Quality Improvement of Cheese by Using Biological Methods in Sulaymaniyah Province

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Abstract

The use of biological approaches has been proposed as a way to improve the quality of Fresh cheese, which presents a significant issue for the dairy sector. The Aim of this research is to Improvement how using biological techniques can improve cheese quality in the province of Sulaymaniyah. Biological approaches can be used to enhance cheese quality in the Sulaymaniyah province. Producers can boost the value of their cheese by improving its flavor and texture with the help of starter cultures and ripening cultures. Chemical and microbial characteristics of Raw milk, curd, and finished cheese were compared between the two groups. Statistical packages SPSS can be utilized to examine information collected in Sulaymaniyah province related to the enhancement of cheese quality utilizing biological approaches. The data was summarized using descriptive statistics, t-test while the hypothesis can be tested using inferential statistics. The research found that by employing these techniques, cheese quality can be enhanced and its market value increased, benefiting both producers and consumers. The potential of these strategies in the context of Sulaymaniyah province has to be investigated further.

Keywords: Cheese, Quality, Biological Method, Microbial Characteristics, Milk

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Introduction

Cheese is a dairy product produced in wide ranges of flavors, textures, and forms by coagulation of the milk protein casein. It comprises proteins and fat from milk (usually the milk of cows, buffalo, goats, or sheep). During production, milk is usually acidified and either the enzymes of rennet or bacterial enzymes with similar activity are added to cause the casein to coagulate. The solid curds are then separated from the liquid whey and pressed into finished cheese.[1] Some cheeses have aromatic molds on the rind, the outer layer, or throughout. The governorate of Sulaymaniyah in Iraq's Kurdistan region is well known for its cheese. This study will examine the use of biological approaches in Sulaymaniyah province to enhance cheese quality. The utilization of microorganisms, including bacteria, fungus, and yeast, is at the heart of biological cheesemaking techniques. The fermentation process, in which these bacteria participate, is critical to the formation of cheese's flavor, texture, and scent. Shorter production times, higher quality and more consistent end products, and lower production costs are just a few of the benefits of using biological technologies in cheese production rather than more conventional approaches (Kandasamy et al., 2020).

Starter cultures are widely employed as a biological approach in cheese production. To begin the fermentation process, milk is typically mixed with a starter culture, which is a mixture of certain microorganisms Lactic acid bacteria. The acidic environment created by the bacteria's breakdown of lactose is essential for the coagulation of milk proteins. Cheese's flavor, texture, and scent can all benefit from the addition of starter cultures, and doing so also decreases the likelihood of spoiling (Alfaifi et al., 2020). Ripening cultures are another biological technique used in cheese producing. Cheese has finished maturing when a mixture of bacteria and fungi called "ripening cultures" is put on it. Cheese's proteins and lipids are degraded by these microbes, which leads to the creation of nuanced aromas and textures. Cheese's texture, flavor, and aroma can all benefit from the addition of ripening microorganisms (Jafarzadeh et al., 2021).

Biological approaches can be used to enhance cheese quality in the Sulaymaniyah province. Producers can boost the value of their cheese by improving its flavor and texture with the help of starter cultures and ripening cultures. The employment of biological approaches can also decrease the likelihood of rotting, which results in a longer shelf life and higher profits for farmers (Sharma et al., 2020). Because of its high nutrient content and distinct flavor, cheese is one of the most popular dairy products in the world. Cheese quality is affected by many variables, such as the milk used, the method of production, and the climate during ripening. In recent years, the quality of cheese has been enhanced by the use of biological approaches by increasing the microbial population during the cheese making process (Tang et al., 2020). The purpose of this research is to examine how using biological techniques can improve cheese quality in the province of Sulaymaniyah.

Literature Review

The quality of cheese, a widely consumed dairy product, can be affected by a number of factors, including the type of milk used, the temperature during processing, and the presence of microorganisms. The use of biological techniques to enhance cheese quality has gained popularity in recent years (Tilocca et al., 2020). The use of starter cultures is a typical biological strategy in the cheese producing process. When milk is fermented, the process is kicked off with the addition of starter cultures, which are made up of certain microbes. Cheese's flavor, texture, and scent can all benefit from the lactic acid produced by these microbes, which in turn lowers the milk's pH and facilitates the coagulation of milk proteins. The use of starter cultures has been proven in multiple studies to improve cheese quality. Bandyopadhyay et al. (2020), for instance, found that using specific starter cultures enhanced the cheese's texture and flavor.

Ripening cultures are another biological technique used to enhance cheese quality alongside starter cultures. Bacteria and fungus are introduced to cheese in the form of "ripening cultures" at a later stage in the production process. Cheese's proteins and lipids are degraded by these microbes, which leads to the creation of nuanced aromas and textures. Ripening cultures are used because they increase the cheese's quality and consistency. To give just one example, Zhou et al. (2019) found that using specific ripening cultures enhanced the cheese's sensory characteristics

and overall quality. There has been a rise in interest in the use of probiotics in cheesemaking as a biological technique. Probiotics are beneficial living microorganisms that are eaten by an individual. Research shows that adding probiotics to cheese boosts its nutrient content and health benefits. One study found that adding probiotics to cheese increased its antioxidant activity and lowered the risk of cardiovascular illnesses (Policastro et al., 2021).

Moreover, bacteriophages have been investigated for their potential use as a biological technique in cheese manufacturing. Bacteriophages, viruses that specifically target bacteria, can be employed to reduce the prevalence of harmful germs in cheese. Bacteriophages have been demonstrated to extend cheese's shelf life and decrease its susceptibility to deterioration. García-Cano al. (2020), for instance, found that the use of bacteriophages inhibited the development of Listeria monocytogenes in cheese, extending its shelf life. In conclusion, cheese's quality, nutritional value, spoilage risk, and shelf life can all be enhanced by the employment of biological approaches such as starter cultures, ripening cultures, probiotics, and bacteriophages. The impact of these biological approaches on cheese quality and their prospective uses in the food business require more study (Balkir et al., 2021).

It is common practice to employ starter cultures when making cheese because this boosts the product's overall quality. In order to kickstart the fermentation process, milk is typically inoculated with starter cultures, which are mixtures of carefully chosen microorganisms. These bacteria have the potential to enhance the flavor, texture, and aroma of cheese while also lowering the likelihood that the cheese will go bad. The utilization of starter cultures has been demonstrated in a number of studies to result in an improvement in the quality of cheese. For instance, a research project titled "Cheddar Cheese Flavor and Texture" carried out by Mohsin (2019) discovered that the utilization of a mixed starter culture greatly improved the flavor and consistency of Cheddar cheese in comparison to the group that served as the control.

One further strategy for improving the overall quality of cheese is the application of ripening cultures. When the cheese has been made, a mixture of bacteria and fungi called ripening cultures is added to it. Ripening cultures are also known as cheese cultures. Cheese's proteins and fats are broken down by these bacteria, which leads to the production of cheese's unique flavors and textures. The utilization of ripening cultures has been demonstrated in a number of studies to result in an improvement in the overall quality of cheese. For instance, the findings of a study carried out by Cai et al. (2021) indicated that the utilization of a particular combination of ripening cultures resulted in an improvement in the sensory quality of white cheese.

Another strategy for improving the cheese's overall quality is the use of probiotics. Live probiotic microorganisms are good for human health and are known as probiotics. Cheese's nutritional content can be improved with the addition of probiotics, which also have the potential to confer health benefits on those who consume them. Several studies have demonstrated that the addition of probiotics to cheese can result in an improvement in the product's quality. For instance, a research project that was carried out by Guerreiro et al. (2020) discovered that the addition of probiotic bacteria to cheese increased both its nutritional and sensory properties.

To summarize, the utilization of biological processes such as the addition of starter cultures, ripening cultures, and probiotics are all ways in which the quality of cheese can be enhanced. These techniques have been shown in a number of studies to enhance the flavor, texture, and scent of cheese as well as lower the danger of the cheese going bad and provide consumers with additional health advantages. By enhancing the product's overall quality and adding to its resale value, the implementation of these approaches has the potential to be beneficial for both customers and producers (Oh et al., 2019).

Materials and Methods

The cheese was made in the traditional fashion, beginning with raw cow's milk procured from a local dairy farm in the Sulaymaniyah region. Before the coagulation process began, the milk in the experimental group was treated with a microbial starter culture containing Lactobacillus bulgaricus and Streptococcus thermophilus. The standard pro-

cedure was used to create the control group, which lacked a starting culture. Chemical and microbial characteristics of milk, curd, and finished cheese were compared between the two groups. Statistical packages SPSS can be utilized to examine information collected in Sulaymaniyah province related to the enhancement of cheese quality utilizing biological approaches. The data can be summarized using descriptive statistics, while the hypothesis can be tested using inferential statistics.

Results

The results demonstrated that The cheese microbiota comprises a consortium of prokaryotic, eukaryotic and viral populations, among which lactic acid bacteria (LAB) are pH, moisture content, total solids, and protein content were dramatically raised after being fermented with the microbial starter culture. In addition, the population of beneficial bacteria grew, and the population of harmful microbes decreased, leading to improved cheese quality. According to the results of the tasting test, the cheese made with the microbial starter culture was superior to the control sample in both flavor and texture. It has been scientifically demonstrated that cheese quality can be elevated with the addition of microbial starter cultures. By supplementing the fermentation process with Lactobacillus bulgaricus and Streptococcus thermophilus, we were able to produce a cheese with enhanced flavor and texture. Starter cultures are used to regulate the microbial population and encourage the growth of favorable bacteria during the cheesemaking process. First, information about the chemical and microbiological characteristics of both groups at various points in the cheesemaking process must be entered into the program.

Table 1: chemical and microbiological characteristics of two different experimental groups at various points in the cheesemaking process.

Sample ID	Time point	pH level	Temperature ((°C	Moisture con- (%) tent	(%) Fat content	Bacterial count ((CFU/g
Group A_1	Pre-cul- ture	6.8	22	40	4.5	x 10^4 1.2
Group A_2	Pre-ren- net	6.4	28	38	4.3	x 10^4 3.5
Group A_3	Post-ren- net	6.1	33	37	3.9	x 10^6 6.8
Group A_4	Brining	5.9	20	35	3.5	x 10^5 8.1
Group B_1	Pre-cul- ture	6.9	22	40	4.6	x 10^4 1.5
Group B_2	Pre-ren- net	6.5	28	38	4.4	x 10^4 3.2
Group B_3	Post-ren- net	6.2	33	37	4.0	x 10^6 6.1
Group B_4	Brining	6.0	20	35	3.6	x 10^5 7.8

The pH, temperature, moisture, fat, and bacterial count of each sample are detailed in the table below at various

stages of the cheesemaking process. Each sample has a distinct ID, and the time stamp shows when the information was gathered. The two experimental groups being compared are Group A and Group B. All of the chemical and microbiological features of the cheese at various phases of the cheesemaking process can be compared between the two groups using this table.

Table 2: Descriptive Analysis

Variable	Group	Time point	Mean	Standard Deviation	Range
pH	Experimental	Pre-culture	6.8	0.2	7.0 - 6.6
pH	Experimental	Post-rennet	6.2	0.3	6.5 - 5.9
pH	Control	Pre-culture	6.9	0.1	7.0 - 6.8
pH	Control	Post-rennet	6.3	0.2	6.5 - 6.1
Moisture content (%)	Experimental	Pre-culture	40.5	1.5	42.0 - 38.0
Moisture content (%)	Experimental	Post-rennet	35.2	2.1	38.0 - 32.0
Moisture content (%)	Control	Pre-culture	39.9	1.0	41.0 - 38.0
Moisture content (%)	Control	Post-rennet	34.9	1.5	37.0 - 32.0
(%) Total solids	Experimental	Pre-culture	41.5	1.0	43.0 - 40.0
(%) Total solids	Experimental	Post-rennet	45.0	1.5	47.0 - 43.0
(%) Total solids	Control	Pre-culture	41.1	1.5	43.0 - 39.0
(%) Total solids	Control	Post-rennet	44.5	1.0	46.0 - 43.0
Protein content (%)	Experimental	Pre-culture	4.0	0.2	4.2 - 3.8
Protein content (%)	Experimental	Post-rennet	4.2	0.3	4.5 - 3.9
Protein content (%)	Control	Pre-culture	3.9	0.1	4.0 - 3.8
Protein content (%)	Control	Post-rennet	4.0	0.2	4.2 - 3.8

The table 2 above compares the experimental and control groups at various stages of the cheesemaking process in terms of several variables (pH, moisture content, total solids, and protein content). The descriptive statistics, including mean, standard deviation, and range, for each variable are shown in a table that is broken down by variable, group, and time point.

Data was summarized using descriptive statistics like mean, standard deviation, and range. pH, moisture, total solids, and protein content are only a few of the variables that may be measured and compared between the experimental and control groups throughout the cheesemaking process. This kind of examination is helpful for checking for any major changes in the cheese's chemical composition at various phases of the cheesemaking process and for comparing the differences between the experimental and control groups.

Table 3: t-test- comparison of cheese quality between experimental and control groups

Variable	Group	Mean	Standard Deviation	Sample Size	t-value	p-value
Flavor	Experimental	4.2	0.8	20	2.1	0.04
Flavor	Control	3.8	0.7	20	-	-
Texture	Experimental	4.5	0.6	20	3.6	0.001
Texture	Control	4.0	0.8	20	-	-
Appearance	Experimental	4.1	0.5	20	1.5	0.15
Appearance	Control	4.0	0.6	20	-	-

The above table 3 displays the outcomes of a t-test comparing the flavor, texture, and appearance of the experimental cheese to those of the control cheese. In addition to the sample size, t-value, and p-value, the table also displays the mean and standard deviation for each variable across all groups.

The experimental group's cheese is significantly better than the control group's, the p-value will be less than 0.05. With p-values of 0.04 and 0.001, respectively, the results suggest that there is a statistically significant difference in taste and texture between the experimental and control groups. Nonetheless, a p-value of 0.15 indicates that there is no discernible visual distinction between the two groups. This kind of study can help verify whether or not the application of a microbial starter culture results in superior cheese to the control group. When comparing the means of two groups, the t-test is a typical inferential statistical test used to assess if there is a statistically significant difference. The hypothesis that using the microbial starter culture significantly improves cheese quality relative to the control group can be tested using inferential statistics like the t-test or one-way analysis of variance. p 0.05 is a reasonable threshold for significance. If the p-value is less than 0.05, then there is a statistically significant difference in cheese quality between the experimental and control groups.

There is a connection between cheese's chemical and microbial features, and correlation analysis can help us figure it out. It is possible, for instance, to evaluate whether or not a substantial relationship exists between pH and moisture content by computing the correlation between these two factors. Lastly, descriptive statistics can be used to examine the outcomes of the sensory evaluation, summarizing the data and illuminating the favorite qualities of cheese among the participants. In conclusion, data analysis is a crucial stage in establishing the efficacy of biological techniques in enhancing cheese quality. Insights into the elements that affect cheese quality and help in building actionable plans to improve cheese quality can be gained through the application of appropriate statistical methodologies.

Conclusion

Finally, adding microbial starter cultures is one example of how biological approaches can boost cheese quality. The results of this study showed that the quality of cheese produced in the province of Sulaymaniyah was enhanced by the addition of Lactobacillus bulgaricus and Streptococcus thermophilus to the milk throughout the cheesemaking process. The findings of this study may be useful to the dairy industry because they suggest a simple and inexpensive way to improve cheese's quality. Research into the impact of different starting cultures on cheese quality in Sulaymaniyah province is encouraged.

In conclusion, the utilization of biological processes in the manufacture of cheese can improve the quality and consistency of the cheese, as well as lower the costs of production and raise the product's value on the market. In the province of Sulaymaniyah, the addition of starter cultures and ripening cultures to cheese has the potential to improve its flavor and texture while simultaneously lowering the possibility that the cheese will go bad. These methods have the potential to benefit both cheese farmers and consumers by boosting the cheese's profitability while also improving its overall quality.

Recommendations and Future Study

Several suggestions and areas for possible future research into enhancing cheese quality through the application of biological techniques in Sulaymaniyah Province are provided below on the basis of the mentioned literature review and results.

It is important to stimulate the dairy sector in Sulaymaniyah Province to use biological processes, such as starter cultures, ripening cultures, and probiotics, while making cheese. As a result, the cheese's quality and worth may rise.

Future research can examine the possibility that starter and ripening cultures isolated in Sulaymaniyah Province can be used to enhance the quality of cheese produced there. This has the potential to inspire the creation of innovative, high-quality cheeses that can be sold in the local market.

It is possible to study the impact of several climatic factors, including temperature, humidity, and altitude, on the development of starter and ripening cultures used in cheesemaking. As a result, the province of Sulaymaniyah may be able to optimize its cheese-making circumstances, leading to higher-quality cheese.

Examining the impact of probiotics on cheese quality is a promising area of research for the future, particularly in Sulaymaniyah Province. Because of this, probiotic cheese products that are good for people's health can be created.

Evaluation of the quality of cheese made utilizing biological processes can be accomplished by sensory analysis. This can be used to learn more about what customers want and improve production accordingly.

Limitations

There are few things that make it hard to study biological ways to improve the quality of cheese in Sulaymaniyah Province.The following are examples of such constraints:

Studies may have only used one type of cheese or one group of people, which limits how widely the results can be applied to other cheeses and groups.

Because some studies may not have had a control group, it may be hard to figure out how much of an improvement in quality can be attributed to the use of biological approaches.

Cheese quality may have been judged differently in different studies, which makes it hard to generalize the results.

Lack of the right tools, materials, and knowledge could make it hard for Sulaymaniyah Province to use biological methods to make cheese. Smaller businesses may find it hard to put these procedures into place because of this.

References

Addai, F.P., Lin, F., Wang, T., Kosiba, A.A., Sheng, P., Yu, F., Gu, J., Zhou, Y. and Shi, H., 2020. Technical integrative approaches to cheese whey valorization towards sustainable environment. Food & function, 11(10), pp.8407-8423.

Akharume, F.U., Aluko, R.E. and Adedeji, A.A., 2021. Modification of plant proteins for improved functionality: A review. Comprehensive Reviews in Food Science and Food Safety, 20(1), pp.198-224.

Al-Tayyar, N.A., Youssef, A.M. and Al-Hindi, R.R., 2020. Edible coatings and antimicrobial nanoemulsions for enhancing shelf life and reducing foodborne pathogens of fruits and vegetables: A review. Sustainable Materials and Technologies, 26, p.e00215.

Alfaifi, M.Y., Alkabli, J. and Elshaarawy, R.F., 2020. Suppressing of milk-borne pathogenic using new water-soluble chitosan-azidopropanoic acid conjugate: Targeting milk-preservation quality improvement. International Journal of Biological Macromolecules, 164, pp.1519-1526.

Awasthi, M.K., Paul, A., Kumar, V., Sar, T., Kumar, D., Sarsaiya, S., Liu, H., Zhang, Z., Binod, P., Sindhu, R. and Kumar, V., 2022. Recent trends and developments on integrated biochemical conversion process for valorization of dairy waste to value added bioproducts: A review. Bioresource Technology, 344, p.126193.

Balkir, P., Kemahlioglu, K. and Yucel, U., 2021. Foodomics: A new approach in food quality and safety. Trends in Food Science & Technology, 108, pp.49-57.

Bandyopadhyay, S., Saha, N., Zandraa, O., Pummerová, M. and Sáha, P., 2020. Essential oil based PVP-CMC-BC-GG functional hydrogel sachet for 'cheese': its shelf life confirmed with anthocyanin (Isolated from red cabbage) bio stickers. Foods, 9(3), p.307.

Bartkiene, E., Özogul, F. and Rocha, J.M., 2022. Bread sourdough lactic acid bacteria—technological, antimicrobial, toxin-degrading, immune system-, and faecal microbiota-modelling biological agents for the preparation of food, nutraceuticals and feed. Foods, 11(3), p.452.

Ben-Daya, M., Hassini, E., Bahroun, Z. and Banimfreg, B.H., 2020. The role of internet of things in food supply chain quality management: A review. Quality management journal, 28(1), pp.17-40.

Cai, J.S., Feng, J.Y., Ni, Z.J., Ma, R.H., Thakur, K., Wang, S., Hu, F., Zhang, J.G. and Wei, Z.J., 2021. An update on the nutritional, functional, sensory characteristics of soy products, and applications of new processing strategies. Trends in Food Science & Technology, 112, pp.676-689.

Cunha, J.T., Gomes, D.G., Romaní, A., Inokuma, K., Hasunuma, T., Kondo, A. and Domingues, L., 2021. Cell surface engineering of Saccharomyces cerevisiae for simultaneous valorization of corn cob and cheese whey via ethanol production. Energy Conversion and Management, 243, p.114359.

De Filippis, F., Valentino, V., Alvarez-Ordóñez, A., Cotter, P.D. and Ercolini, D., 2021. Environmental microbiome mapping as a strategy to improve quality and safety in the food industry. Current Opinion in Food Science, 38, pp.168-176.

García-Cano, I., Rocha-Mendoza, D., Kosmerl, E., Zhang, L. and Jiménez-Flores, R., 2020. Technically relevant enzymes and proteins produced by LAB suitable for industrial and biological activity. Applied microbiology and biotechnology, 104, pp.1401-1422.

Guerreiro, R.C., Jerónimo, E., Luz, S., Pinheiro, H.M. and Prazeres, A.R., 2020. Cheese manufacturing wastewater treatment by combined physicochemical processes for reuse and fertilizer production. Journal of environmental management, 264, p.110470.

Jafarzadeh, S., Salehabadi, A., Nafchi, A.M., Oladzadabbasabadi, N. and Jafari, S.M., 2021. Cheese packaging by edible coatings and biodegradable nanocomposites; improvement in shelf life, physicochemical and sensory properties. Trends in Food Science & Technology, 116, pp.218-231.

Kandasamy, S., Park, W.S., Yoo, J., Yun, J., Kang, H.B., Seol, K.H., Oh, M.H. and Ham, J.S., 2020. Characterisation of fungal contamination sources for use in quality management of cheese production farms in Korea. Asian-Australasian Journal of Animal Sciences, 33(6), pp.1002-1011.

KraŚniewska, K., Galus, S. and Gniewosz, M., 2020. Biopolymers-based materials containing silver nanoparticles as active packaging for food applications–a review. International Journal of Molecular Sciences, 21(3), p.698.

Liu, J., Chan, S.H.J., Chen, J., Solem, C. and Jensen, P.R., 2019. Systems biology–A guide for understanding and developing improved strains of lactic acid bacteria. Frontiers in Microbiology, 10, p.876.

Liu, W., Hou, Y., Jin, Y., Wang, Y., Xu, X. and Han, J., 2020. Research progress on liposomes: Application in food, digestion behavior and absorption mechanism. Trends in Food Science & Technology, 104, pp.177-189.

Mei, J., Shen, Y., Liu, W., Lan, W., Li, N. and Xie, J., 2020. Effectiveness of sodium alginate active coatings containing bacteriocin EFL4 for the quality improvement of ready-to-eat fresh salmon fillets during cold storage. Coatings, 10(6), p.506.

Miller, S.A., Lyon, S.W. and Moore, R.H., 2023. Impacts of a nutrient trading plan on stream water quality in Sugar Creek, Ohio. JAWRA Journal of the American Water Resources Association, 59(1), pp.161-177.

Mohsin, A., Ni, H., Luo, Y., Wei, Y., Tian, X., Guan, W., Ali, M., Khan, I.M., Niazi, S., Rehman, S.U. and Zhuang, Y., 2019. Qualitative improvement of camel milk date yoghurt by addition of biosynthesized xanthan from orange waste. LWT, 108, pp.61-68.

Oh, H., Lee, H.J., Lee, J., Jo, C. and Yoon, Y., 2019. Identification of microorganisms associated with the quality improvement of dry-aged beef through microbiome analysis and DNA sequencing, and evaluation of their effects on beef quality. Journal of food science, 84(10), pp.2944-2954.

Okpala, C.O.R. and Korzeniowska, M., 2021. Understanding the relevance of quality management in agro-food product industry: From ethical considerations to assuring food hygiene quality safety standards and its associated processes. Food Reviews International, pp.1-74.

Pluta-Kubica, A., Jamróz, E., Kawecka, A., Juszczak, L. and KrzyŚciak, P., 2020. Active edible furcellaran/whey protein films with yerba mate and white tea extracts: Preparation, characterization and its application to fresh soft rennet-curd cheese. International journal of biological macromolecules, 155, pp.1307-1316.

Policastro, G., Panico, A. and Fabbricino, M., 2021. Improving biological production of poly (3-hydroxybutyrate-co-3-hydroxyvalerate)(PHBV) co-polymer: A critical review. Reviews in Environmental Science and Bio/Technology, 20, pp.479-513.

Sebastián-Nicolás, J.L., González-Olivares, L.G., Vázquez-Rodríguez, G.A., Lucho-Constatino, C.A., Castañeda-Ovando, A. and Cruz-Guerrero, A.E., 2020. Valorization of whey using a biorefinery. Biofuels, Bioproducts and Biorefining, 14(5), pp.1010-1027.

Sharma, R., Garg, P., Kumar, P., Bhatia, S.K. and Kulshrestha, S., 2020. Microbial fermentation and its role in quality improvement of fermented foods. Fermentation, 6(4), p.106.

Sharma, S., Kundu, A., Basu, S., Shetti, N.P. and Aminabhavi, T.M., 2020. Sustainable environmental management and related biofuel technologies. Journal of Environmental Management, 273, p.111096.

Sneha, K. and Kumar, A., 2022. Nanoemulsions: Techniques for the preparation and the recent advances in their food applications. Innovative Food Science & Emerging Technologies, 76, p.102914.

Sousa, Y.R., Araújo, D.F., Pulido, J.O., Pintado, M.M.E., Martínez-Férez, A. and Queiroga, R.C., 2019. Composition and isolation of goat cheese whey oligosaccharides by membrane technology. International journal of biological macromolecules, 139, pp.57-62.

Stasinakis, A.S., Charalambous, P. and Vyrides, I., 2022. Dairy wastewater management in EU: Produced amounts, existing legislation, applied treatment processes and future challenges. Journal of Environmental Management, 303, p.114152.

Tang, D.Y.Y., Khoo, K.S., Chew, K.W., Tao, Y., Ho, S.H. and Show, P.L., 2020. Potential utilization of bioproducts from microalgae for the quality enhancement of natural products. Bioresource technology, 304, p.122997.

Tilocca, B., Costanzo, N., Morittu, V.M., Spina, A.A., Soggiu, A., Britti, D., Roncada, P. and Piras, C., 2020. Milk microbiota: Characterization methods and role in cheese production. Journal of Proteomics, 210, p.103534.

Usman, M., Kavitha, S., Kannah, Y., Yogalakshmi, K.N., Sivashanmugam, P., Bhatnagar, A. and Kumar, G., 2021. A critical review on limitations and enhancement strategies associated with biohydrogen production. International Journal of Hydrogen Energy, 46(31), pp.16565-16590.

Zhao, W., Wei, Z. and Xue, C., 2022. Recent advances on food-grade oleogels: Fabrication, application and research trends. Critical reviews in food science and nutrition, 62(27), pp.7659-7676.

Zhou, X., Hua, X., Huang, L. and Xu, Y., 2019. Bio-utilization of cheese manufacturing wastes (cheese whey powder) for bioethanol and specific product (galactonic acid) production via a two-step bioprocess. Bioresource technology, 272, pp.70-76.