

Review on Influence of Food Technology on the Flavor of Dairy Product

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Abstract: In contemporary society, people's demand for milk and dairy products is growing rapidly, and people's quality requirements for dairy products are gradually increasing. Currently, most research on dairy products focuses on nutritional composition, taste, and flavor. However, research into the changes in external and internal factors and processing and storage technology caused by flavor changes in dairy products is limited and immature. This paper comprehensively discusses the origin of flavor substances in milk and dairy products, the chemical changes caused by compounds affecting flavor, and the influence of temperature and humidity on flavor.

Keywords: Flavour; volatile compound; gas chromatography-ion mobility spectrometry.

1. Introduction

Global milk and dairy demand has risen, particularly for a diverse range of products including fresh milk and flavored milk like yogurt and cheese. Among these, hard cheese is predominantly produced in countries with dedicated cheese-making traditions like the UK, New Zealand, and Switzerland. Similarly, semi-hard cheese is mainly produced in nations such as New Zealand, the Netherlands, and Finland. In terms of texture, soft cheese is predominantly manufactured in Italy and France, renowned for their artisanal cheese production. Semi-soft cheese, which blends elements from both hard and soft cheese, is mainly produced in countries like the UK, France, Italy, and Brazil. In the realm of flavored dairy products, which extend beyond basic milk types, these products are composed of multiple key ingredients such as milk, sugar, color, and artificial or naturally derived flavor substances.

Compared to original milk, flavored dairy products not only provide the same key nutrients but also cater to the taste and flavor preferences of different consumers. Euromonitor data from 2020 shows that in China, 25% of current pure milk consumption is fresh milk, while 75% is UHT milk consumed at room temperature. In contrast, in foreign developed countries, 80% to 90% or more drink fresh milk. Specifically, in the milk category (subdirectory for fresh milk and room temperature milk), fresh milk consumption accounted for 88.62% in Australia, 99.9% in Canada, 98.27% in Japan, and 98.28% in the United States [3]. Different flavors of dairy products are produced by varying chemical components and influenced by numerous external factors.

2. Volatile Compounds and Their Detection Techniques

The flavor of raw milk is determined by volatile compounds. Volatile compounds in raw milk include terpenoids, acids (C4-C12 fatty acids in milk fat), ketones (methyl ketones), aldehydes (nonenal), esters, phenols and sulfides (dimethyl sulfides), etc., which are produced by the lipolysis or oxidation of fatty acids in milk fat [1]. In this oxidation process, each molecule is in a state of motion

collision, each collision may occur chemical reactions to produce new molecules, such as acid-base neutralization, acid and alcohol esterification, ester and acid, alcohol, ester exchange, aldol and aldehyde aldehyde condensation, aldehyde and amine condensation, molecular rearrangement, polymerization reaction, cleavage reaction, disproportionation reaction, catalytic chain reaction, cyclization and ring-opening reactions of terpenes, etc. [4]. In the processing of dairy products, pasteurization, homogenization, concentration and other processing processes cause other chemical and physical changes, such as hydrolysis of casein, non-enzymatic Browning, denaturation of whey protein and destruction of emulsification properties [5]. During storage, the hydrogen bonds of polyunsaturated fatty acids are easily oxidized to form unstable peroxides [6]. Irritating substances such as aldehydes and ketones will be released through the decomposition of peroxide, causing the deterioration of taste and flavor of dairy products [7].

2.1. Lactones' reaction

At present, researchers have explored the formation mechanism of lactone compounds in food. The formation mechanism of γ -lactone and delta-lactone [1], the one-step lactone exchange reaction pathway [13], the aldol condensation reaction pathway of trigonellactone [14], the fatty acid-acyl coa-lactone formation pathway in fruits [15], and the unsaturated fatty acid-hydroxy-fatty acid - lactone in fruits have been proposed Ester formation pathway [16], et al.

Hundreds of aroma compounds have been identified in cheese, mainly including fatty acids, alcohols, aldehydes, ketones, esters, lactones, pyrazines, sulfur compounds, amines, etc. [8]. Lactones, although usually low in content in cheese, give it a special fruity aroma and can be balanced with other flavors. Lactones in cheese were mainly detected in γ -lactones and delta-lactones, which have stable structures of five-membered ring and six-membered ring respectively [10]. Gamma-lactones are formed from C18 fatty acid and fatty acid converted to hydroxyl acid through water synthesis and then through β -oxygenation in tissue ring [3]. Alpha-lactones and β -lactones cannot be detected in cheese due to their highly reactive and unstable nature [11]. Curioni analyzed the aroma components in Cheddar cheese by gas chromatography and

GC-O and found that the main lactones were γ -decalactone, delta-decalactone and delta-dodecalactone, which presented sweet cream aroma, coconut flavor and nut flavor, respectively. And through aroma extract dilution analysis, AEDA found that gamma-decalactone had a stronger flavor contribution among the three lactones, and the threshold was relatively low (FD value was 27, FD value was 8 and 16). Nowadays, not only the analysis of lactate compounds is carried out through GC-O, but also the rapid update of scientific instruments, and the analysis mode and technology

are constantly improving. selective ion flow tube-mass spectrometry, SIFT-MS) combines flow tube technology, chemical ionization and mass spectrometry to selectively use initial ions such as H_3O^+ , NO^+ and O_2^+ . Real-time multi-component online analysis of volatile flavor substances can be performed in a short time [10]. However, different determination methods have their own advantages and limitations, such as SIF-MS has high requirements for instruments and equipment, and high m/z ions will cause mass discrimination effect [1].

Table 1. Lactones in common dairy and their aroma contribution

Food types	Food name	Main lactone compounds	Aroma contributor	References
Dairy Products	milk	γ -Decalactone, γ -Dodecanolide	Fruity,milky,creamy	[42]
	UHT milk	2,4-pentadiene-4-olactone, 2(5)-heptene-4-olactone, γ -octanolactone	Milky,creamy,coconut	[42,87]
		δ -Octanolactone, γ -nonanolactone, δ -decanolactone	almond,peach,blossom	
	butter	δ -Decalactone. δ -Dodecalactone, δ -Octyllactone, δ -Decalactone, δ -Dodecalactone. δ -Tetradecalactone	Peach,cream, milk flavor	[6-10,88]
	cheddar cheese	δ -caprolactone, δ -nonanolactone, γ -undecalactone, δ -decanolactone. γ -dodecalactone, δ -dodecalactone. β -hydroxy- γ -butyrolactone, δ -tetradecalactone	Peach,coconut,sweet	[5,43]
	Mozzarella Cheese	δ -Decalactone, δ -Dodecalactone,Butyrolactone, γ -Nonalactone, δ -Nonalactone, γ -Dodecalactone	Creamy, coconut, fruity	[12]
	Gouda cheese	δ -octyl lactone, δ -decyl lactone, δ -dodecalactone, γ -caprolactone, δ -tetradecalactone, δ -hexadecanoic acid	Coconut, sweet, apricot flavor	[11]

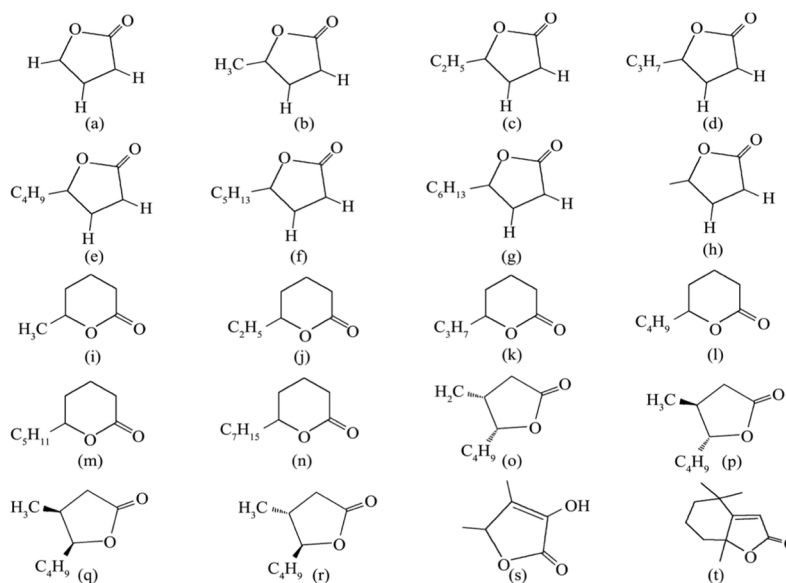


Figure 1. Structural formulas of lactones commonly found in foods

Note :(a)~(g): gamma-butyrolactone ~ gamma-decyl lactone; (h): gamma-dodecolactone; (i)~(m): delta-caprolactone ~ delta-decylactone; (n): delta-dodecolactone; (o): Cis-(3R,4R) -oakenolactone; (p): Trans -(3S,4R) -oakenolactone; (q): Cis-(3S,4S) -oakenolactone; (r): Trans -(3R,4S) -oakenolactone; (s):4, 5-dimethyl-3-hydroxy-2 (5H) -furanone (trigonellone); (t): dihydroactiniolactone.

Among them, 4-hydroxy acids and 5-hydroxy acids are important components of γ -lactones and δ -lactones, respectively. Hydroxylated fatty acids exist in milk fat triglycerides, which can be obtained by enzymatic reaction to decompose fat or heating. They are also produced by the catabolism of unsaturated fatty acids through the action of microbial enzymes (lipoxygenase and hydratase) (Fig. 2) [12].

Chemical reaction analysis indicates that lactone formation in cheese is a one-step non-enzymatic reaction in triglycerides. Medium esterified hydroxyl fatty acids directly release lactones through transesterification (Fig. 3) [17].

In milk and dairy products, there are the following main factors affecting the change of lactone reaction:

1. *Temperature*: After UHT heat treatment, the volatile flavor substances in UHT milk were determined by SPME-GC-MS (see Fig. 2). After being heated at 137 °C and 4s, the ester compounds showed the greatest changes, including 2, 4-pentadiene-4-lactone, 2(5) -heptene-4-lactone, γ -octanolactone, delta-octanolactone, and 2(5)-heptanolactone. Formation of 6 kinds of lactone compounds, γ -nonanolactone and delta-decylactone [18] (see Fig. 4).

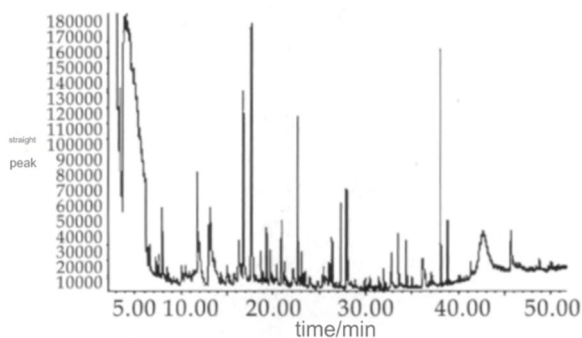


Figure 2. Ion current spectrum of flavor substances in milk after UHT heat treatment

2. *Water activity:* A trace amount of water is indispensable in the formation of lactones and can ensure that lactones are catalyzed during the reaction. When lipase is used to catalyze the production of milk flavor, the maintenance activity of the enzyme depends on water, because water participates in the formation of hydrogen bonds and interacts with hydrophobic bonds, thus guiding various hydrogen bonds, hydrophobic bonds and other non-covalent interactions, and will directly affect the equilibrium state of the reaction system. But there is still controversy over the amount of water. Liu Xiaoyan and other researchers have shown through experiments that an appropriate amount of water can promote enzyme reaction, while excessive water will lead to a decline in enzyme activity [21]. Alewijn et al. found that adding 5%(V/V) of water adequately increased the rate of lactone formation in cheese, but adding more water had no additional effect.

3. *The role of enzymes:* Today's cheese production generally adds protease and lipase at the same time to promote the maturation of cheese, so that cheese produces a unique flavor, can also shorten the ripening time, improve production efficiency. In addition, the action time and addition amount of enzymes in dairy products will affect the type and amount of lactone compounds in dairy products [21,22].

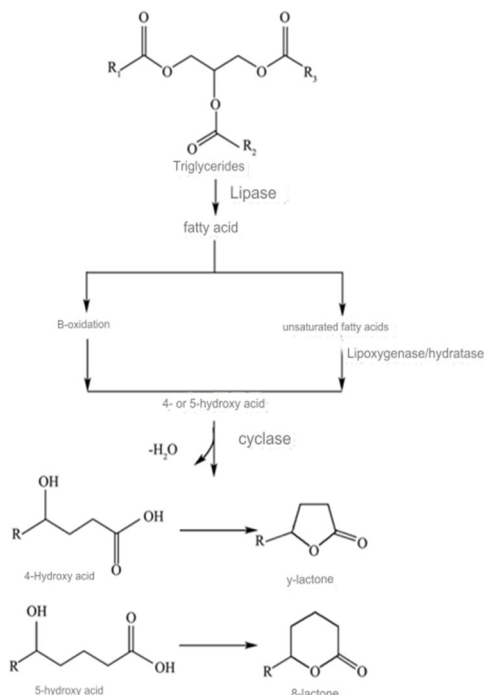


Figure 3. Formation mechanism of lactones in cheeses

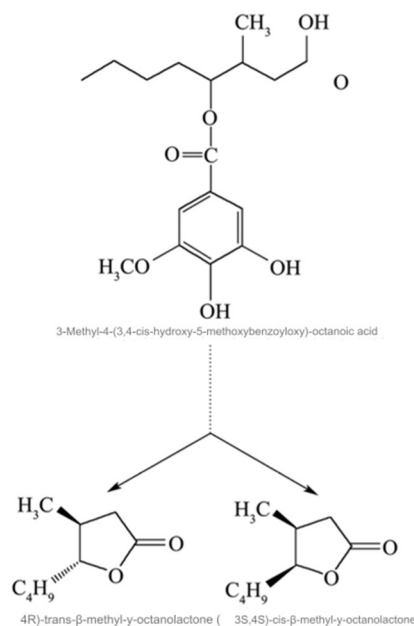


Figure 4. Biochemical formation pathway of oak lactones

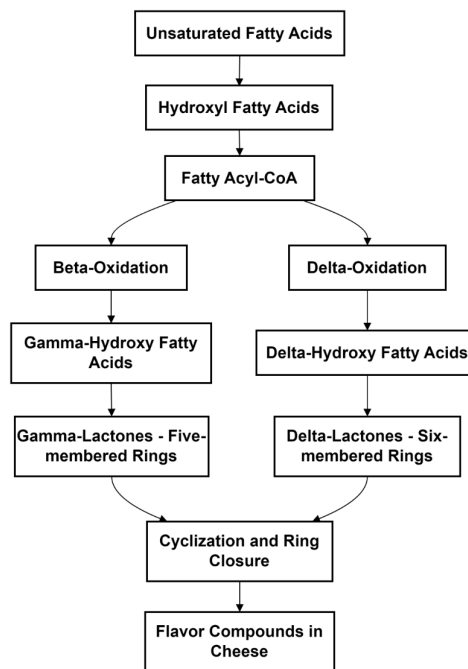


Figure 5. Biochemical pathway for lactone production in dairy products

Figure 5 shows the production process of lactones (gamma-lactone and delta-lactone) from unsaturated fatty acids in dairy products. Fatty acids are first converted into hydroxy fatty acids through enzymatic reactions, and then undergo β -oxidation or δ -oxidation to produce lactones, which are further cyclized to form the final aroma compounds, which have an important impact on the flavor of dairy products such as cheese.

2.2. Aldehyde compounds

Lipid oxidation is thought to be the main cause of quality and flavor changes in lipid-rich dairy products during processing or storage [37]. In addition to nutrient loss, lipid oxidation products (such as aldehydes and ketones) can make dairy products stale and induce odors at very low concentrations, such as fatty, plastic, fishy, metallic, or

cardboard flavors [3].

The Maillard reaction is a complex non-enzymatic Browning reaction between the carbonyl group of a reducing sugar and the amino group of an amino acid, peptide or protein. A series of aldehydes, including furfural, are produced by Maillard reaction during hot processing or high temperature storage of dairy products. Furfural compounds are mainly composed of four compounds: methylfurfural, furfural, furanomethyl ketone and methylfurfural, and can cause certain harm to human body [43]. At present, the detection of aldehydes produced by Maillard reaction mainly focuses on formaldehyde, and the detection methods mainly include spectroscopy, liquid chromatography (HPLC) or gas chromatography-mass spectrometry (GC-MS) [44-49]. Among them, the extraction efficiency of derivative liquid extraction is higher, and the recovery rate of standard addition is close to 100% [43].

2.3. Ketones

Methyl ketone occurs naturally in raw milk and is produced by oxidative degradation of fatty acids. During heat treatment, the degradation of milk fat, the β -oxidation of unsaturated fatty acids and the decarboxylation of β -keto acid can promote the formation of methyl ketone. Acetone and 2-butanone are usually present in small amounts in raw milk, and acetone has a sweet fruity aroma with a content of 0.8 to 27 mg/kg; The flavor characteristics of 2-butanone are similar to those of acetone, with a content of about 0.2mg/kg, which makes little contribution to the flavor of raw milk [3].

3. Improvement of Storage and Processing Technology of Dairy

In dairy products processing, fat oxidation and nutrient loss will also lead to the production of different flavors. Meanwhile, hydrolysis and oxidation reactions should be minimized when dairy products are stored [7].

3.1. The Influence of Packaging Materials on Flavor Preservation in Fresh Milk

The flavor of fresh milk will also be affected by the packaging materials during storage, and the influencing factors include the type, composition, thickness and form of packaging materials. For example, the properties of plastic film and the contact area with milk affect the adsorption and diffusion of flavor substances in milk, the composition of main layer composite packaging material can affect the dissolved oxygen in milk, the addition of protective agents

can protect some sensitive substances in milk, and PET material has better light-blocking performance than PE [24-27]. Through the analysis of the physical properties of different types of liquid flexible packaging films, such as oxygen permeability test, moisture permeability test, light permeability test and sensory flavor changes after holding low-temperature fresh milk, it is concluded that black and white barrier film can ensure the sensory flavor of products during the shelf life in low-temperature storage environment and in special storage and transportation environment (room temperature) [28].

3.2. The Impact of Packaging Gas Ratios on Vacuum Degree and Flavor Stability in Dairy Products

Milk powder is rich in nutrients and susceptible to environmental impacts during storage. In order to reduce oxidation, air conditioning packaging is usually used to ensure the stability of flavor and quality of dairy products. Microorganisms lead to bad flavor of dairy products, mainly fruit taste, bitter taste, rancidity, yeast taste and so on. [31] Bitter taste in dairy products is mostly caused by protease, a microbial metabolic product, which forms bitter polypeptides and amino acids by enzymolysis of casein [31]. The commonly used gases for air conditioning packaging are nitrogen (N₂) and carbon dioxide (CO₂) [30]. N₂ is an inert gas and does not easily react with food to reduce residual oxygen. CO₂ at an appropriate high concentration can inhibit microbial growth and extend shelf life while ensuring product freshness. As shown in Table 2, higher CO₂ concentrations lead to a higher vacuum degree over time, which enhances the storage environment and prolongs the shelf life of dairy products. Time, temperature, CO₂ content ratio, and other factors will also affect the vacuum degree of storage containers [36]. Storage time has significant influence on vacuum degree. Figure 5 illustrates how different formulations of dairy products experience varying vacuum degree formation during storage, further emphasizing the role of these variables in product preservation. Under certain conditions, vacuum degree in tank increases with storage time. In the early stage of storage, the higher the storage temperature, the greater the vacuum degree formed in the tank, and the vacuum degree tends to be the same at room temperature, 37 °C, and 47 °C at 6 months. Under the same conditions, the higher the CO₂ concentration, the higher the vacuum degree in the tank [36] (see Fig. 6).

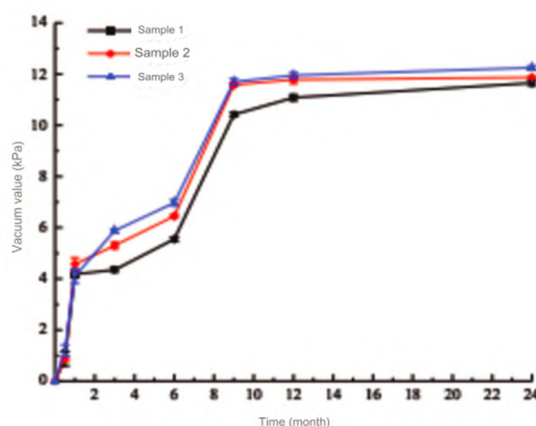


Figure 6. Effect of storage time on vacuum formation of samples with different formulations

Table 2. Vacuum degree formed in the tank with different gas ratios over time

CO ₂ %	Time					
	2 days	7 days	15 days	1 month	2 months	12 months
0	-2.45 ± 1.29 ^a	-2.96 ± 1.21 ^a	-2.54 ± 1.40 ^a	-2.14 ± 1.06 ^a	-1.49 ± 0.80 ^a	-2.74 ± 1.09 ^a
20	-0.90 ± 0.83 ^b	-0.85 ± 0.76 ^b	-0.89 ± 1.07 ^b	0.38 ± 1.31 ^b	1.34 ± 1.52 ^b	0.34 ± 1.53 ^b
30	-0.50 ± 1.12 ^b	0.26 ± 1.64 ^{bc}	0.13 ± 0.52 ^{bc}	2.47 ± 1.06 ^c	4.43 ± 1.70 ^c	2.84 ± 1.59 ^c
40	-0.82 ± 1.40 ^{bc}	0.49 ± 1.15 ^c	1.13 ± 0.96 ^{cd}	3.82 ± 1.36 ^{cd}	5.81 ± 1.54 ^d	4.11 ± 1.61 ^d
60	0.07 ± 1.58 ^c	1.17 ± 1.44 ^c	1.19 ± 1.00 ^d	5.22 ± 1.46 ^d	6.75 ± 1.58 ^d	7.13 ± 1.52 ^e
80	2.04 ± 1.48 ^d	3.52 ± 1.24 ^d	4.03 ± 1.41 ^e	7.55 ± 1.38 ^e	10.02 ± 1.94 ^e	11.78 ± 1.12 ^f
100	2.51 ± 0.70 ^d	3.74 ± 1.51 ^d	5.38 ± 1.07 ^f	8.23 ± 3.01 ^e	12.97 ± 1.17 ^f	15.25 ± 0.95 ^f

3.3. Extending the Shelf Life of Dairy Products through Ultra-High Pressure and Non-Thermal Sterilization Technologies

In the storage process of dairy products, ultra-high pressure technology and non-heating sterilization technology can also be combined. The use of the technology can effectively kill the bacteria and microorganisms in the milk raw materials, reduce the loss of nutrients caused by the traditional thermal sterilization method, does not affect the protein content and activity of milk, and has less impact on the flavor and taste, which can extend the shelf life of dairy products from 10 days to 1 to 3 months. At the same time, the production and processing of dairy products can also use ultra-high pressure technology to replace the application of traditional preservatives, and make dairy products into milk, fermented milk, cheese, and other foods. [34]

4. Conclusions

Flavor has always been one of the hot spots and difficulties in cheese research, and volatile compounds are one of the important contributors to its aroma, which has been widely concerned by the society, and there are many problems to be studied or solved. Based on the analysis of volatile compounds that affect the flavor of dairy products, this paper describes the influence of moisture, temperature and enzyme on lactones and the change of flavor quality of aldehydes and ketones by different factors from the chemical level. Among them, the influence of temperature is a major factor, which will greatly affect the three. The present science and technology on the reaction intermediates and the products after the reaction are briefly discussed. These problems restrict our understanding of the formation and regulation mechanism of volatile compounds in dairy products, and also restrict the development and industrial production of corresponding products. At the same time, it provides a summary of new ideas for the processing and storage of dairy products, and extends the storage time of dairy products to the maximum extent and retains its nutrition and flavor while reducing the cost as much as possible. In the future, it is necessary to further understand the aroma contribution of volatile substances on the basis of current cognition, and at the same time, it is expected to achieve a deeper and thorough level of research on the formation mechanism and synthesis regulation of volatile compounds in the ripening process of dairy products, which is conducive to a comprehensive understanding of volatile compounds in dairy products, their formation and evolution, and further systematically improve

the flavor research of them. It is also helpful to promote transformation and upgrading of Chinese dairy industry, which is of great significance for the rapid development of dairy industry.

References

- [1] CHEN C, LIU Z, YU H, et al. (2020) Flavor Contribution of Lactones in Cheese and Its Biosynthetic Regulation: a Review. *Modern Food Science and Technology*.
- [2] LIN X. (2018). Review of Research on Flavor-rendering Substances for Milk and Dairy Products. *Journal of Sichuan Tourism University*, 18-22.
- [3] CHEN Y, ZHANG Y, LI N, et al. (2024) Research Progress on Flavour Substance Characteristics And Sources in Raw Milk. *China Animal Husbandry & Veterinary Medicine* 51(3):1103-1110
- [4] Lin X. Y. (2001). *Perfume Craft*. Beijing: Chemical Industry Press.
- [5] GUO Y P, ZHANG S W, ZHAO X X, et al. Research progress of liquid goat milk processing[J]. *Journal of Food Safety & Quality*, 2022, 13(6): 1703-1710
- [6] ZHUANG K J, FENG X H, MAN C X, et al. Quality change of milk powder during storage and the main influencing factors[J]. *China Dairy Industry*, 2021, 49(4): 35-41.
- [7] XUE Haiyan, WEI Yi, MENG Yi, et al. (2024) Fatty acid composition and differential analysis during accelerated oxidation of goat milk and milk powder. *Food and Fermentation Industrie*.
- [8] MA Yan-li, CAO Yan-ping, ZHENG Fu-ping, et al. Review on the advancement of cheese flavor components [J]. *China Dairy Industry*, 2013, 41(5): 36-39
- [9] Bovolenta S, Romanzin A, Corazzin M, et al. Volatile compounds and sensory properties of montasio cheese made from the milk of simmental cows grazing on alpine pastures [J]. *Journal of Dairy Science*, 2014, 97(12): 7373-7385
- [10] Eriksen, S. Flavours of milk and milk products [J]. *Mikhwissenschaft*, 1976, 31(1): 549-550
- [11] Fox P F, Wallace J M. Formation of flavor compounds in cheese [J]. *Advances in Applied Microbiology*, 1997, 45: 17-86
- [12] YU Haiyan, YAO Wenqian, CHEN Chen, YUAN Haibin, HUANG Juan, LOU Xinman, TIAN Huaixiang* Flavor Contribution and Biosynthesis Mechanism of Lactone Compounds in Food 2022
- [13] Alewijn M, Smit B A, Sliwinski E L, et al. The formation mechanism of lactones in Gouda cheese [J]. *International Dairy Journal*, 2007, 17(1): 59-66

- [14] Kojiro T, Makoto T, Shin S. 3-Hydroxy-4,5-dimethyl-2(5H)-furanone, a burnt flavoring compound from aged sake [J]. *Journal of the Agricultural Chemical Society of Japan*, 1976, 40(2): 325-330
- [15] Cao X. M. (2019). *Metabolism and regulation of volatile esters in peach fruit* [D]. Hangzhou: Zhejiang University.
- [16] Xi W P, Zhang B O, Liang L I, et al. Postharvest temperature influences volatile lactone production via regulation of acyl-CoA oxidases in peach fruit [J]. *Plant, Cell & Environment*, 2012, 35(3): 534-545
- [17] Ueda S, Sasaki R, Nakabayashi R, et al. Exploring the lipids involved in the formation of characteristic lactones in Japanese black cattle [J]. *Metabolites*, 2021, 11(4): 203-217
- [18] Wang W. H., Mu Z. S. (2012). Effect of UHT treatment on volatile compounds in milk [J]. *China Dairy Industry*, 2012, 40(4): 36-38
- [19] Ueda S, Sasaki R, Nakabayashi R, et al. Exploring the lipids involved in the formation of characteristic lactones in Japanese black cattle [J]. *Metabolites*, 2021, 11(4): 203-217
- [20] Wyatt C J, Pereira R L, Day E A. Lactone precursor in fresh milk fat: isolation and characterization of the precursor [J]. *Journal of Dairy Science*, 1967, 50(11): 1760-1763
- [21] Liu X. Y., Cheng J., Xu X. F. (2007). Study on the Synthesis of Milk Flavor by Lipase Catalysis in Non-Aqueous System.
- [22] Minghui, Pan, Lingjun, et al. Comparison of sensory and electronic tongue analysis combined with HS-SPME-GC-MS in the evaluation of skim milk processed with different preheating treatments [J]. *Molecules (Basel, Switzerland)*, 2019, 24(9): 1650-1665
- [23] Curioni P M G, Bosset J O. Key odorants in various cheese types as determined by gas chromatography-olfactometry [J]. *International Dairy Journal*, 2002, 12(12): 959-984
- [24] Dury-Brun C, Chalier P, Desobry S, et al. Multiple mass transfers of small volatile molecules through flexible food packaging [J]. *Food Rev Int*, 2007, 23(3): 1-59.
- [25] Sun B. Q. (2019). Study on the Adsorption and Diffusion Laws of Characteristic Flavor Compounds in Liquid Food Packaged with Soft Plastic Films [Doctoral dissertation]. Wuxi: Jiangnan University.
- [26] Gui S. L., Xing H. M., Guo L. C., et al. (2012). Study on the Effect of Packaging Types on Dissolved Oxygen in Milk. *Agricultural Products Processing*, (10), 67-69, 73.
- [27] Wang A, H C, Dadmun, et al. Efficacy of light-protective additive pack-aging in protecting milk freshness in a retail dairy case with LED lighting at different light intensities [J]. *Food Research International*, 2018 (114): 1-29
- [28] FU Cuixia, DONG Zhenling, LI Yanjuan, et al, (2022), Influence of Different Soft Package of Liquid Plastic Film on the Flavor of Fresh Milk
- [29] Maniar A B, Marcy J E, Bishop J R, et al. Modified atmosphere packaging to maintain direct- set cottage cheese quality [J]. *Journal of Food Science*, 1994, 59(6): 1305- 1308.
- [30] Wu X. J., Yu J. J., Chen X. (2014). Application of Headspace Analysis Technology in Testing the Gas Content Inside Milk Powder Packaging. *China Packaging*, 34(6), 3.
- [31] Chu S. X., Liu Y. H., Xie S. B., Yang Z. Y., Fan S. Q., Xu Z. B. (2023). Hazards and Control of Microorganisms in Milk and Dairy Products. 1671-4393(11), 69-74.
- [32] Zhou X. L. (2005). Application of MAP Technology in Food Preservation. *Food Industry*, (5), 45-47.
- [33] Puligundla P, Jung, J, Ko S. Carbon dioxide sensors for intelligent food packaging applications [J]. *Food Control*, 2012, 25(1): 328-333.
- [34] Xiong Z. P., Li A. M. (2023). Effects of New Food Processing Technologies on Food Quality.
- [35] Zhu Xinpeng, Yao Min Study on the Method of Enzymatic Hydrolysis Cheese and Flavor Compounds Analysis 2011 1671- 9646 (2011) 05- 0056- 03
- [36] PENG Xiyang, LIN Siyu, XU Mengji, YI Can, WANG Cong, WANG Yifei Study on the Influence Factors of the Vacuum Formation of Canned Milk Powder 2023
- [37] CADWALLADER D C, GERARD P D, DRAKE M A. The role of packaging on the flavor of fluid milk [J]. *Journal of Dairy Science*, 2023, 106 (1): 151-167 .
- [38] WÓJTOWSKI J A, MAJCHER M, DANKÓW R, et al. Effect of herbal feed additives on goat milk volatile Flavor compounds [J]. *Fods*, 2023, 12(15): 2963.
- [39] Zeng W. W., Liu Y. H., Ruan R. S., Wang Y. P., Yang L., Liu C. M., Peng H. (2011). *Sci Technol Food Ind*, 2011, 32 (7) : 447.
- [40] Li Y. L., Liu X. X., Zheng P. H., Wang Y. P. (2012). *Food Sci Technol*, 2012, 37(9) : 82.
- [41] Liu J., Jiang Z. M., Liu X., Shan J., Ai C. M. (2018). *AiCM.ChinDairyInd*, 2018, 46(8):59.
- [42] Liu B., Jiang T. M., Li J. F., Qiao W. C., Bu D. D., Chen L. J. (2018). *Chin J Food*, 2018, 18 (8) : 178.
- [43] CHEN Tongqiang, LI Kailong, XIANG Jun, LIANG Feng, XU Wenyang, LI Can Determination of furfural compounds in infant formula by precolumn derivatization and high performance liquid chromatography 2021
- [44] Shin H S, Lim H H. *Inter J Food Sci Tech*, 2012, 47: 350.
- [45] Chen J, Zhang Y H, Wang Y Y, Wang T T, Li C H, Zhu H. *Chin Dairy Ind*, 2010, 38(8) : 46.
- [46] Wang T, Gao X, Jia T, Chen L. *Food Chem*, 2012, 131: 1577.
- [47] Bianchi F, Careri M, Mangia A. *Food Chem*, 2007, 100: 1049.
- [48] SN/T1547-2011 Determination of Formaldehyde in Food for Import and Export Liquid Chromatographic Method [S]. SN/T 1547-
- [49] Wang F. L., Yang J. Z. (2008). *Textile Tech Fev*, 2008(3) : 58.
- [50] Fu J, He F, Zhu X, et al. Structural characteristics and antioxidant activity of Chinese giant salamander enzymatic hydro lysate-glucose conjugates induced by ultrasound Maillard reaction [J]. *Food Bioscience*, 2024, 58: 103654.
- [51] SHAKOOR, ASHBALA, et al. Maillard reaction chemistry in formation of critical intermediates and flavour compounds and their antioxidant properties. *Food Chemistry* 393 (2022): 133416.