OVERVIEW ON CHEESE FERMENTATION: A REVIEW

[1]Rajvir Singh, [2]Sharma, G.D. and [*3]Anirban Pattanayak, [4] Eshita Manna

[1, 2]Department of AH & Dairy Shri Megh Singh College Abidgarh, Agra, U.P., India

[*3]Guest Teacher, Department of Physiology, Mahishadal Raj College, West Bengal, India

[4] M.Sc. in Food Science, Sambalpur University, Odisha.

Abstract:

A broad range of flavours and forms of food based on fermented milk are produced globally under the general name "cheese." Cheese has developed from its simple beginnings as a method of preserving milk components into a haute cuisine food with epicurean qualities that is also very nourishing. Calcium, protein, phosphorus, zinc, vitamin An, and vitamin B12 are among the vitamins and minerals found in cheddar. The American diet is probably deficient in calcium, one of the supplements. Government statistics show that six out of ten men and nine out of ten women misinterpret calcium guidelines. Cheddar's superior protein content gives the body the building blocks it needs to develop strong muscles. For a complete list of the additives in cheddar, see the table below. This review paper showing that the fermentation and health benefits of cheese.

Keywords: cheese, fermentation, lactic acid, human health, milk, dairy products. bacterial Cultures

Introduction:

Cheddar is a combined curd of milk solids in which coagulated casein and milk fat are intertwined. The physical characteristics of cheddar differ greatly from those of milk, unlike aged milks. This is due to the fact that protein coagulation is accelerated by the application of proteolytic catalysts, and a significant portion of the water content of milk isolates is eliminated as whey. Typically, 10% of milk is required to produce cheddar cheese.

The most popular matured milk product, cheddar, uses more than 33% of the milk that is transported to the United States each year. Raffinated milk is used to deliver both soft and firm cheeses over an extended period of time. You can make specific types of cheese simply by pressing the moisture out of tart cream or yoghurt. However, some varieties of cheddar demand extra time and effort throughout the maturing process. There are more than 2,000 different varieties of cheese, with cheddar, feta, cream, goat, and blue likely being the most well-known **(Beresford & Williams, 2004).**

Nutritional value of cheese

Amount Per 100 grams	
Calories 402	% Daily Value*
Total Fat 33 g	50%
Saturated fat 21 g	104%
Polyunsaturated fat 0.9 g	
Monounsaturated fat 9 g	
Cholesterol 105 mg	35%
Sodium 621 mg	25%
Potassium 98 mg	2%
Total Carbohydrate 1.3 g	0%
Dietary fiber 0 g	0%
Sugar 0.5 g	
Protein 25 g	50%

Table 1: *Nutritional value of cheese (*Lemos *et al.*, 2012)

Cheese production

Given that it consumes more than one-third of the milk produced annually in the United States, cheese may be the most well-known fermented milk product. Milk is cultured for a long time to generate both soft and hard cheeses. You may make several cheeses by merely pressing the liquid from yoghurt or sour cream. However, certain other varieties of cheese call for extra steps in the culturing and fermenting process. There are more than 2,000 different kinds of cheese, some of the most well-known of which are cheddar, feta, cream, goat, and blue **(El-Bakry & Sheehan, 2014)**.

Ingredients

Milk is the main component of cheese. Cow, goat, sheep, water buffalo, or a combination of these milks are used to make cheese.

Depending on the type of cheese preferred, a particular coagulant is utilised. Acid sources like acetic acid (the acid in vinegar) or gluconodelta-lactone (a mild food acid) are utilised to make acid cheeses. Cattle rennet or, more frequently, a rennet made by microbial bioprocessing is used to make rennet cheeses. Sometimes calcium chloride is added to the cheese to enhance the milk's ability to coagulate. Depending on the cheese, flavourings may be applied. Herbs, spices, fiery and sweet peppers, horseradish, and port wine are a few typical ingredients **(López-Expósito et al., 2012)**.

Bacterial Cultures

Lactic acid bacteria (LAB) are the kind of cultures used to make cheese because they primarily utilise the lactose in milk as a source of energy and produce lactic acid as their main metabolic byproduct. There are many different bacterial cultures that can be used to give cheeses unique flavour and texture qualities. for a more thorough explanation of the microbiology and cheese cultures.

By bringing the pH down before adding the rennet, starter cultures are used early in the cheese-making process to help with coagulation. The starting cultures' metabolism produces beneficial taste compounds and inhibits the growth of diseases and spoiling organisms. the typical starting bacterium include *Lactococcus lactis* subsp. *lactis* or *cremoris*, *Streptococcus salivarius* subsp. *thermophilus*, *Lactobacillus delbruckii* subsp. *bulgaricus*, and *Lactobacillus helveticus* **(Talbot-Walsh et al., 2018; Tewari et al., 2019)**.

To supply or improve the distinctive flavours and textures of cheese, adjunct cultures are used. Common adjunct cultures used in manufacturing include Propionibacterium freudenreichii for Swiss cheese's eye production and Lactobacillus casei and Lactobacillus plantarum for flavour in Cheddar cheese. Adjunct cultures, such as Brevibacterium linens of gruyere, brick, and limburger cheeses, can also be utilised as a smear for washing the exterior of the produced cheese.

In order to give some cheeses their distinctive colours and flavours, yeasts and moulds are often utilised. Brick and limberger cheeses are aged using torula yeast in the smear. Molds include Penicillium roqueforti in blue cheeses and Penicillium camemberti in camembert and brie.

General Manufacturing Procedure

The order of processing steps, the use of salting or brining, block formation, and ageing change significantly amongst cheese kinds as do the temperatures, durations, and desired pH for certain steps. The process of manufacturing cheese is outlined in the flow chart that follows. For illustrative purposes, the general Cheddar cheese processing procedures are employed. for a more thorough justification.

General Cheese Processing Steps

- Standardize Milk
- Pasteurize/Heat Treat Milk
- Cool Milk
- Inoculate with Starter & Non-Starter Bacteria and Ripen
- Add Rennet and Form Curd
- Cut Curd and Heat
- Drain Whey

- Texture Curd
- Dry Salt or Brine
- Form Cheese into Blocks
- Store and Age
- Package

Individual formulations and the intended use of the cheese will determine the times, temperatures, and desired pH levels utilised for cheddar cheese. These parameters can be changed to enhance Cheddar cheese's qualities for melting, shredding, or cheese that will be matured for a long time.

- **Standardize Milk**

Before creating cheese, milk is frequently standardised to balance the protein to fat ratio and produce cheese of high quality.

- **Pasteurize/Heat Treat Milk**

In order to lessen the quantity of spoilage organisms and enhance the environment for the starter cultures to thrive, the milk may be pasteurised or lightly heated, depending on the type of cheese desired. Some milk kinds are neither heat- or pasteurized-treated since they are made from raw milk. To lessen the risk of exposure to disease-causing microorganisms (pathogens) that may be present in the milk, raw milk cheeses must be matured for at least 60 days (Macdonald, 2011).

- **Cool Milk**

After pasteurisation or heat treatment, milk is chilled to 90°F (32°C) to reach the temperature where the starting bacteria can flourish. When using raw milk, it must be cooked to 90°F (32°C).

- **Inoculate with Starter & Non-Starter Bacteria and Ripen**

  The starting cultures are introduced to the milk together with any non-starter adjunct bacteria, and the milk is then allowed to mature for 30 minutes at 90°F (32°C). The ripening process enables the bacteria to multiply and start the fermentation process, which lowers the pH and enhances the cheese's flavour.

- **Add Rennet and Form Curd**

Rennet is the enzyme that reacts with the proteins in milk to create curd. Following the addition of the rennet, the curd is left undisturbed for around 30 minutes to allow a hard coagulum to develop.

- **Cut Curd and Heat**

The curd is allowed to ferment until it reaches pH 6.4. The curd is then cut with cheese knives into small pieces and heated to 100°F (38°C). The heating step helps to separate the whey from the curd.

- **Drain whey**

The whey is drained from the vat and the curd forms a mat.

- **Texture curd**

The curd mats are cut into sections and piled on top of each other and flipped periodically. This step is called **cheddarin**g. Cheddaring helps to expel more whey, allows the fermentation to continue until a pH of 5.1 to 5.5 is reached, and allows the mats to "knit" together and form a tighter matted structure. The curd mats are then milled (cut) into smaller pieces.

- **Dry Salt or Brine**

For cheddar cheese, the smaller, milled curd pieces are put back in the vat and salted by sprinkling dry salt on the curd and mixing in the salt. In some cheese varieties, such as mozzarella, the curd is formed into loaves and then the loaves are placed in a brine (salt water solution).

- **Form Cheese into Blocks**

The salted curd pieces are placed in cheese hoops and pressed into blocks to form the cheese.

- **Store and Age**

The cheese is stored in coolers until the desired age is reached. Depending on the variety, cheese can be aged from several months to several years.

- **Package**

Cheese may be cut and packaged into blocks or it may be waxed.

Flow chart of Cheese making process

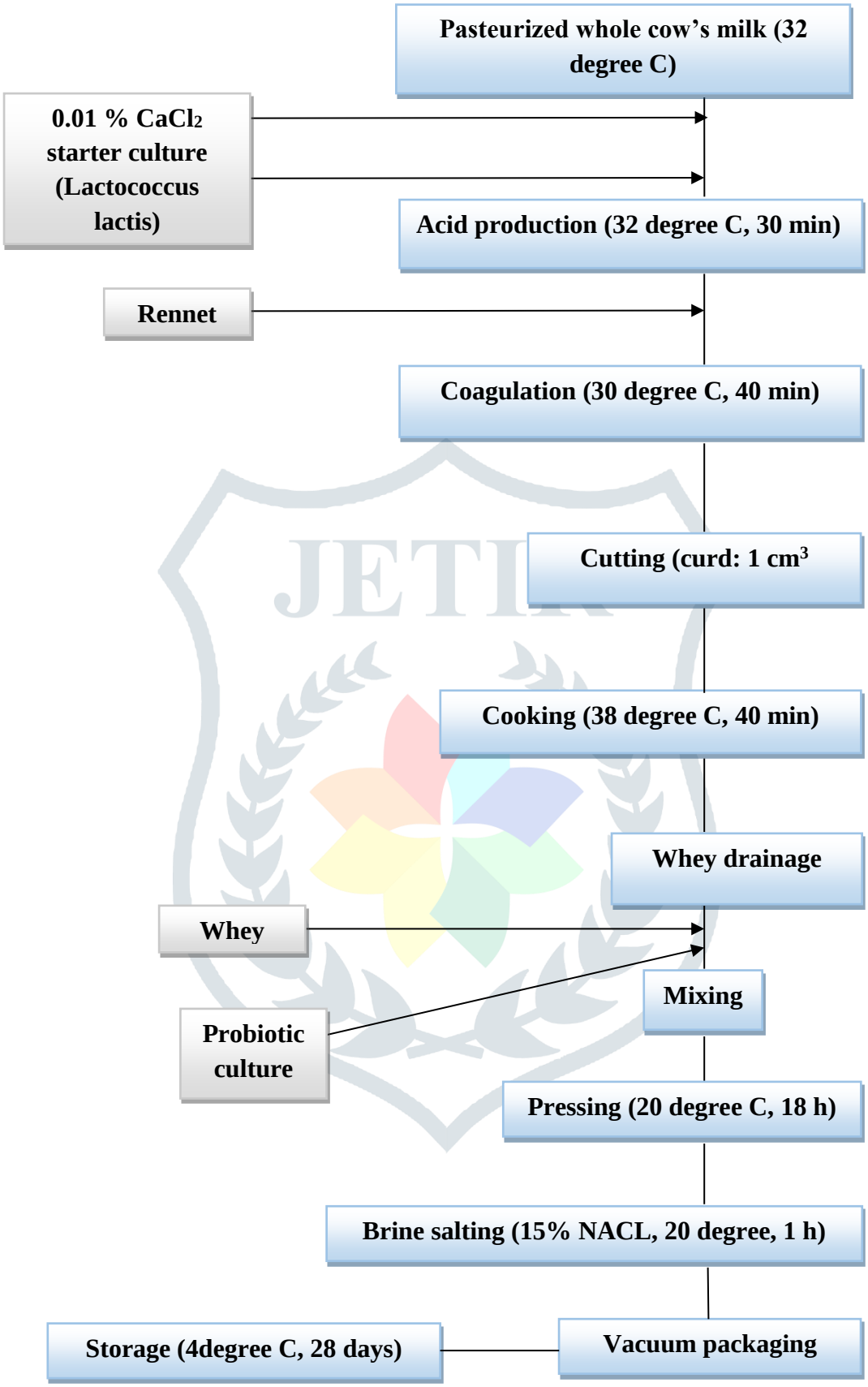

Figure 1: *cheese making process*

Microorganisms Important in Microbiology of Cheese

Starter Bacteria

Most cheeses start with milk that has been purposefully infused with chosen LAB strains that have previously been cultivated in milk or another medium. They are classified as mesophilic and thermophilic and are referred to as "starters" because they initiate the formation of lactic acid. Lactococci and occasionally leuconostocs are found in mesophilic starters, and Streptococcus thermophilus and thermophilic lactobacilli are found in thermophilic cultures. Mesophilic starters are employed in Cheddar, soft and most Dutch-type cheeses. The cultures are often chosen for their capacity to resist bacteriophage attack, to produce cheese with the desired flavour, and to produce lactic acid at a rate acceptable for the cheese being made. In Europe, certain handmade cheeses are produced without a beginning on purpose. Lactococci, which are naturally occurring pollutants in milk, are also a significant portion of the microflora in these cheeses towards the onset of ripening. Cheddar cheese, which was formerly only manufactured with mesophilic cultures, is now made with a combination of mesophilic and thermophilic cultures, mainly S. thermophilus. Depending on the kind of cheese, the starting bacteria in cheese milk start out at 105 to 107 cfu mL 1 and quickly increase to _109 cfu g 1 in almost all cheeses within a few hours of being added to the milk. As a result, starter germs predominate in cheese at the start of the ripening process. When cheese ripens, the majority of the starting bacteria lyse rather quickly, releasing the intracellular enzymes that, along with chymosin, contribute to the flavour development of the cheese. Cheese made by faster-lysing strains typically develops flavour faster than cheese made by slower-lysing strains. An internal muraminidase that hydrolyzes the bacterial cell wall causes lysis. The fact that Lactococcus lactis subsp. cremoris strains often lyse more quickly than Lactococcus lactis subsp. lactis strains explains in part why the former organism is regarded to create cheese with a greater flavour than the latter. The amount of salt in the cheese and the presence of prophages in the starting germs, which are brought on by the high cooking temperature utilised during the production of particular cheeses, are two factors that affect lysis. Though this feature has not been thoroughly researched, it is also likely that a limited number of lytic phage contribute to lysis.

Enterococci

High levels of enterococci (>107 g 1) are present in many artisanal cheeses, and these bacteria may have been intentionally added to milk during the cheese-making process, such as probiotic cultures. Because of this, enterococci (E. faecalis and E. faecium) have been tried as starter cultures in starter combinations of many European cheeses, including mozzarella, feta, venaco, and cebreiro. They can tolerate pasteurisation, therefore they can be found in cheeses made from pasteurised milk as well as cheeses manufactured from raw milk. The majority of the research points to them as having a considerable impact on flavour development in the cheeses that include them **(Schär & Bosset, 2002)**.

Non-starter Lactic Acid Bacteria

With the exception of unripened cheeses, all cheeses that have ripened for any amount of time include non-starter lactic acid bacteria (NSLAB). Pediococcus species and obligately heterofermentative Lactobacillus

species, like Lactobacillus brevis and L. fermentum, are infrequently discovered in them. However, they primarily consist of facultatively heterofermentative lactobacilli, particularly Lactobacillus casei and L. paracasei. The main sources of NSLAB in cheese are raw milk and/or the industrial environment. Some hard cheeses, like Emmental, which is traditionally manufactured from raw milk, can survive pasteurisation and the high heating temperature (52 _C) employed in their production. The majority of NSLAB are facultative anaerobes that can grow well in cheese because they are salt- and acid-tolerant. They require a fermentable carbohydrate for energy synthesis and growth, however the energy source they use in cheese is unknown because lactose was not present during the exponential expansion of NSLAB. The sugars found in the glycoproteins of milk fat globules are a possible source. Citrate and amino acids are two additional potential sources, however there isn't much support for either. Within the first few days of ripening, the initial number of NSLAB in cheese is relatively modest (_100 cfu g 1) compared to the starter, but they increase quickly to large levels (_108 cfu g 1). Their development pace is mostly influenced by the specific strains present, the cheese's moisture level, and the ripening temperature. High-moisture cheeses will grow more quickly than low-moisture cheeses. It took 8.5 days for the NSLAB in the cheese to be generated **(Chatzipaschali & Stamatis, 2012)**.

The contribution of NSLAB to the evolution of cheese flavour is unclear despite considerable studies. There is a lot of interest in expediting ripening and/or increasing flavour by inoculating cheese milk with carefully chosen mesophilic lactobacilli. Hard cheese NSLAB die off much more gradually than starter cells do, and their intracellular enzymes are probably not released into the cheese matrix. However, NSLAB cells are still alive and exhibit significant metabolic activity at the high cell densities present in cheese, such as the conversion of L-lactate to D-lactate **(Luongo et al., 2019)**.

Health Benefits of Cheese

Cheddar contains a variety of vitamins and minerals, including calcium, protein, phosphorus, zinc, vitamin An, and vitamin B12. One of the supplements that is likely to be insufficient in the American diet is calcium. According to government data, nine out of ten women and six out of ten males misjudge calcium recommendations. The top-notch protein in cheddar provides the body with the necessary building blocks for strong muscles. See the table below for a complete listing of the supplements in cheddar.

If you have a lactose intolerance, you should know that many cheeses, especially aged cheeses like Cheddar and Swiss, contain almost little lactose and are typically well-tolerates.

It has been believed for at least 30 years that saturated fat, which can be found in meats, eggs, cheddar, spread, whole milk, grease, and a few oils, is a major cause of cardiovascular disease. However, recent studies show that saturated fat has just a little impact on the risk of developing cardiovascular disease, changing the conventional wisdom that "soaked fat is bad" and allowing people to eat more cheddar and

other favourite foods. It is necessary to conduct additional research that shows outstanding logical knowledge **(Tewari, 2019)**.

Calories are important despite the fact that subcutaneous fat is less of a concern. You can use smaller amounts of pungent and sharp cheeses for their delicious cheddar flavour or mesh or sprinkle tougher cheeses over your foods to cut calories. Additionally available are numerous cheese varieties with reduced fat. More information on the appeals and difficulties of cheese is provided in this article from the Food and Nutrition Magazine from 2014.

According to the Dietary Guidelines for Americans, persons who are at least nine years old should consume three servings per day of milk, cheese, or yoghurt, while children between the ages of four and eight should get two and a half. One and a half ounces of hard cheddar, a 33 percent cup of ground cheddar, and two ounces of prepared cheddar constitute one serving.

Conclusion:

Under the umbrella term "cheese," a wide variety of flavours and food types based on fermented milk are created internationally. From its humble beginnings as a way to preserve milk components, cheese has evolved into a haute cuisine dish with epicurean qualities that is also incredibly healthy. Cheddar contains a variety of vitamins and minerals, including calcium, protein, phosphorus, zinc, vitamin A, and vitamin B12. One of the supplements, calcium, is definitely lacking in the typical American diet. According to government figures, nine out of ten women and six out of ten men misread calcium recommendations. Under the umbrella term "cheese," a variety of flavours and food preparation methods based on fermented milk are created worldwide. Since its early days as a crude technique of retaining milk components, cheese has evolved into a haute cuisine dish with epicurean qualities that is also incredibly healthy. Among the vitamins and minerals present in cheddar are calcium, protein, phosphorus, zinc, vitamin A, and vitamin B12. One of the supplements, calcium, is likely underrepresented in the American diet. According to government data, six out of ten men and nine out of ten women interpret calcium recommendations incorrectly.

References:

- Beresford, T., & Williams, A. (2004). The microbiology of cheese ripening. *Cheese: chemistry, physics and microbiology*, *1*, 287-318.
- Chatzipaschali, A. A., & Stamatis, A. G. (2012). Biotechnological utilization with a focus on anaerobic treatment of cheese whey: current status and prospects. *Energies*, *5*(9), 3492-3525.
- CREAMER, L. K., & OLSON, N. F. (1982). Rheological evaluation of maturing Cheddar cheese. *Journal of Food Science*, *47*(2), 631-636.

- El-Bakry, M., & Sheehan, J. (2014). Analysing cheese microstructure: A review of recent developments. *Journal of Food Engineering*, *125*, 84-96.
- Fox, P. F., Guinee, T. P., Cogan, T. M., & McSweeney, P. L. (2017). *Fundamentals of cheese science* (pp. 185-229). New York: Springer.
- Kosikowski, F., & Mistry, V. V. (1977). *Cheese and fermented milk foods* (Vol. 586). Edwards Bros.
- Lemos, A. D. R., Capriles, V. D., Pinto e Silva, M. E. M., & Arêas, J. A. G. (2012). Effect of incorporation of amaranth on the physical properties and nutritional value of cheese bread. *Food Science and Technology*, *32*, 427-431.
- López-Expósito, I., Amigo, L., & Recio, I. (2012). A mini-review on health and nutritional aspects of cheese with a focus on bioactive peptides. *Dairy science & technology*, *92*(5), 419-438.
- Luongo, V., Policastro, G., Ghimire, A., Pirozzi, F., & Fabbricino, M. (2019). Repeated-batch fermentation of cheese whey for semi-continuous lactic acid production using mixed cultures at uncontrolled pH. *Sustainability*, *11*(12), 3330.
- Macdonald, L. E., Brett, J., Kelton, D., Majowicz, S. E., Snedeker, K., & Sargeant, J. M. (2011). A systematic review and meta-analysis of the effects of pasteurization on milk vitamins, and evidence for raw milk consumption and other health-related outcomes. *Journal of food protection*, *74*(11), 1814-1832.
- McSweeney, P. L. (2004). Biochemistry of cheese ripening. *International journal of dairy technology*, *57*(2-3), 127-144.
- Prazeres, A. R., Carvalho, F., & Rivas, J. (2012). Cheese whey management: A review. *Journal of environmental management*, *110*, 48-68.
- Schär, W., & Bosset, J. O. (2002). Chemical and physico-chemical changes in processed cheese and ready-made fondue during storage. A review. *LWT-Food Science and Technology*, *35*(1), 15-20.
- Talbot-Walsh, G., Kannar, D., & Selomulya, C. (2018). A review on technological parameters and recent advances in the fortification of processed cheese. *Trends in Food Science & Technology*, *81*, 193-202.
- Tewari, S., (2019). Therapeutic diet to control diseases, AkiNik Publications, 1-79.
- Tewari, S., David, J., & Gautam, A. (2019). A review on probiotic dairy products and digestive health. *J. Pharmacogn. Phytochem*, *8*(3), 368-372.