on the grains or utensils grows rapidly more numerous than the initial contaminants and controlling the fermentation. The microorganism present in the batter produce carbon dioxide and lactic acid that makes the batter anaerobic and leavens the product Reddy and Salunkhe et al., (1993).

As a supplier of micro-organisms and fermenting substrate black gram gives a most important contribution in idli fermentation. Radhakrishnamurthy et al., (1993).

The native fermentation of coarsely ground dehulled black gram dhal batter at 25, 30 and 35 ˚C for 12 and 18 h minimized the quantities of Phytic acid and polyphenols significantly ($P < 0.05$). The non-fermented black gram dhal batter had great quantities of polyphenols (998 mg / 100 g) and phytic acid (1000 mg / 100 g) and these were minimized to very nearly half in the produce fermented at 35 ˚C for 18 hrs. In vitro digestibility of starch and protein increased considerably ($P < 0.05$) with increases in the temperatures and time of fermentation. A considerable ($P < 0.01$) and negative relationship found among the in vitro digestibility and the anti- nutrient further strengthens. Yadav and Khetarpaul et al., (1994).

An automatic idli manufacturing machine that produces 1200 idlis per hour. The unit contains automatic idli batter 25 depositor, a distinctive idli pan conveyor, steam compartment and idli scooping system (Murthy et al., (1994)

The thermal diffusivity (α) of idli batter was defined experimentally assuming infinite slab geometry beneath transitory heat transfer environments. The continuous (1.1×10^{-7} m2 s -1) idli steaming units and the value α of batter determined using batch (1.38×10^{-7} m2 s -1) were compared with the value obtained using Riedel's equation (1.42×10^{-7} m2 s -1) and Martens equation (1.1×10^{-7} m2 s -1) Murthy and Rao et al., (1997).

Fermentation of idli was accumplished in the traditional way that the batter having rice and black gram in the proportion of 2:1, 3:1 and 4:1 at atmospheric temperature. Brookfield viscometer having disc spindles assessed the rheology of the product. Yield stress values were in between 13- 43 Pa and touched an extreme value after 7 hrs of fermentation. Flow performance includes were in the range 0.287- 0.605. Flow behaviour indices at 23 hrs were considerably lower than those at O h. Consistency index values, at any fermentation time, enhanced as the rice to black gram proportion improved. 500 to 600 μm was mean partical size range and there was no fixed trend observed with respect to period of fermentation and rice to black gram proportion. There was a steep alteration in volume rise after 4 h fermentation. Nagaraju and Manohar et al., (2000)

Idli is eaten as breakfast or snack food. It is low calorie, starchy and healthful food. Steamed idli comprises nearly 3.4% protein, 20.3% carbohydrate and 70% moisture. Teniola and Odunfa et al., (2001).

The conventional fermented foodstuffs contain high nutritional value and developed a variety of flavours, aromas and consistencies in food substrates (Steinkraus et al., (2005).

With numerous hydrocolloids and certain surface active agents temperature (28- 30 ˚C) and refrigerated storing (4- 8 ˚C) the stabilization of the idli batter at room was examined. The slurry was assessed in terms of percentage reduction in volume and percent whey separation. Although hydrocolloids gave effective stabilization, surface active agents failed to stabilize the batter even though they minimized whey separation. Among the numerous hydrocolloids 0.1% guar gave greatest batter stabilization and idlis produced there from after 10 days of atmospheric temperature and 30 days of refrigerated storing of slurry were found to be of desirable quality (Nisha et al., (2005).

Nutritional composition of idli

Idli can be prepared locally also used as a nutritional supplement in emerging countries to cure the people suffering from kwashiorkor protein calorie malnutrition. Idli, a famous fermented breakfast foodstuff consumed mostly in the south India contains mostly of rice and black gram dhal. Idli fermentation was carried out in traditional manner in a batter having rice to black gram in the proportions of 2:1, 3:1 and 4:1 at normal temperature. Protein, calories and vitamins, specifically B-complex vitamins obtained from processed idlis equated to the unfermented raw ingredients (Nagaraju and Manohar, 2000).

The finest technique used for standardization of idli fermentation is Adding microflora Saccharomyces cerevisiae, together with natural bacterial flora of the ingredients to improved leavening, nutritional constituents and organoleptic characteristics. Traditional idli fermentation

includes a number of bacteria and yeasts, from the raw materials rice, black gram and the atmosphere, with overall 6dominance of the former in bringing about various changes. Idli fermentation increases total acids, batter volume, total soluble solids, reducing sugars, non-protein nitrogen, free amino acids, amylases, proteinases and water soluble vitamins B1, B2 and B12 contents, therefore accounting for enhanced digestibility and nutritious value of the staples. Novel idli batter are mostly preferred than traditional black gram with additional legumes, shown substantial alteration but using alteration in the levels of some biochemical components (Soni and Sandhu, 1989).

The fermented batter of idli and dosa contained greater quantity of existing lysine, cystine and methionine in fermented idli batter. After processing, maximum preservation of lysine, methionine and cystine was detected after processing idli (Riat and Sadana, 2009).

Progress and nitrogen stability serving practices were evaluated using rats to define the protein value of idli, a fermented steamed cake manufactured by using beans (*Phaseolusvulgaris*) and rice. Feed Efficiency Ratio (FER), Protein Efficiency Ratio (PER) and Relative PER (RPER) in unfermented idli are significantly higher than the fermented idli. The Digestibility Coefficient (DC) and Net Protein Utilization (NPU) of non-fermented idli intakes are significantly higher than the DC and NPU of fermented idli intakes. The BV of a casein control intake was alike to Biological Value (BV) of fermented also non-fermented idli intakes Fermentation does not increase the protein value of idli manufactured by usin beans and rice (Joseph and Swanson, 1994).

Physicochemical Characteristics of Idli:

Balasubramanian and Viswanathan (2007a) has made known that idli batter was prepared by soaking polished parboiled rice and decorticated black gram. The mixture with a proportion of 2:1, 3:1 and 4:1 (v/v) and the batter was permitted for fermentation (0, 6, 12, 18 and 24 h) with addition of two percent of salt. Additional legumes for example soybeans and Great Northern beans possibly will be replaced for black gram in manufacturing of idli (Reddy *et al.,* 1981). Fermentation period of the batter differs from 14 to 24 hrs through full night fermentation being the most regular time period. The ingredients for idli are cautiously washed, soaked in water independently, grounded, mixed, and lastly permitted to ferment overnight. Once the batter has been raised up adequately, it is prepared by steaming and served hot. The produce has a too soft and spongy texture and an appropriately acidic flavour and taste. The black gram was rinsed several times, firstly using normal water and lastly using distilled water to remove the surface microorganisms. These were found to create off flavour in the idli without they were washed out (Mukherjee *et al.,* 1965).

Mukherjee *et al*., (1965), studied the fermentation of idli batter. The microbial population responsible for the characteristic alterations in the batter were isolated and recognized. Even though there is in sequence alteration in the bacterial population, the main microorganism responsible for giving acidic flavour, along with for gas formation, was found to be *Leuconostoc mesenteroides*. In the later stages of fermentation, growth of *Streptococcus faecalis* and,

followed by *Pediococcus cerevisiae* became significant. The fermentation of *idli* determines a leavening accomplishment caused due to the action of the hetero fermentative lactic acid bacterium, *L. mesenteroides*. As far as is known, this is the first record of a leavening activity produced completely by the action of a lactic acid bacterium.

Idli is conventional fermented rice and black gram based breakfast foodstuff of South India. Idli batter was produced from soaking polished parboiled rice and decorticated black gram for 4 hrs at 30 ± 1oC in water. The soaked quantity was ground to 0.5 to 0.7 mm particle proportions batter using wet grinder with appropriate amount of water. The idli batter properties such as bulk density, pH, total acidity, flow behaviour index and consistency coefficients were studied for variety of fermentation times and combination ratios. The bulk density, pH and percentage total acidity of batter during different fermentation periods and blend proportions fluctuated between 0.94 and 0.59 g/cm3, 5.9 and 4.1 and 0.443 and 0.910%, correspondingly. The consistency coefficient at any fermentation period gives growing trend as the rice to black gram proportion increased. The flow behaviour index point to strong non-Newtonian fluid performance (pseudoplastic) of idli batter at altered fermentation periods and mixture proportions (Balasubramanian and Viswanathan 2007a).

The rheology of the *idli* batter was evaluated with a Brookfield viscometer having disc spindles. Power law model with yield stress sufficiently fitted the data. Yield stress value were in the range of 13-43 Pa and touched an extreme value after 7 h of fermentation. Flow performance indices were in the range of 0.287-0.605. Flow performance indices at 23 h were expressively lesser than those at 0 h. Consistency index values, at any fermentation interval, improved as the rice to black gram proportion improved. Mean particle size fluctuated from 500 to 600 micro meter and there was no fixed trend observed with respect to period of fermentation and rice to black gram proportion. There was a steep variation in volume rise after 4-h fermentation (Nagaraju and Manohar, 2000).

The idli batter involves lactic acid bacteria and yeasts and causes an enhancement in the nutritious, textural and flavour appearances of the final produce. The required flavour composites such as ketones, diols and acids were found to be present up to eight days of storing, although unwanted flavour compounds similar to sulphurous and oxazolidone compounds, ethanone and thiazole appeared in the batter subsequent to six days of storing. The sensory characteristics of idli (produce) manufactured from the stored batter associated well to the described flavour profile (Agrawal *et al*., 2000).

The work completed by Nisha *et al*., (2005) stabilized the idli batter at room temperature (28- 30°C) and refrigerated storage (4-8°C) with a number of hydrocolloids and several surfaceactive agents. The batter was assessed in terms of decrease in volume, and whey separation. While hydrocolloids gave advantageous stabilization, surface-active agents unsuccessful to stabilize the batter and they minimized whey separation. Amongst the numerous hydrocolloids, 0.1percent guar gave greatest batter stabilization, and idli prepared after ten days of room temperature storing and 30 days of refrigerated storing of batter were found to be of desirable superiority. Reduction in the fermentation period of the idli batter is of abundant profitable importance for large-scale idli manufacture and can be possibly accomplished by accumulation of enzymes.

The study done by (Iyer and Anathanarayan, (2008) was carry out to explore the probability of accelerating the *idli* batter fermentation practice by accumulating an exogenous source of α-amylase enzyme. 5, 15 and 25 U per 100 g batter of amylase addition to the idli batter was permitted to ferment. Different considerations were supervised and sensory characteristics were also considered and equated using that of the control set. The fermentation period was minimized from a traditional 14 h to 8 h and the sensory characteristics of the final produce were also effectively preserved.

Texture Profile Analysis (TPA) assessment was completed for idli, preparing cylindrical samples (13.5 mm diameter, 10 mm long) of *idli*. In Pearson correlation matrix, majority of the attributes were positively correlated at $p<0.01$ and $p<0.05$. The firmness value positively correlated with gumminess and chewiness, which describes the softness of idli (Balasubramanian and Viswanathan 2007b).

STEAMER:

Steam producing constructions are a portion of nearly all main manufacturing practice today. Thirty-seven out of a hundred of the relic fuel burned in US business is burned in the production of steam. This steam, sequentially, is used to concentrate liquids, to heat procedures, or is used straight as a raw stuff. All the manufacturing vigor handlers give substantial quantities of their relic fuel feeding to steam manufacturing: pulp and paper (81 %), food processing (57%), chemical components (42%), petroleum purifying (23%), and prime metals (10%). Subsequently manufacturing systems are varied, but frequently have steam systems in general, it creates a valuable goal for energy effectiveness measures (Dan Einstein).

For the duration of the previous few years, the quantity of well-being difficulties has increased associated with lack of nutrition. Due to open markets and globalisation, people have never had such an enormous collection of food products. Therefore, the correct choice of cooking preparation be able to help in overcoming the health difficulties. The greatest hopeful method that conserves organoleptic food attributes as well as nutritional attributes, seems to be steaming (Emilie Descours).

Large numbers of foods such as meat, fish, poultry processed by a steamer and products passed there over in a spiral conveyor path. Filling and dropping situations outside the oven are provided by way of the constantly running conveyor and using a constantly practicable spray washing-up liquid cleaning bath. Sanitation means include an internal cleaning spray system, getting higher of equipment parts outdoor the oven, admittance to all sides of the cookery compartment for sanitizing and other apparatus features (Charles E. Williams, et al 1996).

Food products are efficiently cooked on a plastic modular conveyor belt at atmospheric pressure in the occurrence of saturated steam protected by a containing vessel from dilution by insulating air. The steam condenses by the heat transfer and the condensate dropping in downward direction in the receptacle due to gravity (Brent A. Ledet, et al 1993).A Steaming

cooker for cooking and heating of vegetables, Such as potatoes, corn, and includes a container, with a removable opening lid.

Idli is a nutritious, starchy and low fat breakfast food. Steamed *Idli* holds about20% carbohydrate, 65-70% moistureand3% protein. Generally, large scale manufacturing of *idli* is done with the batch compartmental steamers. This method have need of manual handling of *idli* batter, making it an unhygienic manufacturing system. With the increasing demand for hygienic and fast food preparing large capacity machines mostly for commercial providing institutions, the Central Food Technological Research Institute (CFTRI), Mysore has taken the inventiveness and developed such machines. The machine designed and fabricated at CFTRI can produce upto 1200 Idli's / hr.

The food steamer is a device used for cooking or heating food received there with steam. The foodstuff steamer includes a vessel with an open internal region adjusted for receiving a volume of water there for boiling. A food receptaculum is releasably supported on an upper peripheral edge of the vessel. The food receptacle includes at least one sidewall and a lower wall. The lower wall has a multiplicity of apertures formed therethrough for the passage of steam therethrough when the volume of water in the vessel is boiled. Within the food receptacle at least one tray is removably received. One tray is adapted for supporting food to be cooked by the steam passing through the multiplicity of apertures (Will C. Jamison et al 2011).

A device which is used to generate steam by way of applying heat to water is known as boiler. To produce a source for heat or power, an enclosed container known as boiler is used in which water is heated and circulated, either by way of hot water or steam. A heating plant at middle may have one or more boilers that use oil, gas or coal as fuel. To deliver steam for cleaning, sterilizing, cooking and laundering operations, to offer hot water, and to heat buildings the generated steam is used. To provide hot water and steam for small buildings small package boilers are used. To achieve useful information of steam generation, types of boilers felicitous to boiler operation, different fittings commonly found on boilers etc. a cautious study of this topic can help. Developing the skill in the operation, maintenance and repair of boilers is the primary object (Babu Bhaskaran et al 2016).

Steaming delivers a rapid-cook option for preparation of large amounts of foodstuff while preserving important nutrients in cooked product. Steamers should be assessed with regard to long-term effectiveness and working costs characterized by means of production capacity, cooking energy effectiveness and water intake (Todd Bell et al 1999).

The concept of steam for food preparation is forever inspirational since it is extreme greater over the methods how we prepare the food at the present. Steam cookery includes heat as of the steam which is straightly exposed on the food material or metal utensil which is used as a heat transfer medium, here is no boiling water in both the cases, which commonly take away more of the nutritional components from the cooked foodstuff in conventional cookery methods. The vaporous phase of water is technically termed as steam, it is formed because of the boiling of water. Steam is unseen and cannot be visible in terms of the physics and chemistry; but in

common words it is denote to observable mist or vapor of water dews formed as this water vapour condenses in the occurrence of atmospheric air (Babu Mohan 2015).

The variability of cookery methods similar to boiling and frying are carried out by means of a high temperature cooking appliance which heats and prepares cooking material; dry steam in an effective way without losing moisture and nutritional components of the cooking material along with conserving the food's own flavour. The more heated dry steam cookery instrument containing a tray with a extension for accepting thereon cookery stuff, a steam baffle for covering the tray, a cookery bowl for holding water and lid for covering the cooking vessel. The upper part of the cookery container is fashioned of stepped quotas for receiving of the tray, the lid, the steam daze. Cutting partially the stepped portion resulting in formation of steam paths between the outlying of the tray and the internal partition of the cooking vessel. Cooking vessel generates steam which is then heated in the interval among the tray and the inner divider of the cookery vessel to a high- temperature dry state. The dry steam of high-temperature is spurted up out of the steam path which is then guided by the steam baffle toward the cooking material in the tray (Teruhiko Takeda et al, 1994).

A steam cooker having a chamber which generates heat and essential steam-producing compartment in exposed communication with the heating compartment such that steam produced in the steam-producing compartment flows easily from the steam generation into the heating cavity to generate heat, a cooking compartment maintained in the heating cavity in a location to be open through the important share of its whole surface to the steam in heating chamber and outlet in the certain of the exposed surfaces of the cookery compartment throughout which steam is entered to the cooking compartment (Lorne B. Alden et al, 1984).

A smaller perforated container fitting within the outer container and defining a water space there between, a perforated steam plate situated on the small container; at least one further container can be positioned on the steam plate and the outer container covered by a lid and thereby enclosing said smaller perforated container, steam plate and further container comprising a handled food cooker (Octaviano Roa Ludena et al, 1974).

A foodstuff steamer containing a section for in receipt of food, having a water container with a discharge valve, and a reservoir in intercourse with the water tank and the receiving chamber. A cumber separates the reservoir in a receiving section and a different boiling section. A passage in the cumber permits the receiving chamber and the boiling compartment to communicate with each other. In usage, water flows from the water reservoir into the receiving chamber, and then from the receiving chamber into the boiling compartment to be transmuted into steam. The cumber resist heat transfer from the water in the boiling compartment to the water in the receiving chamber to avoid the water in the receiving chamber from becoming agitated to an limit where air would be permitted to blow through the discharge valve into the water reservoir, thereby causing an unsuitable discharge of water from the water reservoir into the tank (Charles R. Bullard et al 1996).

OBJECTIVES:

- To design steamer for idli making.
- Standardization of idli making process with steamer.
- Calculate energy requirement of steamer.
- Mass and energy balancing to make idli with steamer.
- Cost optimization of idli making.

METHODOLOGY:

There is a global trend to minimal food processing and conservation. Customer demand for “Ready-to-Eat” preservative-free foodstuffs, that preserve their nutritious and sensorial attributes for the period of processing and ingesting, is on the increase. The shelf-life of food shortens by applying minimal processing and preservation practices to accomplish that purpose. It may place foodstuffs at danger and may compromise consumer fitness. The microbial, chemical or physical contamination of food can be reduced by good hygienic engineering and design practice. Produce 'held-up' inside the process apparatus where it can deteriorate and disturb product quality on rejoining the main produce flow may removed by appropriate hygiene design. Hygienically designed machinery will be more cost effective in the long term but originally more costly than likewise performing poorly designed machinery.

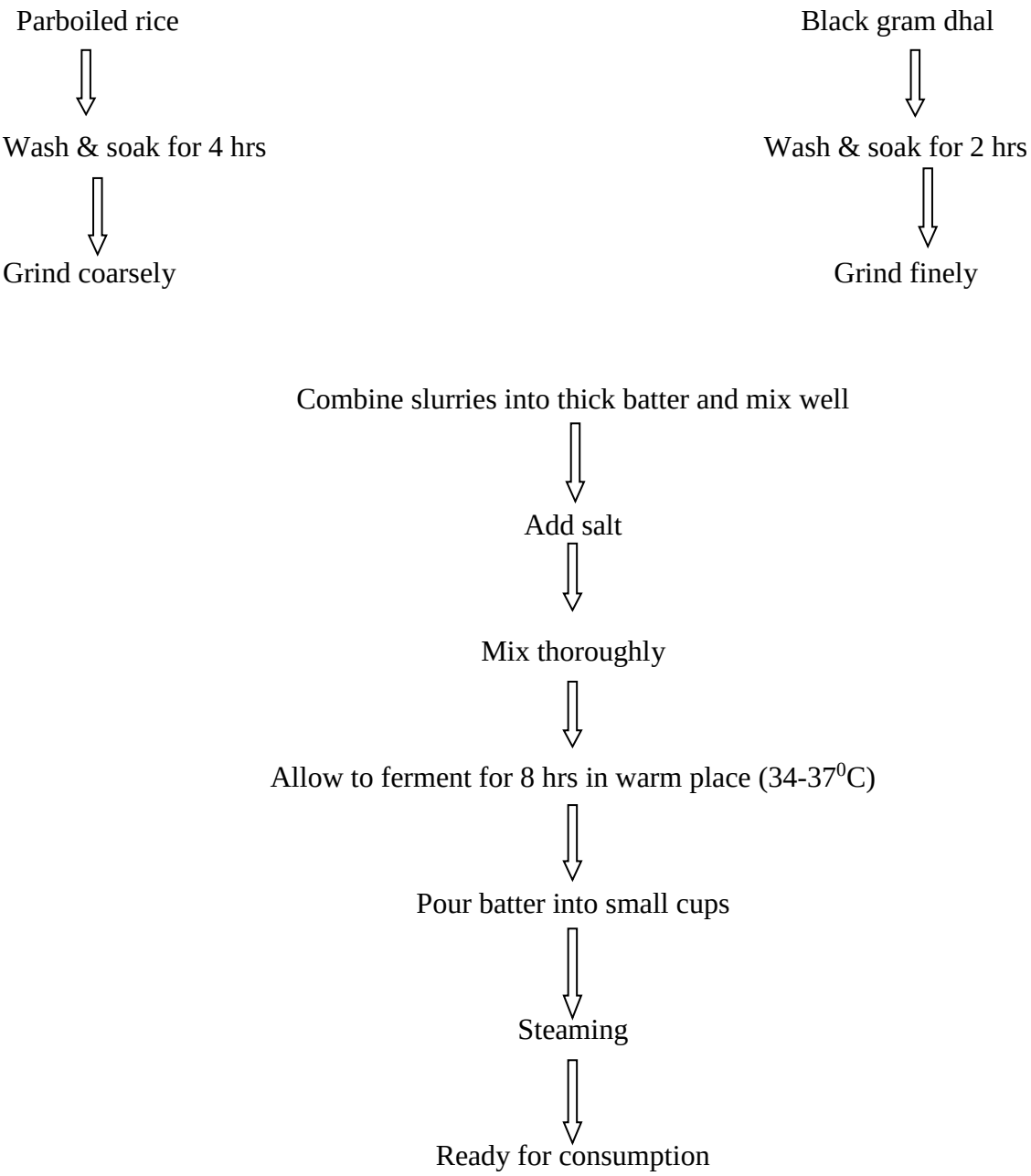
Manufacture materials for foodstuff processing machinery, process piping and values should be standardized, hygienic, inert (non-reactive to oil, fat, salt, etc.; may not contaminate the foodstuff by communicating deleterious ingredients to it, nor disturb its organoleptic appearances), chemical resistant (corrosion resistant; non-degrading and preserving its original surface finish after sustained interaction with produce, procedure chemicals, sanitizing agents and antiseptics), physically long-lasting and mechanical stable (unaffected by steam, moisture, cold, heat, the actions of cleaning and sanitizing agents; resistant to impact, stress and fatigue; resistant to wear, abrasion, erosion and chipping; not prone to crashes, cracks, cuts and pits, unbreakable) and easily to conserve.

Produce interaction exteriors –

All the exteriors open to direct interaction with the produce as well as indirectly impacted exteriors from which splashed produce, condensate, liquid or solid elements may run off, drop off, or may fall into the produce - should be created of materials that meet the highest hygienic necessities, while materials used in the manufacturing of apparatuses located in the non-food interaction area may be of a inferior grade.

Particularly the austenitic chrome-nickel or chrome-nickel-molybdenium steels are used for the manufacturing of equipment and machining in the food production. Stainless steel AISI SS 316(L) is frequently used as building material for food manufacturing equipment. Though, as temperatures approach 150°C, even AISI SS 316 stainless steels may undergo from stress-corrosion cracking in areas of high pressure and open to high levels of chloride. Consequently, other stainless steel types were industrialized to overcome that problem (e.g., duplex steel and nickel alloys) (Hauser et al., 2004a).

Flow chart for idli preparation



The best suitable rice, variant of black gram and ratios of rice and black gram dhal. The varieties of rice selected were parboiled rice, raw rice, ration rice, broken rice and red rice.

The differences in black gram dhal were black gram with husk, husk removed and husk detached after soaking. The dissimilar proportions of rice to black gram dhal used were 3:1, 3:1.5, 3:2, 3:2.5, 3:3 and 4:1 correspondingly. The change in batter volume after fermentation and the consistency of idli based on sensory was used to screen the constituents and proportions. The rice and black gram dhal were soaked for 4 h and ground independently to a rough consistency and mixed together. The batter was left overnight for fermentation with adding salt. The fermented batter was mixed thoroughly to expel the gas made because of the discharge of CO_2. The batter was transferred in idli cups, and cooked in the idli steamer.

MATERIALS:

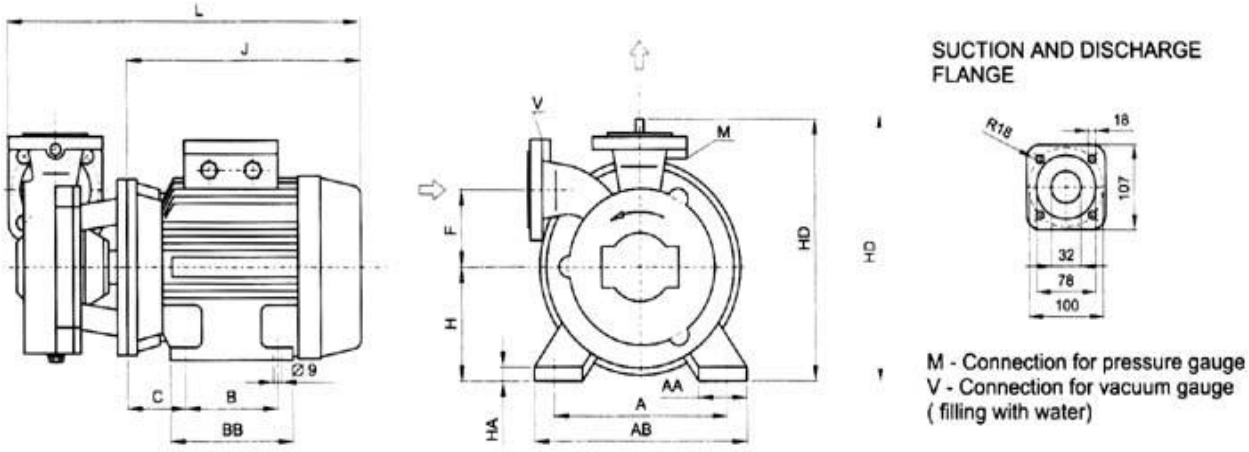
- Stainless steel AISI SS 316(L) Plates
- Motor (Pumps)
- Digital thermometer
- Stainless steel AISI SS 316(L) pipes
- Gear box
- Iron
- Belt and Pulley
- Plastic components
- Bearings
- Electric Heater

DESIGN:

Designing practice necessitates a prepared combination of recognized factors and the application of inventive thinking. Design is the principle area of technical creativity and closely interrelated to the production. The designer has to keep in mind the most economical way, for the product designed and manufactured. The machine should be suitable with the consumer needs and their requirement. In determining the final design, Regulations, national codes, safety norms play a decisive role.

TRANSPORT PUMP:

The fermented batter transportation requires transport pump, with sufficient power and piping. Transport pump with adjusted speed which provide required amount of batter to filling machine with constant feed outlet. Batter from fermenter should be provided aseptically and without coming in contact with environment to the filling machine.



As per the requirement 1.5hp i,e 1118.55 watt power transport pump is sufficient to transfer the batter from fermenter to filling machine. Seven outlets of filling pump provide batter to seven moulds of idli at one time. 168gm of batter is require to fill seven moulds of idli, according to that filling machine require continuous supply of batter to fill the moulds. One mould of idli is of 9cm diameter, and including outer surface of mould (4cm) it becomes 13cm. Between 13cm space of mould 168gm batter is required.

The speed of the moulds on conveyor is 92cm/min.

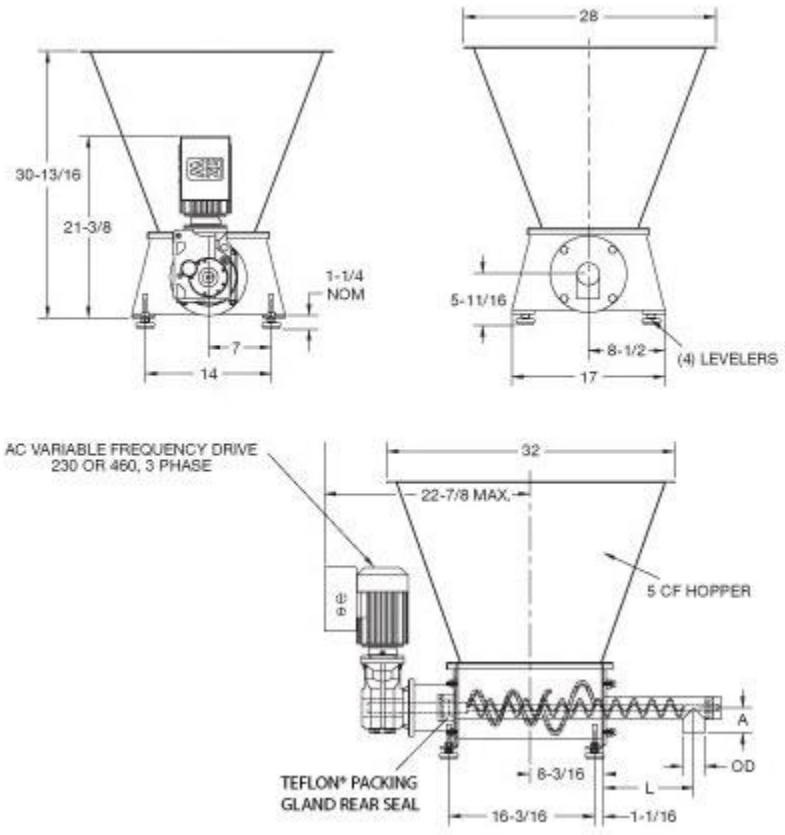
For 13cm it is, $= \frac{60}{92} \times 13$

$= 8.478$ seconds

So the speed of transport pump is adjusted such a way that, it should provide 168gm batter in 8.478seconds i,e 19.815gm/second.

FILLING MACHINE:

During continuous processing of idli, the continuous filling of batter into the moulds / cups is necessary, for that filling machine is required. Filling machine is applied as a part of steamer at the starting point of conveyor of steamer. Speed of conveyor and filling machine is adjusted in such a way that, if we increase the speed of conveyor speed of filling also increases.



23 to 24gm batter is required to produce one idli, so 23 to 24gm batter should be filled in one mould at one time. Seven filling outlets are applied to fill 7 moulds at one time.168gm batter is require to fill seven moulds. The speed of filling machine is adjusted as per the speed of conveyor of the steamer. One column of conveyor contains seven moulds and conveyor rotates with the speed of 92cm/min i,e 1.533cm/second.

24 gm batter for one idli, so

$$24 \times 7 = 168 \text{ gm}$$

For seven idli's 168gm batter is needed.

Speed of conveyor is 92cm/min or 1.533cm/sec

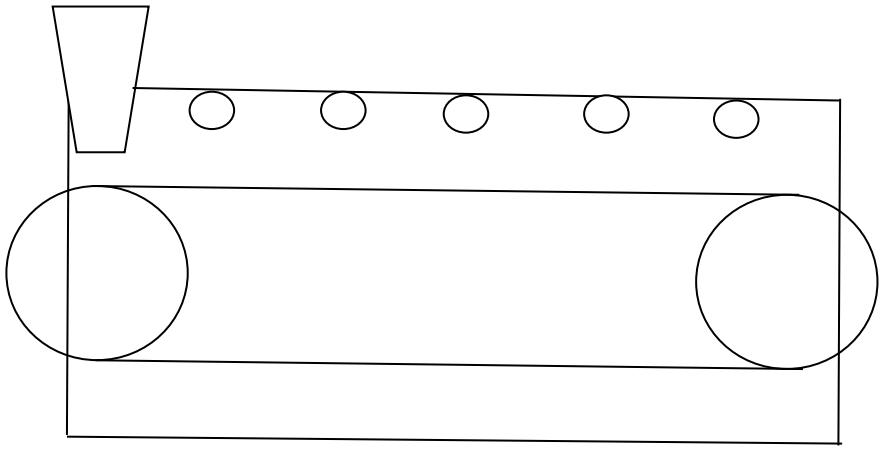
Generally idli's have diameter 7-10cm so diameter of designed mould on conveyor is 9cm, and with the surface area it is 13cm. So 24gm batter in each mould (168gm in seven) is filled after every 13cm movement of the conveyor.

Time require for conveyor to pass 13cm is 8.478seconds which is calculated. Filling machine provides 24gm batter to each mould i,e 168gm to seven mould continuously after time interval of 8.478 seconds.

CONVEYOR STEAMER:

When foodstuff is prepared with the heat as of water vapours, it is called steaming, and the equipment used is called as steamer. Steaming reduces the time interval of cooking and supports to protect nutritional quality, colour, flavor and deliciousness of food. Pressure cooking destroys all pathogens and hereafter the foodstuff is safe and hygienic to eat.

To give continuous steam to idli's for cooking, mould containing conveyor is required. Which is continuously rotating with constant speed.



Diameter of one mould is 9cm
Space between two moulds is 4cm
Length of the conveyor is 500cm
Breadth of the conveyor is 100cm

With the diameter of mould 9cm and blank space between two moulds 4cm, one mould acquire 13cm area.

One column is of 13cm. So columns on the upper surface of the conveyor at one time are,

$$= \frac{lenght\ of\ conveyor}{lenght\ of\ one\ column}$$

$$= \frac{500}{13}$$

$$= 38.46$$

i,e 38 columns are on the upper side of the conveyor at one time.

Area acquired by one mould is 13cm,
Breadth of conveyor or column is 100cm
Moulds on one conveyor are

$$= \frac{breadth\ of\ the\ column}{area\ of\ the\ mould}$$

$$= \frac{100}{13}$$

$$= 7.46$$

So, one column contains 7 moulds of idli.

To produce 3000 idli's per hr

$$= \frac{3000}{60}$$

= 50idli's/minute

I,e
One column contains 7 moulds

$$= \frac{50}{7}$$

$$= 7.142$$

7.142 column come out within a minute,

I,e

Total length per minute = No. of columns × length of column

$$= 7.142 \times 13$$

$$= 92.85 \text{ cm}$$

For the production of 3000 idlis per hr the speed of conveyor is 92.85cm/min calculated.

To move the distance of 500cm one column will take,

$$= \frac{60}{92.85} \times 500$$

$$= 323.10 \text{ seconds}$$

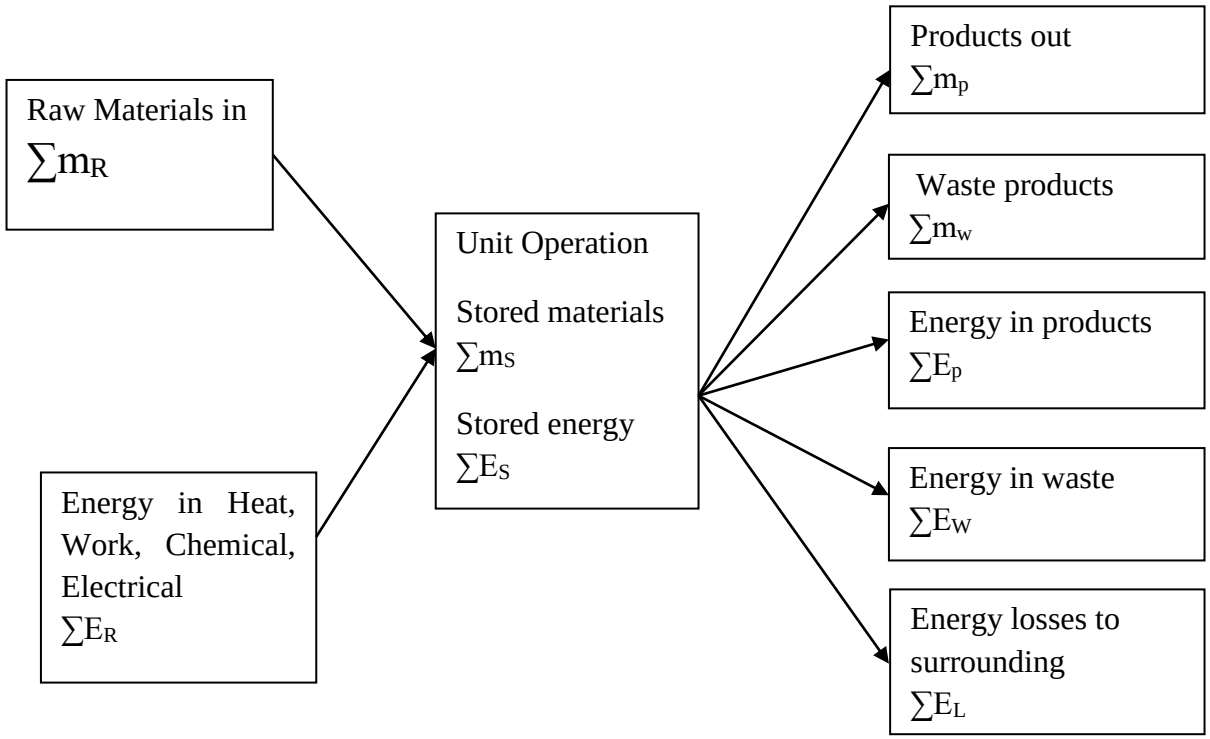
One mould on the conveyor will take 324 seconds (5.4mins) to pass through the steamer, with the 500cm length and 100cm breadth of the steamer.

Moulds containing conveyor which is rotating, steam is applied on that for cooking of Idlis. We adjust the temperature of steam at 140 to 145^0 C with the pressure of 14.7 to 17.6 psi.

ENERGY & MATERIAL BALANCING:

Material balances describe material amounts as they permitted throughout processing procedures. Conservation of mass is statmented by such balances. Similarly, energy balance describes energy quantities, which are declarations on the preservation of energy. For the batch and continuous operations it is true that if there is no storing, what goes into a process must come out. Energy and material balances are very significant in manufacturing. Material balances are the fundamentals in the controlling yield of the products. From the uncooked material to the finished produce energy balances are used in the inspection of the numerous stages of a procedure. The increasing cost of energy has caused the manufacturers to inspect decreasing energy feeding in processing.

If the part of process, whatever its nature is seen as a whole it might be characterized diagrammatically as a box, as shown in Figure. The mass and energy coming into the box must balance with the mass and energy coming out.



Mass In = Mass Out + Mass Stored

Specific heat of Idli (avg) = 3.05kJ/kg.k

From rice batter weight,

Mass of Idli (before cooking) = 20.7kg

Mass of Idli (after cooking) = 36kg

Inlet steam pressure = 15psi = 103.4211Kpa

Outlet steam pressure = 12psi = 82.737Kpa

Inlet steam temp = 145^0C

Outlet steam temp = 70^0C

Time required for cooking = 324sec

Mass flow rate (inlet) = 4kg/min = 0.066kg/sec

Mass flow rate (outlet) = 0.037kg/sec

P_1 = 103.42Kpa, $T_1 = 140^0$C

P_2 = 82.737Kpa, $T_2 = 70^0$C

From steam table, enthalpy

h_1 = 2776.6kJ/kg

Apply energy balance equation:

$$m_1\left[h_1 + \frac{C_1^2}{2\times1000} + \frac{gz_1}{1000}\right] + Q = m_2\left[h_2 + \frac{C_2^2}{2\times1000} + \frac{gz_2}{1000}\right] + W$$

($\frac{C_1^2}{2\times1000}$ = 0, $\frac{C_2^2}{2\times1000}$ = 0)

C_1 = Inlet velocity

C_2 = Outlet velocity

Change in C_1 & C_2 is negligible

$$0.066[2776.6] = 0.036\ [h_2]$$

h_2 = 5090.43g/kg

5090.43g/kg is the heat energy absorbed by Idli during cooking.

ENERGY REQUIREMENT OF EQUIPMENTS:

Transport pump:

Transport pump is of 1.5hp. Energy consumption is

$$E = \frac{P \times t}{1000}$$

$$E = \frac{1.5 \times 745.7 \times 1}{1000}$$

E = 1.11855 kWh

Conveyor steamer:

It requires 2hp motor to pull the belt conveyor.

$$E = \frac{P \times t}{1000}$$

$$E = \frac{2 \times 745.7 \times 1}{1000}$$

E = 1.4914 kWh

For production of steam at 15 to 17 psi pressure require 50kWh energy for time of 5hrs. For 1hr it will take

$$= \frac{50}{5}$$

=10kWh.

EXPECTED RESEARCH OUTCOMES:

The main objective of 'IDLI STEAMER DESIGN AND MANUFACTURING' is to produce the hygienic and good quality Idli's for the human consumption. . To prepare Idli's with a cheaper way and within less time i,e no transfer of infection or contaminants. Process control and automation from other equipment must be taken into consideration. In this age of automation it will help to reduce the labour cost by producing Idli's in bulk.

REFERENCE:

1) Alden, Lorne B., and Theodore A. Richardson. "Pressureless steam cooker." U.S. Patent No. 4,460,822. 17 Jul. 1984.

2) Bullard, Charles R. "Steam oven." U.S. Patent No. 5,515,773. 14 May 1996.

3) Descours, Emilie, et al. "Aroma behaviour during steam cooking within a potato starch-based model matrix." *Carbohydrate polymers* 95.1 (2013): 560-568.

4) Desikachar, H. S. R., R. Radhakrishna Murty, and G. Rama Rao. "Studies on idli fermentation: Part I—Some accompanying changes in the batter." *Journal of Scientific and Industrial Research* 19 (1960): 168-172.

5) Einstein, Dan, Ernst Worrell, and Marta Khrushch. *Steam systems in industry: Energy use and energy efficiency improvement potentials*. No. LBNL--49081. Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA (US), 2001.

6) Henley, Ernest Justus, and Edward M. Rosen. *Material and energy balance computations*. John Wiley & Sons, 1969.

7) Holden, Matthew TG, et al. "Complete genomes of two clinical Staphylococcus aureus strains: evidence for the rapid evolution of virulence and drug resistance." *Proceedings of the National Academy of Sciences of the United States of America* 101.26 (2004): 9786-9791.

8) Izatt, Joseph A., et al. "Micrometer-scale resolution imaging of the anterior eye in vivo with optical coherence tomography." *Archives of ophthalmology* 112.12 (1994): 1584-1589.

9) Ledet, Brent A. "High efficiency steam cooker." U.S. Patent No. 5,184,538. 9 Feb. 1993.

10) Lelieveld, Huub LM, John Holah, and David Napper, eds. *Hygiene in food processing: principles and practice*. Elsevier, 2014.

11) Ludena, O. "Steam cooker." U.S. Patent No. 3,808,963. 7 May 1974.

12) Murthy, Sreerama K., Simon Kasif, and Steven Salzberg. "A system for induction of oblique decision trees." *Journal of artificial intelligence research* 2 (1994): 1-32.

13) Nagaraju, V. D., and B. Manohar. "Rheology and particle size changes during Idli fermentation." *Journal of Food Engineering* 43.3 (2000): 167-171.

14) Nisha, M., et al. "Effect of substrate temperature on the growth of ITO thin films." *Applied Surface Science* 252.5 (2005): 1430-1435.

15) Reddy, Junuthula Narasimha. *An introduction to the finite element method*. Vol. 2. No. 2.2. New York: McGraw-Hill, 1993.

16) Riat, P., and B. Sadana. "Effect of fermentation on amino acid composition of cereal and pulse based foods." *Journal of Food Science and Technology (Mysore)* 46.3 (2009): 247-250.

17) Sridevi, J., Prakash M. Halami, and S. V. N. Vijayendra. "Selection of starter cultures for idli batter fermentation and their effect on quality of idlis." *Journal of food science and technology* 47.5 (2010): 557-563.

18) Steinkraus, K. H., A. G. VanVeen, and D. B. Thiebeau. "Studies on idli-an Indian fermented black gram-rice food." *Food Technology* 21.6 (1967): 916-+.

19) Takeda, Teruhiko. "High-temperature dry steam cooking utensil." U.S. Patent No. 5,287,798. 22 Feb. 1994.

20) Teniola, O. D., and S. A. Odunfa. "The effects of processing methods on the levels of lysine, methionine and the general acceptability of ogi processed using starter cultures." *International journal of food microbiology* 63.1 (2001): 1-9.

21) Ullmann, Andrew J., et al. "Posaconazole or fluconazole for prophylaxis in severe graft-versus-host disease." *New England Journal of Medicine* 356.4 (2007): 335-347.

22) Williams, Charles E. "High humidity steam cooker with continuously running conveyor." U.S. Patent No. 4,582,047. 15 Apr. 1986.