Damascus University Journal of Agricultural Sciences
Vo 40 No.2 (2025): 331-344

مجلة جامعة دمشق للعلوم الزراعية
المجلد 40 العدد 2 (2025): 331-344

# Metabolic Products and Biological Roles of Lactic Acid Bacteria in Fermented Products of Dairy: A Review

**Raghad Saad Musa Al Musa*[1], Esraa Sabah Ethafa [2], Zainab Abd Ali Hasan [3], Ahed Elias Abou Younes[4], and Alla Mohammed Sadkhan Al-Baidhani [5]**

[1] *Teaching Assistant in Food Science Department, Agriculture College, Basrah University, Iraq *Corresponding author Email : raghad.saad@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0001-9260-4335*

[2] *Teaching Assistant in Food Science Department, Agriculture College, Basrah University, Iraq Email: esraa.sabah@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-1285-2783*

[3] *Teaching Dr. Food Science Department, Agriculture College, Basrah University, Iraq Email: zainab.abdali@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-7792-7985*

[4]*Prof. Dr. in Department of food science, Faculty of Agriculture, Damascus University, Damascus, Syria. Email: ahed.abouyounes@damascusuniversity.edu.sy*
*ORCID: https://orcid.org/0000-0003-4428-9064*

[5] *Prof Assistant Dr. in Food Science Department, Agriculture College, Basrah University, Iraq Email: :alaa.sadkhan@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-1539-1409*

Received: 30/11/2024
Accepted: 11/6/2025



## Abstract:

Fermented products of dairy are widely popular worldwide and play various roles, including extending the shelf life of milk and providing health benefits to manufactured products. Fermented products of dairy provide essential nutrients in the human diet, along with compounds typically found in milk or added as precursors, including lactic acid bacteria (LAB), produced, too. Peptides, organic acids, vitamins, and active compounds are among the biologically active compounds that LAB are capable of producing. Due to their metabolic activity, LAB secrete specialized enzymes such as proteases, lipases, and lactases, which break down the main components of milk, including proteins, fats, and carbohydrates. These enzymes also produce active peptides such as angiotensin I-converting enzyme (ACE) inhibitory peptides and bacteriocins, along with biologically active external polysaccharides, making them functional foods with health-promoting effects. In recent years, there has been significant progress in understanding how LAB are medically important. The consumption of fermented products of dairy has been associated with several health-promoting effects, such as lowering cholesterol, and hypertension, as well as antioxidant activity, antimicrobial activity, and immune benefits, including protection against cancer, lactose intolerance, milk allergy, and hypoglycemya. The sensory approval of dairy products is also enhanced by the addition of LAB, that increase the acidity of the product and impart a desirable flavor, aroma, and texture.

**Keywords:** Angiotensin I-converting enzyme, Enzymes, Exopolysaccharides, GABA, Lactose intolerance.

# المنتجات الأيضية والأدوار البيولوجية لبكتيريا حامض اللاكتيك في منتجات الألبان المتخمرة: (مراجعة علمية)

**رغد سعد موسى الموسى[1*]، اسراء صباح عذافة[2]، زينب عبد علي حسن[3]، عهد الياس أبو يونس[4]، الاء محمد سدخان البيضاني[5]**

[1] مدرس مساعد في قسم علوم الأغذية، كلية الزراعة، جامعة البصرة، العراق
*Email : raghad.saad@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0001-9260-4335*

[2] مدرس مساعد في قسم علوم الأغذية، كلية الزراعة، جامعة البصرة، العراق
*Email: esraa.sabah@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-1285-2783*

[3] مدرس دكتور في قسم علوم الأغذية، كلية الزراعة، جامعة البصرة، العراق
*Iraq Email: zainab.abdali@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-7792-7985*

[4] أستاذ دكتور في قسم علوم الأغذية، كلية الزراعة، جامعة دمشق، دمشق، سوريا.
*Email: ahed.abouyounes@damascusuniversity.edu.sy*
*ORCID:*

[5] أستاذ مساعد دكتور في قسم علوم الأغذية، كلية الزراعة، جامعة البصرة، العراق
*Email: :alaa.sadkhan@uobasrah.edu.iq*
*ORCID: https://orcid.org/0000-0002-1539-1409*

تاريخ الايداع:2024/11/30
تاريخ القبول: 2025/6/11



## الملخص:

المنتجات المتخمرة من الألبان التي تحظى بشعبية واسعة في جميع أنحاء العالم وتلعب أدوارًا مختلفة، بما في ذلك إطالة العمر الخزني للحليب وتوفير الفوائد الصحية للمنتجات المصنعة. توفر المنتجات المتخمرة من الألبان العناصر الغذائية الأساسية في النظام الغذائي للمستهلك، إلى جانب المركبات الموجودة عادة في الحليب أو المضافة كمواد أولية، بما في ذلك بكتيريا حامض اللاكتيك LAB ، المنتجة أيضًا. تعد الببتيدات والأحماض العضوية والفيتامينات والمركبات النشطة من بين المركبات النشطة بيولوجيًا التي يمكن لبكتيريا حامض اللاكتيك إنتاجها. نظرًا لنشاطها الأيضي، تفرز LAB إنزيمات متخصصة مثل البروتييز واللاييز واللاكتيز، والتي تحلل المكونات الرئيسية للحليب، بما في ذلك البروتينات والدهون والكربوهيدرات. تنتج هذه الإنزيمات أيضًا ببتيدات نشطة مثل الببتيدات المثبطة لإنزيم تحويل الأنجيوتنسين ACE والبكتيريا، إلى جانب السكريات الخارجية النشطة بيولوجيًا، مما يجعلها أغذية وظيفية ذات تأثيرات تعزز الصحة. في السنوات الأخيرة، كان هناك تقدم كبير في فهم مدى أهمية LAB طبيًا، ارتبط استهلاك منتجات الألبان المتخمرة بالعديد من التأثيرات المعززة للصحة، مثل خفض الكوليسترول وارتفاع ضغط الدم، فضلاً عن نشاط مضادات الأكسدة، ونشاط مضادات الميكروبات والفوائد المناعية بما في ذلك الحماية من السرطان وعدم تحمل اللاكتوز وحساسية الحليب وانخفاض سكر الدم. كما يتم تعزيز الموافقة الحسية على منتجات الألبان من خلال إضافة LAB، مما يزيد من حموضة المنتج ويضفي نكهة ورائحة وملمسًا مرغوبًا.

**الكلمات المفتاحية:** إنزيم تحويل الأنجيوتنسين I، الإنزيمات، عديد السكاريد الخارج، حامض جاما أمينوبوتيريك، عدم تحمل اللاكتوز.

# 1. Introduction:

The dairy market is rapidly evolving and is subject to innovations to develop and produce products of high quality, value, and food safety, in addition to enhancing the sensory characteristics of these products (Ribeiro *et al.,* 2024, Alzerawi and Abou Younes, 2023). Fermented products of dairy such as yogurt and cheese play vital roles in maintaining human health, either directly through the interaction of these organisms with the host or indirectly through the metabolic products formed during fermentation (Yan *et al.,* 2024, Kairout *et al.*, 2022). Fermented products including dairy products are an ideal vehicle for delivering probiotic bacteria to the intestine and providing an ideal environment for their work, and improving the biochemical processes in the body (Kaur *et al.,* 2022, Tlay *et al.,* 2024). The health and functional properties of dairy products are improved by LAB, including elimination of heart and blood vessels disease, hypertension, diabetes, osteoporosis, cancer, and digestive ailments (Kaur *et al.*, 2020). LAB produce many functional components such as peptides, Exopolysaccharides, and fatty acids, in addition to giving the final product the desired sensory appearance (Shah *et al.,* 2023). LAB can produce effective compounds that enhance the vital roles of fermented products of dairy, and enzymes such as proteases, lactases, and lipases, which can analyze the components of milk (Abarquero *et al.*, 2022). Harpreet *et al*. (2022) stated that LAB produce biologically active compounds during milk fermentation by decomposing carbohydrates and producing organic acids, in addition to decomposing proteins and producing active peptides that inhibit pathogens. Letizia *et al*. (2022) ascribed the reason for selection of LAB as probiotics due to ability to produce of active compounds, such as gamma-aminobutyric acid (GABA), which offer safeguard the heart, stimulate nerves and enhance intestinal function. Kariyawasam *et al*. (2021) indicated that LAB and probiotics contribute to modulating immunity by inhibiting the activity of ACE that raise blood pressure, producing exopolysaccharides and bacteriocins, and having anti-inflammatory activity. Different methods produce fermented products of dairy. Yogurt is produced by adding starter cultures containing Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus thermophilus to milk, and kefir is produced by fermenting milk with kefir grains composed of Kluyveromyces marxianus, Saccharomyces unisporus, and Saccharomyces cerevisiae and has a sour, effervescent, alcoholic taste and a thick consistency (Da Anunciação *et al.,* 2024). Koumis Mare's milk spontaneously ferments into koumis, which has a smooth, rich taste due to its low protein and high fat content.  acid bacteria and the yeast Geotrichum candidum ferment Viili, giving it a thick consistency (Shah *et al.,* 2023). Enzymes formed as a result of the metabolic activity of LAB ferment cheese, a dairy product. Coagulation occurs after lowering the pH to the isoelectric point of casein due to the conversion of lactose into organic acids. Several types of LAB are present worldwide (Tamang et al, 2020). This review offers a comprehensive examination of the metabolic products formed by LAB, which provide wellbeing-related properties to final product and improve its sensory acceptance. It also shows the biological roles of LAB with positive effects in fermented products of dairy.

# 2. Characteristics of LAB:

Milk and its products are a major source of LAB that are found naturally or can be introduced into dairy products as starters that can exhibit probiotic properties used to treat or prevent some diseases such as intestinal infections and pathogens (Mgomi *et al.,* 2023). LAB are essential to the fermentation of milk, having been classified as "generally recognized as safe" (GRAS) due to their technological and health importance and resistance to acids and bile (Abdul Hakim *et al.,* 2023). Table 1 shows some types of LAB, their genera, shapes, and oxygen utilization. Lactic acid is one of the most important biologically active components resulting from the decomposition and fermentation of lactose sugar, as well as polysaccharides, fatty acids and active peptides, which give the product health-promoting properties such as immune system modulation and protection against diseases due to its inhibitory, vital, antioxidant and anti-cancer effects (Yu *et al.,* 2020). LAB such as Lactobacillus, Streptococcus and Bifidobacterium and fungal species such as Saccharomyces produce secondary metabolic bioproducts such as organic acids, enzymes, peptides, polysaccharides and short-chain fatty acids that help prevent respiratory infections and promote gut health

(Abdul Hakim *et al.,* 2023). Existing literature demonstrated most common types of LAB and probiotics are Lactobacillus acidophilus, Lactobacillus fermentum, Lactobacillus casei, Lactobacillus plantarum, and Enterococcus faecalis (Amini *et al.,* 2022). LAB fermentation alleviates lactose intolerance symptoms by producing the enzymes linoleic acid isomerase and lactase, which hydrolyze lactose into glucose and galactose, which converts linoleic acid into conjugated linoleic acid, which has antioxidant activity (Al Musa & Al Garory, 2023). LAB have recently gained widespread interest in scientific research, which has led to the introduction of new probiotic strains, including Lactobacillus johnsonii, which can interact with the normal intestinal flora to tolerate acids and bile and produce short chain fatty acids and exoglycerides (Ale *et al.,* 2020). Lactobacillus bacteria are involved in the production of fermented foods such as dairy products, alcoholic beverages, bread, pasta, meat, fish, and fermented vegetables (Shah *et al.,* 2023). LAB metabolize glucose, lactose and fructose into lactic acid and hydrolyze proteins into active peptides (Behera *et al.,* 2018). Additionally, LAB, categorized as "generally recognized as safe" (GRAS), are essential to the milk fermentation process due to their technological and health significance, as well as their resistance to acids and bile salt (Abdul Hakim *et al.,* 2023). Table 1 shows some types of LAB, their genera, shapes, and oxygen utilization. The decomposition and fermentation of lactose sugar produces lactic acid, one of the most important biologically active components, along with polysaccharides, fatty acids, and active peptides. These components give the product health promoting properties such as immune system modulation and protection against diseases due to their inhibitory, vital, antioxidant, and anti-cancer effects (Yu *et al.,* 2020). LAB such as Lactobacillus, Streptococcus, and Bifidobacterium and fungal species such as Saccharomyces produce secondary metabolic bioproducts, including short-chain fatty acids, peptides, enzymes, polysaccharides, and organic acids, are able to prevent respiratory infections and promote gastrointestinal health (Abdul Hakim *et al.,* 2023). Lactobacillus acidophilus, Lactobacillus fermentum, Lactobacillus casei, Lactobacillus plantarum, and Enterococcus faecalis are the most prevalent forms of LAB and probiotics, according to recent research (Amini *et al.,* 2022). Due to the formation of the enzyme lactase, which hydrolyzes lactose into glucose and galactose, the symptoms of lactose intolerance are alleviated by LAB fermentation, as well as the enzyme linoleic acid isomerase, which converts linoleic acid into conjugated linoleic acid, which has antioxidant activity (Al Musa & Al Garory, 2023). LAB have recently gained widespread interest in scientific research, which has led to the introduction of new probiotic strains which can interact with the normal intestinal flora (Ale *et al.*, 2020).

**Table 1. Some Types of LAB in Fermented Products of Dairy**

| Family | Genus | Shape | Respiration | References |
|---|---|---|---|---|
| *Lactobacillaceae* | *Lactobacillus Pediococcus* | Rod<br>Spherical | Facultative anaerobic | Mokoena,2017 |
| *Steptococcaceae* | *Streptococcus*<br>*Lactococcus* | Coccoid<br>Coccoid | Facultative anaerobic | Kabelitz *et al.*,2021 |
| *Leuconostocaecae* | *Leuconostoc* | Spherical,oval | Facultative anaerobic | Raimondi *et al.*,2022 |
| *Bifidobacteriaceae* | *Bifidobacterium* | Rod-branch | Anaerobic | Sabater *et al.*,2021 |
| *Enterococcaceae* | *Enterococcus* | Coccoid | Facultative anaerobic | Brackmann *et al.*,2021 |
| *Propionibacteriaceae* | *Propionibacterium* | Rod | Anaerobic | Piwowarek *et al.*,2020 |

## 3. Metabolic Products of LAB in Fermented Products of Dairy

Lactic acid bacteria can synthesize lactic acid as the major product from large food molecules as well as the propionic, butyric and acetic acid, that cause improving biological properties, they also reduce the pH (Abdul Hakim *et al.,* 2023). LAB produce secondary metabolic products with health-promoting biological activities that contribute to antioxidant, antibacterial, anti-allergic, immunomodulatory, intestinal health, and anti-ulcer activity, as well as enzyme production (Mathur *et al.,* 2020).

## 3.1. Enzymes

LAB carry out the intracellular metabolism of carbohydrates, proteins, and fats using the hydrolytic enzymes they produce as a result of these metabolic processes (Kabelitz *et al.*, 2021). Table 2 indicates some types of LAB, the enzymes they produce, as well as related roles in fermented dairy. The hydrolytic enzymes produced by LAB perform important functions in fermented products of dairy as they act as biocatalysts, participate in the processes of demolition and construction, and reduce the activation energy of biochemical reactions (Behera *et al.*, 2018).

**Table 2. Types of LAB, Enzymes they Produce, their Roles in Fermented Products of Dairy**

| LAB | Enzymes | Bioactivity | References |
|---|---|---|---|
| *Lactobacillus plantarum* | Dipeptides | Degradation of proteins and production Active Peptides | Behera *et al.*,2018 |
| | $\alpha$-Glucosidase | Hydrolysis of glycosides | |
| | β-Glucosidase | | |
| | Esterase | Production of phenolic alcohol, short chain esters ,and fatty acids | |
| | Lipase | Fat degradation into fatty acids | |
| *Lactococcus lactis* | Proteinases | Caseins break down into smaller particles | Kabelitz *et al.*,2021 |
| *Lactococcus thermophiles* | oligopeptidases | Intracellular degradation of peptides | Kabelitz *et al.*,2021 |
| | aminopeptidases | Removal of amino acids in both terminals C and N for peptides | |
| *Lactobacilluse acidophilus* | β-galactosidase | Lactose degradation to glucose and galctose | Juma *et al.*,2021 |
| *Lactobacilluse Casei* | | | |
| *Lactobacilluse delubrici* subsp.*bulgaricus* | | Treatment of the Lactose intolerance | |
| *Streptococcus thermophiles* | | | |
| *Lactobacillus delbrueckii* | proteases – peptidases | Production of angiotensin I-converting enzyme (ACE) inhibitory peptides | Rubak *et al.*,2020 |
| *Lactococcus lactis* ssp. *Lactis* | | | |
| *Lactobacillus kefiri* | | | |
| *Lactococcus lactis - Lacticaseibacillus rhamnonus* | proteases – peptidases | Formation of Gamma -aminobutyric acid (GABA) | Galli *et al.*,2022 |
| *Lactobacillus namurensis- Lactobacillus paracasei- Lactobacillus brevis* | glutamate decarboxylase | Formation of Gamma -aminobutyric acid (GABA) | Abdul Hakim *et al.*,2023 |
| *Bacillus licheniformis* | Lactase | Treatment of the Lactose intolerance | Amin *et al.*,2023 |

## 3.2. Peptides

Proteolysis by LAB plays an important role by producing active peptides that have antioxidant, antihypertensive, anti-cardiovascular, anti-diabetic, and immune-modulating effects (Chourasia *et al.*, 2023). Fermentation, in addition to food preservation, converts large protein molecules into smaller molecules with health-beneficial properties, and the health consequences are contingent upon the specific strains of LAB used in fermentation (Abedin *et al.*, 2022). Depending on the length of the chain in the active transport process, carriers use ATP energy to transport peptides that result from enzymes breaking down caseins across the cell membrane and into the cell (Kabelitz *et al.,* 2022). Bacteriocins, one of the most important antimicrobial peptides, are formed in dairy products fermented by LAB. They are characterized by their biological importance and their ability to inhibit pathogenic bacteria by hindering their cellular processes and interfering with cell proteins or nucleic acid (Abdul Hakim *et al.,* 2023).

Mokoena (2017) defined bacteriocins as cations composed of 30–60 hydrophilic amino acids that protect LAB from toxins through specific gene expression. The cytoplasmic membrane of the cell concentrates bacteriocins, which target active membrane vesicles to disrupt the proton motive force and exhibit antimicrobial effects. Peptides derived from food proteins, including dairy proteins, after fermentation exhibit ACE inhibitory properties, giving the final product health-improving properties such as antihypertensive effects, antimicrobial and antifungal activity, antioxidant production, anticoagulation, and immune regulation (Abedin *et al.,* 2022). Researchers have conducted extensive studies to investigate how far LAB are able to form peptides that not only reduce the formation of free radicals and active oxygen molecules, which increase the risk of cardiovascular diseases, but also inhibit the stimulation of the ACE. This enzyme produces angiotensin, which constricts blood vessels, releases the hormone aldosterone, and it causes hypertension (Li *et al.,* 2020).

### 3.3. Exopolysaccharides

Exopolysaccharides are defined as high-molecular-weight biopolymers released outside cells and suitable for eating resulting from the metabolism of microorganisms, including LAB, that contribute to providing health-promoting properties in functional foods (Gangoiti *et al.,* 2017). Monosaccharides are the basic unit to the exopolysaccharides which important to improve the sensory and biological properties of fermented products due to their ability to retain liquids, therefore they can be used as stabilizers and emulsifiers (Mahmoud *et al.,* 2023). Research has indicated that Exopolysaccharides presence with a high molecular mass in dairy products fermented gives them functional properties such as immune modulation, and antioxidant and cholesterol lowering activities (Behera *et al.,* 2018). Exopolysaccharides are classified into two types:

1.Homogeneous polysaccharides consisting of one type of monosaccharides

2.Heterogeneous polysaccharides consisting of different types of monosaccharides (Abdul Hakim *et al.,* 2023).

Han *et al.* (2016) indicated that various factors affect the formation of exopolysaccharides, including pH, temperature, and strains, which improves the sensory properties of fermented Products of Dairy. Exopolysaccharides can be considered as food additives that improved the texture and melting properties, they are also good alternatives to fats, due to their ability to retain moisture (Abdul Hakim *et al.,* 2023).

### 3.4. Organic Acids

Organic acids are the basic metabolic products of LAB, which enters into metabolic pathways to produce lactic acid, along with many organic acids (Abdul Hakim *et al.,* 2023).

Garavand *et al.* (2023) stated that LAB use lactose to produce organic acids, it gives an acidic flavor in fermented products of dairy is a result of the presence of organic acids. Organic acids play vital roles including antimicrobial activity, this is due to its effect on the membranes and walls of bacteria by lowering the pH to levels that prevent their growth (Bangar *et al.,* 2022). They also penetrate the lipid membrane of bacteria and affect the cell cytoplasm, which increases the consumption of Adenosine Tri Phosphate (ATP) and thus depletes energy (Bangar *et al.,* 2022). Al Musa & Al Garory (2022) indicated that the organic acids can inhibit bacteria by reducing the pH, which causes the cessation or prevention of molecular interactions, also can penetrating the lipid of cell membrane and consuming ATP energy in bacterial cells. The organic acids in fermented products of dairy have great importance antioxidant activity and inhibiting pathogens, which led to their introduction into many food applications such as, flavoring, food preservation, and preventing spoilage (Bangar *et al.,*2022). Organic acids provide an environment that prevents the growth of pathogens, which leads to inhibition of the bacterial cell cycle, stopping the synthesis of the target cell wall, forming pores in the cytoplasmic membrane, damaging DNA, and thus inhibiting the bacterial cell (Hossain *et al.,* 2020).

## 3.5. Vitamins

Recent research has shown that vitamin deficiency in the body is a very serious matter, and since most vitamins cannot be manufactured within the body in sufficient quantities and heat or manufacturing processes cause their damage, alternative methods must be followed to obtain these vitamins (Shah *et al.,* 2023). Some types of LAB can produce many vitamins, including vitamin B2 and B12, which are resistant to bile acids (Behera *et al.,* 2018). Water-soluble riboflavin B2 is created by Streptococcus thermophiles, and it also works to synthesize flavin adenine dinucleotide and flavin mononucleotide, which are necessary for enzymes that assist oxidation and reduce reactions (Abdul Hakim *et al.,* 2023). Fermentation increases the percentage of vitamins, including folic acid vitamin B9, which is produced by some species of Bifidobacteria spp. (Shah *et al.,* 2023). Lactobacillus plantarum bacteria show the highest production of water-soluble folic acid, which is essential for the biosynthesis of nucleotides and proteins (Abdul Hakim *et al.,* 2023). (Fu et al. (2017), Albardawel and Abou younes., 2019). Indicated that different genera of LAB, including Lactobacillus, Carnobacterium, Enterococcus, Lactococcus, Pediococcus, and Streptococcus, specialize in the production of vitamin K2 in full cream fermented milk, as it is a fat-soluble vitamin.

## 3.6. Gamma-Aminobutyric Acid (GABA)

It is a biologically active compound and is known as a neurotransmitter produced by LAB and stimulated by the enzyme glutamate decarboxylase and pyridoxal-5-phosphate as a cofactor that produces many health benefits for the body, including lowering cholesterol, reducing anxiety, regulating hypertension, and having anti-cancer effects (Abdul Hakim *et al.,* 2023). GABA enhances brain metabolism, regulates hormone secretion, synthesizes proteins, burns fats, and improves oxygen delivery and blood flow, which reduces hypertension (Alizadeh Behbahani *et al.,* 2020). Recently, some strains of LAB, have been discovered to have the ability to produce GABA, including Streptococcus thermophilus, Lactococcus lactis, and Leuconostoc, (Abdul Hakim *et al.,* 2023). The availability of glutamic acid or its salts, temperature, pH, nitrogen, and carbon sources for LAB are the main factors in the production of GABA (Alizadeh Behbahani *et al.,* 2020). Some strains of LAB, can convert sodium mono glutamate and glutamic acid to GABA (Yunes *et al.,* 2016).

## 3.7. Flavor Compounds

Fermented products of dairy product synthesized the flavor compounds (organic acids, and diacetyl) produced by LAB through biosynthesis, thermal decomposition oxidative, enzymatic reaction (Abdul Hakim *et al.,* 2023). Flavor compounds are formed in fermented products of dairy through the metabolism of amino acids, fatty acids, and carbohydrates by LAB (Wang *et al.,* 2021). Different metabolic pathways are involved in the production of flavor compounds, including the citric acid pathway, which plays a role in the production of citric acid and succinic acid as intermediate compounds (Abdul Hakim *et al.,* 2023). The process of converting sugar into alcohol contributes to imparting a sweet taste to the final product (Abdul Hakim *et al.,* 2023).

### 4. Biological Roles of LAB in Fermented Products of Dairy

LAB are characteristized by their ability to produce secondary metabolic products and bioactive compounds (Mathur *et al.,* 2020). LAB are used to obtain more benefit products with biological important, in addition to extending the shelf life of these products (Behera *et al.,* 2018). Fermentation with LAB is used to preserve the nutrients of milk from spoilage and improving its quality (Shah *et al.,* 2023). Some of the biological roles of LAB can be included as follows:

## 4.1. Antioxidant Activity:

Antioxidant activity protects the body from oxidative stress that causes many diseases such as type II diabetes, obesity, cardiovascular diseases and cancer (Fardet & Rock, 2018). Antioxidants can protect the human body from harmful molecules known as free radicals that are responsible for the development of metabolic diseases, heart diseases and cancer, as antioxidants protect against oxidative stress, regulate the immune system and reduce the risk of chronic diseases and aging (Sarıtaş *et al.,* 2024). Natural antioxidants protect the body from free radicals that cause oxidation of body functions and include non-enzymatic antioxidants such as vitamin C, tocopherol, carotenoids and phenolic compounds that have a biological effect on gut bacteria as well as enzyme systems such as glutathione peroxidase, superoxide dismutase and catalase (Shah *et al.*, 2023). Fermented products of dairy have antioxidant activity due to the bioavailability of active peptides resulting from the proteolysis of caseins, alpha-lactoalbumin and beta-lactoglobulin and the production of the antioxidant conjugated linoleic acid resulting from the decomposition of fats (Melini *et al.*, 2019). The antioxidant activity of dairy products depends on several factors, including the source of milk, its fat content, fermenting bacterial strains, and the availability of some amino acids, including methionine, tryptophan and tyrosine, and their sequence in the peptide chain (Shah *et al.,* 2023). The formation of biologically active peptides is an outcome of fermentation, which inhibits the conversion of an ACE. This enzyme is responsible for the conversion of angiotensin I to angiotensin II, which functions to constrict blood vessels and hypertension (Mathur *et al.,* 2020). LAB produce active peptides that inhibit the converting enzyme and phenolic substances and work to synthesize the antioxidant GABA, which leads to the removal of free radicals and the reduction of active oxygen species to protect against oxidative damage (Shah *et al.*, 2023). LAB engage in various vital roles, as they help reduce the level of total cholesterol, low-density lipoprotein (LDL) and triglycerides, improve the level of high-density lipoprotein (HDL), hypoglycemya, and reduce the risk of cardiovascular diseases and hypertension (Al Musa & Al Garory, 2023). Linoleic acid combined with vitamins A, E and carotene enhances the antioxidant activity of fermented milk as well as folic acid, one that is developed by anaerobic LAB (Shah *et al.*, 2023).

## 4.2. Antimicrobial Activity:

Food spoilage by microorganisms leads to economic losses and major health problems, which necessitates the need to find natural, effective, and alternative methods of biopreservation to methods that cause harmful synthetic chemical effects, namely the use of LAB and some of their strains used as probiotics (Kalhoro *et al.,* 2023). LAB form multiple metabolites and antimicrobial components that increase the safety and quality of food, including organic acids, including propionic, acetic, and lactic acids, and succinic acids, which lower the pH and affect bacterial cell membranes, thus inhibiting them (Behera *et al.*, 2018). LAB can resist low pH and high bile concentrations and their ability to survive in digestive fluids (Kalhoro *et al.*, 2023). LAB reduce the transmission of pathogens and inhibit their adhesion to cell walls, in addition to producing active antimicrobial compounds and acting as natural biological preservatives (Kalhoro *et al.*, 2023). LAB can adhere to intestinal cells and treat gastrointestinal diseases by producing metabolic substances that play a role in inhibiting bacteria, such as organic acids and bacteriocins that exhibit broad antibacterial activities and thus inhibit their growth (Palkovicsné Pézsa *et al.*, 2023). The reason for the increased production of organic acids is the ability to decompose protein and produce moderate amounts of organic acids during fermentation that act as preservatives due to the low Pka value, which obstruct the formation of yeasts, molds, and bacteria (Al Musa & Al Garory, 2022).

## 4.3. Probiotics

The consumption of probiotics has attracted wide attention from the Food and Agriculture Organization (FAW) and the World Health Organization (WHO) for providing the body with health benefits when consumed (Behera *et al.,* 2018). Probiotics are microorganisms which pass into body through food or drink that enhance health effects by enhancing the intestinal microbial balance and also alleviate symptoms of lactose intolerance (Ahn *et al.*, 2023). Fermentation contributes to reducing the percentage of lactose in milk after converting it into organic acids that lead to alleviating symptoms of lactose intolerance that occurs in some people who have low levels of the lactase enzyme in the intestines, which is represented by bloating and digestive problems (Shah *et al.,* 2023). Streptococcus thermophilus and Lactobacillus delbrueckii spp. bacteria have Bulgaricus have been shown to have a significant activity against lactose intolerance due to their high levels of carbohydrate-degrading β-galactosidase compared to (Ahn *et al.*, 2023). Probiotics work either through a prebiotic effect or through the interaction between the microorganisms in fermented products of dairy and the host as they promote formation and continuation of LAB. Fermented products of dairy act like carriers for probiotic bacteria due to the difficulty of their entry into the gastrointestinal tract and their metabolism (Shah *et al.,* 2023).Shah et al. (2023) posited that probiotics are medically beneficial, as they improve the immune response by activating macrophages, enhancing cytokine and immunoglobulin levels, and reducing weight. Probiotics formed in fermented products of dairy reduce symptoms of urinary tract infections, are resistant to bile and acids, inhibit the adhesion of pathogens, and reduce the absorption of heavy metals in the intestine, which reduces their accumulation in tissues and reduces oxidative stress (Behera *et al.,* 2018). Some genera of LAB classified into probiotics, such as Bifidobacterium and Lactobacillus, are characterized by their ability to adhere to epithelial cells and mucosal membranes of the intestine, which enhances the environment of the intestine and the digestive system and gives them an antimicrobial effect against pathogenic microorganisms (Kim *et al.,* 2022). M'hamed et al. (2022) indicated that probiotics can treat many diseases including inflammatory bowel disease, constipation, diarrhea, irritable bowel syndrome, allergies, high blood pressure, diabetes, the ability to absorb cholesterol, decompose bile salts, prolong storage life, and antimicrobial properties. Probiotic strains have important technological properties, including their tolerance to heat treatments, as well as their ability to produce exopolysaccharides that are used as indigestible fibers, which gives them positive health effects (Khushboo *et al.,* 2023).

## 5. Conclusion:

According to FAO and WHO, the characteristics of LAB must be perceived in order to guarantee optimal health and functional outcomes. The metabolic products and biological functions that LAB produce and perform in fermented products of dairy are summarized in this study. Fermented products of dairy are supported by LAB, which, when present in the appropriate quantities, have numerous health benefits. The biosynthesis of organic acids, enzymes, peptides, exopolysaccharides, short chain fatty acids, and active compounds such as GABA are the main mechanisms that give the product many health benefits, such as antimicrobial, antioxidant, antidiabetic, antihypertensive, cardiovascular, digestive, and probiotic effects, as well as the high level of vitamins in them resulting from fermentation. To enhance health, mitigate consumer risks, and prolong the expiration life of products as healthful alternatives, LAB help reduce the use of industrial chemicals and antibiotics.

### Acknowledgement

The author's gratitude to the Department of Food Science, College of Agriculture, University of Basrah for supporting this research work.

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