OXFORD JOURNAL
OF STUDENT
SCHOLARSHIP

# Evaluating the Role of Goat Milk Bioactives in Immune Modulation of Seasonal Allergic Rhinitis

Aelita Adilkhan
aelitaadilkhan62@gmail.com

## ABSTRACT

Seasonal allergies, also known as allergic rhinitis immune overreaction to environmental allergens such as pollen. The overreactions include processes that result in inflammation and symptoms such as sneezing, nasal congestion, rhinorrhea, and irritation of the respiratory tract (Akhouri & House, 2023; Husna et al., 2022). Since seasonal allergies are characterized by dysregulation of immune responses and inflammation, recent studies have been more focused on the effects of nutritional bioactive compounds on the immune system. This literature review explored the possible effect of bioactive compounds in goat milk on the immune responses to seasonal allergies. The main compounds found in goat milk include caseins, whey proteins, bioactive peptides, fatty acids, and oligosaccharides. Current evidence suggests that peptides released during digestion from goat milk may have an impact on the regulation of cytokines, lower inflammation, and contribute to broader Immunomodulatory effects (Hassan et al., 2026). Goat milk is additionally introduced as a functional food because of its digestibility and biologically active composition (AlKaisy et al., 2023). Yet, at this time there is not much direct clinical research or evidence to prove that goat milk improves immune responses associated with seasonal allergies. While this review indicates that bioactive compounds of goat milk could be biologically applicable to immune pathways involved in seasonal allergies, their medicinal role is still unclear and should be researched further *in vivo*.

## INTRODUCTION

Allergic rhinitis is a common inflammatory condition of the upper respiratory tract, often triggered by environmental allergens like pollen. Its symptoms, which include sneezing, nasal obstruction, rhinorrhea and itching, could cause problems with sleep, concentration, and overall quality of life (Akhouri & House, 2023;Schuler Iv & Montejo, 2023). Allergic rhinitis are often approached as a respiratory problem, but they also involve wider immune regulation, as the body overreacts to innocent substances.The human diet has meanwhile become a topic of great interest in relation to immune function and regulation. Food consists of bioactive compounds, which can influence physiological processes beyond fundamental nutrition. For instance, probiotic and prebiotic interventions have been studied in allergic rhinitis, as they may change the gut microbiome composition and influence immune regulation. There is some clinical evidence that supplemental intake with probiotics may boost the symptoms and quality of life of allergic

rhinitis, but the effects depend on the strains used and the study design (Lungaro et al., 2024). In this case, goat milk is important because it is usually characterized as a food that is functional with a sophisticated nutritional and biochemical composition (AlKaisy et al., 2023). Its composition makes it a useful subject to investigate potential connections between nutrition and immune system conditions. Nevertheless, the relationship between goat milk and seasonal allergies has not been thoroughly investigated. Most of the research done so far has been on general nutritional benefits, milk allergy or digestive properties, and not on seasonal allergic responses. Thus, the present paper explores the potential association between the bioactive substances in goat milk and the immune responses associated with seasonal allergies.

**Literature Review Methodology**

The scientific databases PubMed, Google Scholar, ScienceDirect, and SpringerLink were used in this narrative literature review. Studies published mostly between 2004 and 2026 were the main focus of the literature search. Goat milk, bioactive compounds, bioactive peptides, oligosaccharides, fatty acids, immune modulation, allergic rhinitis, seasonal allergies, gut microbiome, and inflammation were among the search terms used. Peer-reviewed review articles, experimental studies, animal studies, and available human clinical studies examining goat milk bioactives and immune function were given priority. Articles that had nothing to do with immune regulation or allergic diseases, or that only discussed unrelated dairy products, were not included. Due to the paucity of direct clinical research on goat milk and seasonal allergic rhinitis, more research on related immune modulation, inflammatory, and other mechanisms

## SEASONAL ALLERGIC RHINITIS AND IMMUNE RESPONSE

As shown in Figure 1, exposure to environmental allergens such as pollen activates IgE-mediated immune pathways, leading to histamine release, inflammation, and allergy-related syndrome. Symptoms typically involve sneezing, nasal congestion, rhinorrhea, and itching. These symptoms can negatively affect people's lifestyle (Akhouri & House, 2023). Rhinitis has become a common subject in recent years and is estimated to affect about 400 million people all around the world. (Husna et al., 2022). The physiology of seasonal allergic rhinitis involves an early and a late-phase immunologic responses. Allergen triggering of allergen-specific IgE antibodies bound to mast cells occurs in the early phase. It affects the exit of inflammatory compounds like histamine that cause immediate symptoms like sneezing and a runny nose. Later in the process, other immune cells are stimulated and cytokines such as interleukin-4 (IL-4) and interleukin-13 (IL-13) are produced, triggering prolonged inflammation and tissue sensitivity (Akhouri & House, 2023).

Such mechanisms demonstrate that seasonal allergies are a very complex type of immune system disorder rather than just a medical illness. This understanding of immune system pathways is crucial for evaluating signs that may affect allergy responses. The contribution of cytokine signaling with inflammatory mediators is important because it indicates that outside influences, such as nutrition, could affect immune function. Because cytokines signalling and inflammatory mediators have a crucial role in allergies,

researchers have increasingly investigated whether dietary factors might affect these immune pathways. For instance, probiotic and prebiotic interventions have been linked with changes in gut microbiome and reduced inflammatory overreactions in some allergy-related
reviews (Lungaro et al., 2024).

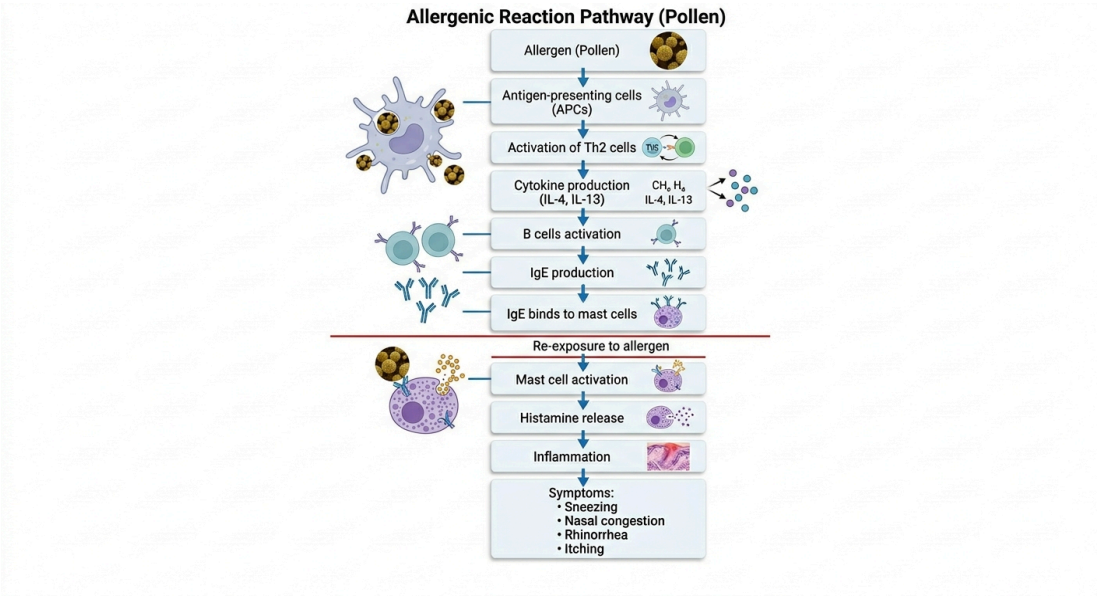


**Figure 1.** Simplified immune mechanism of seasonal allergic rhinitis.

## DIET AND IMMUNE REGULATION

Recent research indicates that diet may affect immune-related processes via a number of hidden biological pathways. Some nutrients and compounds produced from foods have been associated to inflammatory signalling, oxidative stress regulation and gut microbiome composition, which are associated with immune system activity (Jutel et al., 2018). There are evidences already for immune effects related to diet outside the context of goat milk. For example, omega-3 fatty acids have been associated with anti-inflammatory effects and dietary fibre intake with changes in gut microbial composition and short-chain fatty acid production that may affect immune regulation (Tan et al., 2021; Wastyk et al., 2021).

Nevertheless, many of these relationships are sophisticated and non-homodirectional , particularly in the interplay of gut microbiome and immune function. For allergy related research the gut–immune axis is of special relevance. The gut microbiome interacts with immune cells and contributes to immune homeostasis via microbial metabolites, epithelial signalling and cytokine modulation. And then microbial composition can be affected by immune activity. Consequently, the present data cannot be used to support

a simple unidirectional association between microbiome composition and immune responses (Belkaid & Hand, 2014).

## GOAT MILK AS FUNCTIONAL FOOD AND SOURCE OF BIOACTIVE COMPOUNDS

Scientific interest in goat milk has grown in recent years, largely due to the presence of several biologically active compounds which may affect physiological processes in addition to basic nutrition. Functional foods are generally defined as foods that have an advantageous impact on target functions in the body beyond basic nutrition, and provide additional health-related benefits. Researchers have been interested about whether some specific compounds that are naturally found in goat milk can influence immune-related pathways, inflammation regulation, digestion, and the composition of the gut microbiome (AlKaissy et al., 2023; Hassan et al., 2026).This interest is especially relevant in the context of allergic diseases.Goat milk has been investigated as asubject of study, given that it contains proteins, peptides, oligosaccharides and fatty acids that can interact subsequently with these mechanisms, as nutrition has been shown to be linked with immune and inflammatory pathways in multiple investigations (Jutel et al., 2018). Goat milk, however, should not be treated as a single, uniform entity with a single biological effect. Different compounds in goat milk may be involved in various physiological processes . The strength of current evidence varies widely according to the compound under study . Furthermore, the existing literature originates mainly from experimental or animal models, instead of large clinical trials in humans. Furthermore, current findings should be taken with caution. As shown in Figure 2, goat milk involves several major groups of bioactive compounds, including proteins, peptides, oligosaccharides, and fatty acids. Those compounds have been associated with physiological pathways linked to digestion, microbial regulation, inflammatory signalling, and immune responses.

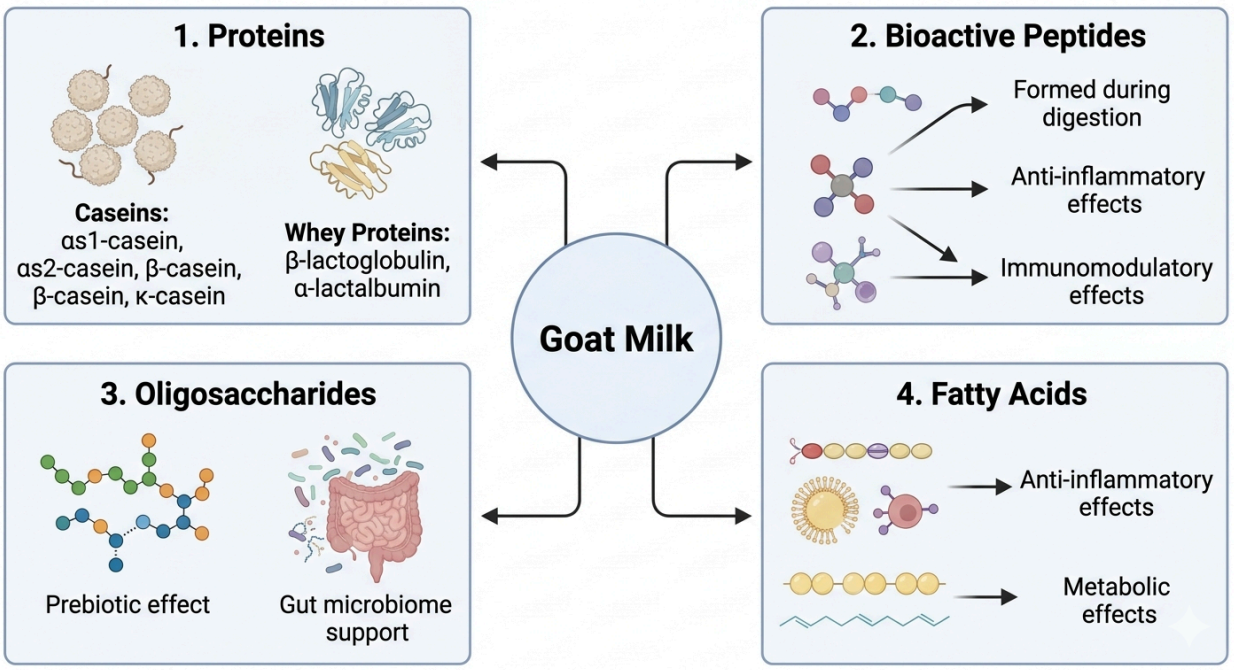


**Figure 2.** Main bioactive compounds in goat milk and their potential biological roles.

## PROTEINS

The protein part of goat milk is among the most well-known or well-studied groups of bioactive compounds. Goat milk proteins are primarily divided into caseins and whey proteins. Caseins include αs1-casein, αs2-casein, β-casein, and κ-casein, while whey proteins mainly consist of β-lactoglobulin and α-lactalbumin. Those protein fractions differentiate in structure, digestibility, and biological activity.Goat milk has been studied in nutrition research in part because it has a lower concentration of αs1-casein than many forms of cow milk has. Variability in αs1-casein content has been linked to differences in protein digestibility and curd formation over digestion (Ballabio et al., 2011).

Some researchers have attributed gastrointestinal tolerance in some individuals to these structural distinctions. Nevertheless, the evidence for reduced allergenicity is not conclusive as allergic reactions to milk proteins depend on multiple immune mechanisms and individual sensitivities (Petherick, 2018)Importantly, goat milk proteins are not only relevant via a nutritional point of view, yet they can also be precursors in the form of smaller biologically active molecules that are released during digestion. Consequently,researchers have studied the functional properties of goat milk proteins not only as sources of amino acids and energy.

## PEPTIDES

Bioactive peptides are small protein fragments released from milk proteins upon digestion or enzymatic hydrolysis. These peptides have been the main focus of considerable attention in the field of functional foods as some studies have suggested they might be active in inflammatory and immune-related pathways.Antioxidant, antimicrobial, anti-inflammatory and immunomodulatory properties connected to goat milk-derived peptides have been identified in experimental studies (Hassan et al., 2026). Some peptides have been linked to cytokine regulation, including pathways involving interleukin-10 (IL-10) and tumour necrosis factor alpha (TNF-α), both of which are involved in inflammatory responses. Peptides are relatively tiny and may interact with cellular signalling mechanisms when digested, maybe even affecting on physiology beyond the scope of nutrition. But so far the evidences are limited. Many of the findings concerning goat milk peptides originate from laboratory or animal studies rather than clinical trials in patients with allergic rhinitis. In addition, immune regulation is very complex and influenced concurrently by genetic, environmental, microbial and dietary factors. Current research does not support direct claims that goat milk peptides can prevent or treat seasonal allergies. Rather, the current literature suggests that goat milk peptides might be one possible mechanism by which milk-derived compounds can indirectly affect immune-related pathways. This difference is important; it does not exaggerate conclusions that are not supported by clinical evidence.

## OLIGOSACCARIDES

Goat milk also contains oligosaccharides, complex carbohydrates that have been of interest due to their potential association with the gut microbiome and mucosal immunity. The structural relationship of goat milk oligosaccharides to some human milk oligosaccharides is higher than that of oligosaccharides commonly identified in cow milk, which has increased the interest of scientists in their biological functions (Leong et al.,2019). So , unlike proteins and peptides , oligosaccharides are not mostly digested for nutrition .

Rather, they can serve as substrates in order for microbial fermentation in the gastrointestinal tract. Some oligosaccharides have been shown to affect the microbial composition of the gut microbiome, which includes bacterial populations that are associated with intestinal homeostasis and mucosal barrier maintenance (van Leeuwen et al., 2020). The gut-immune axis is highly pertinent to this discussion. The gut microbiome communicates with epithelial and immune cells via signalling molecules, microbial metabolites and cytokine associated pathways that might be involved in immune regulation . At the same time, immune activity can influence the microbial composition itself, so the relationship between the microbiome and immunity is not one-sided but instead bidirectional (Belkaid & Hand, 2014). Experimental studies suggest that oligosaccharides of goat milk may contribute to the maintenance of intestinal barrier strength and microbial balance, which could indirectly affect inflammatory regulation. For example, some studies have reported a reduction in inflammatory markers and improved mucosal conditions in food-allergy experiments after exposure to goat milk oligosaccharides (Li et al., 2020). Nevertheless, these studies are mostly in the context of gastrointestinal or food allergy, and not seasonal

respiratory allergy. Furthermore, goat milk oligosaccharides should not be described as straight treatments for seasonal allergic rhinitis. Instead, they are more accurately understood as compounds that might indirectly modulate immune- related pathways via interactions including the gut microbiome and mucosal immune signalling.

## FATTY ACIDS

Fatty acids are another important category of bioactive compounds in goat milk. Goat milk contains saturated, monounsaturated and polyunsaturated fatty acids, some of which are involved in metabolic and inflammatory processes. Medium chain fatty acids are particularly characteristic of the composition of goat milk. These fatty acids are metabolized different ways than long-chain fatty acids and might contribute to digestibility and energy metabolism . Furthermore, in the wider field of nutrition research, some unsaturated fatty acids have been associated with anti-inflammatory pathways (Tan et al., 2021). Some studies suggest that lipid-derived substances may influence regulation of oxidative stress and production of inflammatory mediators. Given that allergic conditions are a form of chronic inflammation, researchers have looked into whether fatty acids in goat milk may be involved in more general immune-related processes.Since allergic conditions involve chronic inflammation, researchers have investigated whether fatty acids in goat's milk might play a role in broader immune-related processes. But there is still limited and indirect evidence linking goat milk fatty acids with seasonal allergic rhinitis right away.

As with the other bioactive compounds discussed, the biological effects of fatty acids are affected by a number of factors, including dose, dietary context, their metabolism, and their interactions with other physiological systems. Therefore, simple conclusions cannot be drawn on goat milk and allergy prevention from the existing literature.

In conclusion, goat milk contains several groups of biologically active compounds that may be involved in physiological processes related to digestion, microbial regulation, inflammatory signalling and immune function. Proteins, peptides, oligosaccharides and fatty acids are all different classes of compounds and can have different biological functions. Experimental data are promising, especially with regard to immunomodulatory and microbiome-related pathways, but current evidence remains still early in many aspects. Further clinical studies are needed to assess whether these mechanisms have a significant impact on seasonal allergic rhinitis in individuals.

| **Bioactive compound** | **Proposed immune mechanism** | **Level of evidence** | **Relevance to seasonal allergic rhinitis** |
|---|---|---|---|
| Proteins | Digestion, precursor of peptides | Animal / Human | Indirect |

| | | | |
|---|---|---|---|
| Bioactive Peptides | Cytokine regulation, anti-inflammatory activity | Mainly animal & in vitro | Moderate mechanistic evidence |
| Oligosaccharides | Gut microbiome modulation | Animal / in vitro | Indirect |
| Fatty acids | Anti-inflammatory pathways | Mainly Indirect | Limited evidence |

## DISCUSSION

According to the literature reviewed in this paper, goat milk has a biologically plausible relationship with immune responses associated with seasonal allergies; however, additional research is needed to understand this relationship better. Currently, the scientific literature does not provide compelling evidence for a direct therapeutic effect of goat milk, but instead suggests several possible pathways by which bioactive compounds in goat milk might modulate immune-related pathways.

A significant trend seen across all of the articles reviewed was that various classes or types of immune-related compounds impacted immune function using different methods of action. Specifically, studies examining immune-related peptides typically demonstrated that the peptides had a direct effect on cytokine regulation and inflammatory signaling compared to studies examining non-peptides (e.g., oligosaccharides), which mostly demonstrated that the effects of the oligosaccharides on immune function were mediated through microbiome modulation. This finding is significant in that it indicates that goat milk is not simply one biologically uniform compound but rather a complex mixture of compounds with potentially diverse physiological impacts.

Another important finding from the reviewed studies was that the vast majority of the evidence available does not evaluate seasonal allergic rhinitis. Instead, most studies looked either at food allergies, immunity in the gastrointestinal tract or inflammatory-related immune function. Goat milk consumption has reduced the amount of allergen-induced airway inflammation in experimental animal studies (Kao et al. 2020) and several studies report that the differences in allergenicity between goat and cow milk are due to the difference in the αs1-casein composition (Lara-Villoslada et al., 2004; Hodgkinson et al., 2012). However, it is not valid to generalise these findings into the general population due to the very complex environmental and immunological interactions involved in causing seasonal allergic rhinitis.

Additionally, there are many limitations in the reviewed literature. A lot of studies are either animal based, in vitro, or biochemical work rather than controlled clinical trials with human subjects. As a result, it is difficult to establish if these biological mechanisms will produce a clinically meaningful effect in humans. In addition, there are so many differences between goat breeds, the methods of milk production

(for example: feeding methods, stage of lactation, & processing method) it is complicated to compare the studies with one another and limits the reproducibility of the findings to current studies.
Therefore, there is currently insufficient evidence to support that goat milk contains biologically active compounds that may be of immune modulating significant to the host. However, since the current body of literature is still in the early phases, stronger clinical evidence is needed to conclude on the role of goat milk on seasonal allergic rhinitis.

Because more experimental research has shown that bioactive peptides have immunomodulatory qualities, the evidence for them seems to be stronger overall than that for proteins, oligosaccharides, or fatty acids. However, the majority of the evidence for all compound classes is still mechanistic, and there aren't many human clinical studies that specifically address seasonal allergic rhinitis.

## CONCLUSION

This literature review targeted to explore the potential relationship of bioactive compounds from goat milk with immune mechanisms involved in seasonal allergies. Several biologically active components, including casein- and whey-derived peptides, oligosaccharides and fatty acids, have been found to be able to connect with immune-related pathways. These compounds are relevant because seasonal allergic rhinitis is not only respiratory illnesses, but also an illness of immune dysregulation, inflammation and cytokine signalling.

Among the compounds discussed, bioactive peptides probably have the strongest mechanistic link to immune regulation. Their possible role in cytokine modulation and inflammatory signalling suggests that they are possibly biologically relevant to allergy-related immune pathways. Other components, not proteins, such as oligosaccharides and fatty acids, may additionally have an indirect effect, specifically through gut microbiome interactions and broader inflammatory processes.

Still, the existing evidence does not support the conclusion that goat milk is specifically beneficial for seasonal allergy symptoms in humans. Much of the available research is based on animal models, food allergy, or general immune modulation rather than clinical studies on seasonal allergic rhinitis. Hence, goat milk should not be promoted as a treatment or cure for seasonal allergies. Conversely, the bioactive compounds contained in it should be investigated as potential agents of immune-related mechanisms needing additional research.

Future research looks into human clinical investigations that more directly examine the effects of goat milk consumption on immune markers and seasonal allergy responses. Such studies will be useful to figure out whether the mechanisms identified in experimental research have practical relevance for individuals with seasonal allergic rhinitis.

## LIMITATIONS AND VARIABILITY OF GOAT MILK COMPOSITION

There are a number of limitations to regard when looking at the potential association between dairy goat milk bioactive compounds with immune response related to seasonal allergies. The first area of limitation stems from the number of studies that are available in the literature presently. There is currently very limited evidence from human clinical trials, which means that most of the available evidence is based on animal models, in vitro, or outcomes from biochemical assessments of dairy goat milk bioactive compounds. While these many studies identify biologically plausible mechanisms for biological activities, it is unclear whether these mechanisms translate into clinically significant outcomes for humans with seasonal allergic rhinitis or other forms of seasonal allergies.

The second area of limitation would be that the majority of available literature has focused on studies with food allergies, gastrointestinal immunity or general inflammation as opposed to studies focused specifically on seasonal allergic rhinitis and or other forms of seasonal allergies. Therefore, while biologically plausible mechanisms are identified in the literature when dealing with studies regarding food allergies and/or studies involving experimental inflammation, these biological mechanisms may not translate directly to the complex biologically active pathways involved in environmental allergies such as seasonal allergic rhinitis from pollen exposure. In addition to the limitations regarding the type of studies published, the composition of goat milk itself poses challenges for the interpretation of results from these studies, as goat milk is not considered a uniform biological material and the composition of goat milk can vary greatly based on many different factors including breed of goat; genetics; feeding environment; environmental exposures; phase of lactation; as well as processing methods (Ballabio et al. 2011). All of these factors may have a significant impact on the concentration and/or activity of proteins, peptides, oligosaccharides, and fatty acids contained in goat milk.

Milk compounds' biological activity may be altered by how the milk is processed, such as through pasteurization, fermentation of the milk, or how it is stored. Because goat milk can have many variations and different levels of bioactive agents, it is very difficult to compare results from study to study. Many of the published studies have not used the same dosages or products, which makes it difficult to reproduce and generalize their findings.

Allergic reactions can also be influenced by many different environmental and physical factors including the amount of exposure to allergens, the makeup of the microbiome, genetics, stress, and one's lifestyle. Given the complexity of allergens, isolating the exact contribution of consuming goat milk to an individual's allergic response is very difficult. Therefore, while much of the literature does provide some evidence of goat milk bioactive compounds may function in a mechanistic manner, the evidence is still in the early stages and should be viewed cautiously.

## REFERENCES

*Andreou et al. (2025) — Boosting Immunity Through Nutrition and Gut Health*
https://pmc.ncbi.nlm.nih.gov/articles/PMC12114198/

*Akhouri, S., & House, S. A. (2023). Allergic rhinitis. In StatPearls. StatPearls Publishing.*
https://www.ncbi.nlm.nih.gov/books/NBK538186/

*Akesaka, S., & Shigeoka, H. (2023). The effect of pollen exposure on allergic diseases: Evidence from population-based data. medRxiv.*
https://www.medrxiv.org/content/10.1101/2023.09.08.23294325v1.full

*AlKaisy, H., et al. (2023). Nutritional and functional properties of goat milk. Functional Nutrition.*
https://cae.usp-pl.com/index.php/fnc/article/view/285

*Ballabio, C., et al. (2011). Goat milk allergenicity as a function of αs1-casein genetic polymorphism. Journal of Dairy Science.*
https://pubmed.ncbi.nlm.nih.gov/21257068/

*Benjamin-van Aalst, M., et al. (2024). Goat milk allergy and a potential role for goat milk in cow's milk allergy prevention and treatment. Nutrients.*
https://pmc.ncbi.nlm.nih.gov/articles/PMC11314217/

*Food-Info.net. (n.d.). Milk proteins. Wageningen University.*
https://www.food-info.net/uk/protein/milk.htm

*Hassan, M., et al. (2026). Bioactive peptides derived from goat milk and their biological activities. Springer.*
https://link.springer.com/article/10.1007/s44463-026-00061-0

*Hodgkinson, A. J., et al. (2012). Allergic responses induced by goat milk αS1-casein in a mouse model. Journal of Dairy Science.*
https://pubmed.ncbi.nlm.nih.gov/22192186/

*Hu et al. (2024). Association Between Gut and Nasal Microbiota and Allergic Rhinitis: A Systematic Review* https://pubmed.ncbi.nlm.nih.gov/39006241/

*Husna, S. M. N., et al. (2022). Allergic rhinitis: Epidemiology and pathophysiology.*
https://pmc.ncbi.nlm.nih.gov/articles/PMC9021509/

*Jutel, M., Akdis, M., & Akdis, C. A. (2018). Immunological mechanisms of allergen-specific immunotherapy. Frontiers in Immunology.*
*https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2018.00143/full*

*Kaczynska et al. (2022). The crosstalk between the gut microbiota composition and the clinical course of allergic rhinitis: The use of probiotics, prebiotics and bacterial lysates in the treatment of allergic rhinitis*
*https://www.mdpi.com/2072-6643/14/20/4328*

*Kao, H. F., et al. (2020). Goat milk consumption enhances innate and adaptive immunities and alleviates allergen-induced airway inflammation in offspring mice. Nutrients.*
*https://pmc.ncbi.nlm.nih.gov/articles/PMC7040033/*

*Lara-Villoslada, F., et al. (2004). Goat milk is less immunogenic than cow milk in a murine model. Journal of Pediatric Gastroenterology and Nutrition.*
*https://pubmed.ncbi.nlm.nih.gov/15448424/*

*Leong, A., et al. (2019). Goat milk oligosaccharides and their potential functional role in infant nutrition.*
*https://pmc.ncbi.nlm.nih.gov/articles/PMC6616537/*

*Li et al. (2025). Association between gut microbiota and allergic rhinitis*
*https://pmc.ncbi.nlm.nih.gov/articles/PMC12121621/*

*Li, X., et al. (2025). α2,6-linked sialylated oligosaccharides enriched in goat milk alleviate food allergy by regulating gut flora and mucin O-glycosylation. Carbohydrate Polymers.*
*https://www.sciencedirect.com/science/article/abs/pii/S014486172401275X*

*Li, Y., et al. (2020). Bioactive peptides derived from goat milk proteins and their potential biological functions. Food Chemistry.*
*https://pubmed.ncbi.nlm.nih.gov/32132998/*

*Lungaro, M., et al. (2024). Probiotics and allergic rhinitis: Current evidence and clinical implications.*
*https://pmc.ncbi.nlm.nih.gov/*

*Milk Genomics. (2018). Goat's milk: An easily digestible and hypoallergenic option?*
*https://www.milkgenomics.org/?splash=goats-milk-an-easily-digestible-and-hypoallergenic-option*

*Muñoz-Salinas, F., et al. (2022). Comparative analysis of the protein composition of goat milk colostrum and mature milk and cow milk. Foods.*
*https://pmc.ncbi.nlm.nih.gov/articles/PMC9454708/*

*Ncube, B., et al. (2025). Bioactive components of milk and their role in immune function. International Journal of Molecular Sciences.*
*https://www.mdpi.com/1422-0067/26/3/893*

*Pascal et al. (2018). Microbiome and allergic diseases*
*https://www.frontiersin.org/journals/immunology/articles/10.3389/fim mu.2018.01584/full*

*Pawankar, R., et al. (2001). Nasal mast cells in perennial allergic rhinitis exhibit increased expression of FcεRI, CD40L, IL-4, and IL-13 and induce IgE synthesis in B cells. Allergy.*
*https://onlinelibrary.wiley.com/doi/full/10.1034/j.1398-9995.2001.00908.x*

*Petherick, A. (2018). Goat's milk: An easily digestible and hypoallergenic option? Milk Genomics.*
*https://www.milkgenomics.org/?splash=goats-milk-an-easily-digestible-and-hypoallergenic-option*

*Schuler IV, C. F., & Montejo, J. M. (2023). Allergic rhinitis in children and adults: Clinical features and diagnosis. npj Primary Care Respiratory Medicine.*
*https://www.nature.com/articles/s41533-022-00319-2*

*Tan, J., et al. (2021). Dietary fiber and bacterial short-chain fatty acids in immunity and inflammation.*
*https://pmc.ncbi.nlm.nih.gov/*

*van Leeuwen, S. S., et al. (2020). Goat milk oligosaccharides: Their diversity, quantity, and functional properties in comparison to human milk oligosaccharides. Journal of Agricultural and Food Chemistry.*
*https://pmc.ncbi.nlm.nih.gov/articles/PMC7705968/*

*Wastyk, H. C., et al. (2021). Gut-microbiota-targeted diets modulate human immune status. Cell.*

*https://pmc.ncbi.nlm.nih.gov/articles/PMC8189552/*

*Some visual elements (figures) in this paper were created with the assistance of artificial intelligence tools, specifically Google Gemini. The tool was used to generate initial diagram structures, which were then manually reviewed, edited, and adapted to accurately reflect the scientific concepts discussed in the paper.*

***Appendix***

## PERSONAL MOTIVATION AND OBSERVATIONAL CONTEXT

A personal experience about seasonal allergies, environmental exposure, and dietary habits served as some of the driving force for this research. Over a number of years, a family member, my brother, developed sensitivity to specific animals and recurrent seasonal allergy symptoms. These symptoms

seemed to significantly lessen over a three-month stay in a rural setting, at our grandparents' farm. Goat milk products, such as fresh goat milk drunk twice a day, porridge made with goat milk, and tea made with goat milk, formed a common part of the daily diet during this period of time.

This observation prompted concerns on the possibility of interactions between immune-related processes linked to allergy reactions and dietary variables. Particularly it raised curiosity about the potential impact of naturally occurring bioactive chemicals in goat milk on immunological or inflammatory pathways. However, it is essential to understand that such results cannot be used as proof of causation or scientific evidence.

The observed modifications could possibly have been caused by a number of other reasons. As shown in Figure 3, multiple life-style or environmental related factors could influence the observed changes in allergic responses. It is challenging to pinpoint the exact effect of a single food component since allergic responses are impacted by a complex interaction of environmental, immunological, and physiological factors. Nevertheless, the scientific literature on goat milk bioactive components and their potential significance to immune modulation was explored as a result of this personal discovery. Instead of serving as proof, it served as a springboard for examining if physiological connections between the content of goat milk and allergic immunological reactions had been found in earlier research.

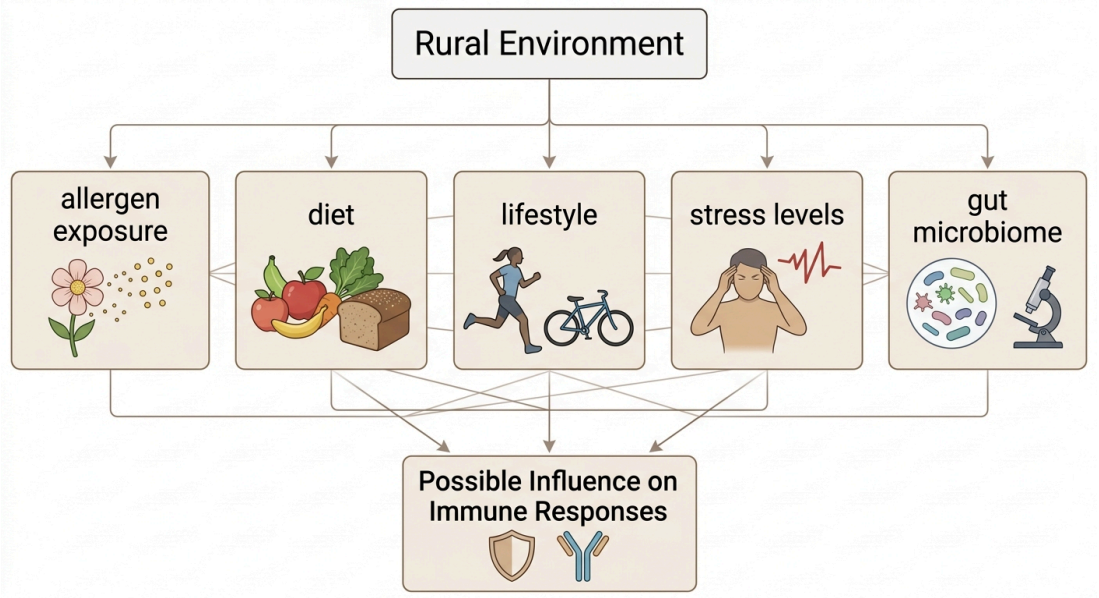


**Figure 3.** Environmental and lifestyle factors that may influence immune responses associated with allergic conditions.