

Case Report

Adverse Reactions to Yeast Beta-Glucan Supplementation in Two Dogs with Inflammatory Bowel Disease

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Abstract

Beta-glucans are immunomodulatory compounds known to act as adjuvants in the beneficial regulation of various allergic conditions, particularly atopic dermatitis, as well as in the modulation of dysbiosis in patients with chronic gastrointestinal disorders. However, certain underlying conditions, such as inflammatory bowel disease (IBD) and the associated loss of oral tolerance, may alter the expected outcomes of supplementation and lead to dysregulated immune responses. This study reports cases of cutaneous allergic reactions in dogs with IBD following the oral administration of yeast-derived beta-glucan. Two dogs with controlled IBD received 9.13 ± 1.14 mg/kg of beta-glucan in a double-blind study designed to investigate its effects on the intestinal microbiota in IBD. Both animals were withdrawn from the study due to adverse effects, including cutaneous allergic manifestations and intense pruritus. These findings suggest that patients with impaired oral tolerance may develop cutaneous reactions following the ingestion of yeast-derived prebiotics.

Keywords: gut inflammation; *Saccharomyces cerevisiae*; skin dermatitis

1. Introduction

Beta-glucans are polysaccharides formed by glucose monomers joined by alternating linear bonds to glucose monomers [1]. These glucose polymers are naturally present in a variety of plants, as well as constituents of some pathogenic bacteria, fungi and yeasts [2]. In contrast, beta-glucans are not found in mammalian cells [3] and are therefore recognized by the immune system as foreign antigens. Through interaction with pattern recognition receptors, particularly the Dectin-1 receptor expressed on innate immune cells, beta-glucans activate intracellular signaling cascades that promote a protective and regulatory immune response [4]. These mechanisms include macrophage activation, cytokine modulation, and crosstalk between innate and adaptive immunity. For this reason, its use has been extensively investigated as an immunomodulatory strategy in both human and veterinary medicine, especially in chronic inflammatory disorders such as inflammatory bowel disease (IBD) and conditions associated with intestinal dysbiosis [5].

IBD is a common chronic enteropathy [6] characterized by an inappropriate immune response to luminal antigens, in which the presence of polymorphisms in genes related



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to the recognition of pathogen-associated molecular patterns (PAMPs) in enterocytes has been discussed, as these alterations may trigger exacerbated immune responses leading to the loss of intestinal barrier integrity [7]. Increased intestinal permeability facilitates abnormal antigen translocation across the mucosa, amplifying mucosal inflammation and immune dysregulation. Among the many consequences of this process, loss of tolerance can interfere in the tolerance of the gut microbiota independently if it is beneficial or pathogenic causing an undesired imbalance known as dysbiosis [6].

According to Matsuoka et al. (2015) [8], although it was initially believed that the immune system responded solely to microbial pathogenicity, it is now known that intestinal bacteria interact directly with immune cells, reinforcing the importance of microbial balance and the potential role of prebiotics, such as beta-glucans, in the treatment and management of IBD. In this context, prebiotics such as beta-glucans have been proposed as therapeutic tools capable of modulating the microbiota–immune axis by promoting beneficial bacterial populations and influencing immune signaling pathways. Recent randomized, double-blinded clinical studies in dogs with mild IBD have demonstrated that supplementation with beta-glucans and mannanoligosaccharides over a 60-day period was able to modulate the intestinal microbiota, increasing bacterial diversity and favoring taxa associated with gut health [9].

However, despite substantial support for the use of beta-glucans due to their immunomodulatory properties, limited information is available regarding their potential adverse reactions and overall safety in patients with chronic inflammatory conditions. Based on this evidence and considering that IBD is associated with chronic mucosal inflammation and increased intestinal permeability, the loss of oral tolerance may predispose affected patients to aberrant immune responses against previously tolerated antigens, including dietary components and prebiotics. From a veterinary perspective, identifying circumstances in which widely used nutraceuticals may elicit unexpected immunological responses is clinically relevant, as it contributes to safer nutritional strategies and supports individualized therapeutic decision-making in dogs with IBD.

Based on this, the present study aims to report cutaneous allergic reactions in two dogs with IBD following the oral intake of yeast-derived beta-glucan.

2. Case Reports

Initially, dogs were referred to the Veterinary Nutrology Service of the Veterinary Teaching Hospital, School of Veterinary Medicine and Animal Science, University of São Paulo, for inclusion in a clinical trial aimed at evaluating the effects of prebiotic supplementation on fecal microbiota, fermentation products, and safety in dogs with IBD. For inclusion in the study, dogs were diagnosed with IBD according to the 2010 ACVIM Consensus Statement [10].

During the diagnostic phase, screening tests were performed for endoparasites, hypoadrenocorticism, pancreatitis, and exocrine pancreatic insufficiency (EPI). Exclusion criteria included recent use (within the previous 30 days) of prebiotics, probiotics, corticosteroids, or antibiotics, as well as any need to modify or initiate treatments during the study period. Prior to selection, dogs underwent a 60-day dietary trial to identify food allergies. As part of this process, antibiotic therapy had been discontinued for at least 90 days before enrollment.

Subsequently, eighteen dogs with controlled IBD [Canine Chronic Enteropathy Clinical Activity Index (CCECAI ≤ 3) [11] and Canine Inflammatory Bowel Disease Activity Index (CIBDAI ≤ 3) [12] who met the inclusion criteria were selected and underwent a 30-day acclimation period, during which they were fed a commercial hydrolyzed-protein diet (Royal Canin Hypoallergenic Small Dog, Royal Canin do Brasil, Descalvado, Brazil) (Table 1).

Table 1. Nutritional values of a commercial dry dog food with hydrolyzed protein, according to the manufacturer’s information (Hypoallergenic Small Dog, Royal Canin, Brazil).

Nutrients	g/1000 Kcal
Humidity	27.16
Protein	54.32
Ethereal extract	34.57
Fibrous matter	4.94
Mineral matter	26.91
Calcium (min)	2.00
Calcium (max)	2.99
Match (min)	1.58
Sodium (min)	1.97
Metabolizable energy (kcal/kg)	3.816

Ingredients: Brewers rice, hydrolyzed soy protein, chicken fat, natural flavors, vegetable oil, dried plain beet pulp, sodium aluminosilicate, calcium sulfate, salt, potassium chloride, fish oil, fructooligosaccharides, monocalcium phosphate, calcium carbonate, DL-methionine, sodium tripolyphosphate, vitamins [DL-alpha tocopherol acetate (source of vitamin E), niacin supplement, L-ascorbyl-2-polyphosphate (source of vitamin C), D-calcium pantothenate, biotin, pyridoxine hydrochloride (vitamin B6), riboflavin supplement, thiamine mononitrate (vitamin B1), vitamin A acetate, vitamin B12 supplement, folic acid, vitamin D3 supplement], choline chloride, taurine, GLA safflower oil, marigold extract (*Tagetes erecta* L.), trace minerals [zinc proteinate, zinc oxide, manganese proteinate, manganous oxide, copper sulfate, ferrous sulfate, sodium selenite, copper proteinate, calcium iodate], magnesium oxide, rosemary extract, preserved with mixed tocopherols and citric acid.

After this period, while maintaining normalization of both the CCECAI score and the CIBDAI, the dogs were randomized into three experimental groups: A–0.1% of a yeast-based beta-glucan prebiotic (60% beta-glucan); B–0.1% of a prebiotic blend (25% mannanoligosaccharides and 20% yeast beta-glucan); or C–0.1% placebo (ground form of the hypoallergenic diet). The composition of the prebiotics is presented in Table 2.

Table 2. Chemical composition, characteristics, and ingredients of prebiotics.

Variable	Value
B-glucano ¹	
Beta-glucans g/100 g (min)	60.0
Fat g/100 g (máx)	18.0
Protein (N × 6.25) g/100 g (max)	8.0
Ash g/100 g (max)	10.0
Water retention capacity	7.4
Water solubility index	7.9
Blend ²	
Beta-glucans g/100 g	25.0
Mannanoligosaccharides (MOS) g/100 g	20.0
Water solubility index (MOS)	100.0

¹ A–0.1% of a yeast-based beta-glucan prebiotic (60% beta-glucan). ² B–0.1% of a prebiotic blend (25% mannanoligosaccharides and 20% yeast beta-glucan).

The amount of each treatment was defined to correspond to 0.1% of the daily food intake (in grams), equivalent to 15 mg per kg of body weight, and was calculated to meet the estimated energy requirements for inactive adult dogs, according to the National Research Council (2006) [13]. Experimental treatments were administered orally, encapsulated in hypoallergenic capsules, once daily. Throughout the 60-day experimental period, all dogs were maintained exclusively on the same hydrolyzed-protein diet used during the standardization phase.

However, among the 18 dogs included in the clinical trial, three developed unexpected acute adverse cutaneous reactions, mainly characterized by generalized allergic signs such as erythema and intense pruritus, and were therefore withdrawn from the study. The

remaining dogs did not exhibit cutaneous reactions, remained in good overall clinical condition, and maintained controlled IBD throughout the experimental period. After completion of the trial, the treatments were unblinded, revealing that all three affected dogs belonged to treatment group A (0.1% beta-glucan). Nevertheless, only two cases could be reported in this study, as the third dog was promptly treated with corticosteroids by the owner (a veterinarian), and no photographic records were obtained. For the two reported cases, all owners provided written informed consent for case publication.

2.1. Case 1

A 3-year-old spayed female mixed-breed dog, with a body condition score (BCS) of 5 out of 9 [14] and a muscle mass score (MMS) of 3 out of 4 [15], diagnosed with IBD through exploratory laparoscopy, was included in the aforementioned clinical trial. Histopathological analysis confirmed moderate lymphoplasmacytic and eosinophilic enteritis. Analysis of the mesenteric lymph node revealed mild eosinophilic lymphadenitis. Microscopic evaluation of the small intestine showed mild villus atrophy, superficial edema of the lamina propria, mild lymphatic ectasia, and hyperplasia of the mucosa-associated lymphoid tissue.

At the time of the first visit, the CCECAI score was 2, which was attributed to recurrent ear pruritus that worsened at night during sleep. Ten days after the initiation of prebiotic supplementation, the owner presented the dog for an unscheduled visit due to intense generalized pruritus (score 10 on the linear scale) [16] and the presence of skin lesions on the abdomen, mainly in the inguinal region and around the vulva (Figure 1).

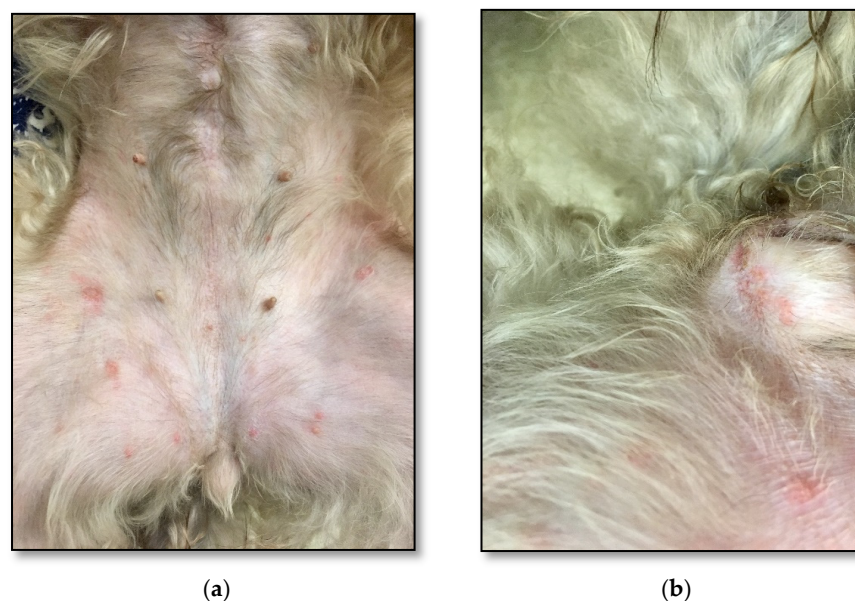


Figure 1. Animal 1 in the ventrodorsal position, showing papules, erythema, and pustules on the abdomen (a) and vulvar region (b).

Clinical signs began two days prior to the unscheduled visit, and the patient also showed a marked reduction in food intake, consuming only approximately 30% of the prescribed amount despite persistent encouragement from the owner. The dog was withdrawn from the study and referred to the Dermatology Service, where cytological examination revealed neutrophils and epithelial cells, findings consistent with superficial allergic dermatitis. Treatment included soothing and antiseptic bathing solutions, as well as corticosteroids, which were indicated due to the clinical presentation suggestive of an acute allergic reaction and the need for rapid symptomatic relief.

2.2. Case 2

A 10-year-old spayed female mixed-breed dog, with a BCS of 6 out of 9 and a MMS of 3 out of 4, also diagnosed with IBD, was included in the clinical trial. Intestinal biopsy fragments collected through exploratory laparotomy revealed diffuse eosinophilic lymphoplasmacytic enteritis, along with crypt hyperplasia and Peyer's patch hyperplasia. At the time of the first visit, the CIBDAI score was 1 (slightly reduced appetite), and the CCECAI score was 3, which included regular ear pruritus that worsened at night.

Twenty days after the initiation of treatment, the CIBDAI score increased to 3 and the CCECAI to 4, as the owner reported weekly episodes of vomiting and mildly reduced activity and attitude. Forty days after the start of treatment, the CIBDAI score further increased to 4, indicating worsening gastrointestinal signs, and the CCECAI score reached 7. The owner also reported generalized pruritus with a score of 8 on the linear scale; however, itching was more pronounced in the inguinal region, vulva, perineum, tail base (Figure 2), and interdigital areas.



Figure 2. Animal 2 in the ventrodorsal position, showing alopecia, hyperkeratosis, hyperpigmentation, and erythema in the vulvar, perineal, and abdominal regions.

The patient was withdrawn from the study and referred to the Dermatology Service, where cytological examination revealed the presence of a few coccoid bacteria, rare neutrophils, and epithelial cells. Treatment included the use of soothing and antiseptic bathing solutions, as well as corticosteroids, aiming to provide immediate relief of clinical signs consistent with an acute allergic reaction.

3. Discussion

While side effects of β -glucans in dogs have been rarely reported, their beneficial effects have been well documented in humans and in animal models of skin diseases [17–19]. These yeast-derived β -glucans are purified from the cell wall of *Saccharomyces cerevisiae* [20], allowing the immune system to properly recognize their molecular patterns and trigger the expected immune response. However, some proteins present in the yeast cell wall are known to promote adverse cutaneous reactions in individuals with food hypersensitivity, likely due to their molecular weight and the loss of oral tolerance observed in patients with IBD [21–24].

According to Heelan et al. (1991) [25], the *Saccharomyces cerevisiae* cell wall contains a heat-stable protein and a soluble glycoprotein, gp200, with a molecular weight of approxi-

mately 200 kDa, which is immunogenic in humans. McKenzie et al. (1990) [26] reported elevated IgG antibody levels against 11 out of 12 strains of *Saccharomyces cerevisiae* in patients with Crohn's disease (CD). The authors suggested that increased antibody levels against dietary antigens may be attributed to enhanced absorption across the inflamed intestinal mucosa. Similarly, Barnes et al. (1990) [27] detected anti-*Saccharomyces* IgG in the serum of 63% of patients with CD, compared with only 8% of healthy adult controls. Elevated concentrations of anti-*Saccharomyces* IgA were also identified in the serum of 17 out of 40 patients with CD, further supporting a strong association between these antibodies and the disease in humans.

Additionally, anti-gp200 IgE was detected in an in vitro study in 67% of human patients with an atopic predisposition, 63% of patients with mild atopic dermatitis, and 86% of patients with severe atopic dermatitis [28], indicating another clinical context in which this glycoprotein may induce adverse effects.

According to some researchers, anti-*Saccharomyces cerevisiae* antibodies directed against the yeast cell wall are considered an important and specific serological marker for CD [29]. Nevertheless, these antibodies have also been identified in individuals with systemic lupus erythematosus, type 1 diabetes mellitus, rheumatoid arthritis [29], and obesity [30].

The mechanisms by which this prebiotic exerts its effects are not yet fully understood. Municio et al. (2013) [23] demonstrated that the immunological effects of β -glucans are highly dependent on the inflammatory environment, in which they may either enhance or attenuate pro-inflammatory responses. In a recent and unique study reporting an allergic reaction in an obese dog following the ingestion of purified β -1,3/1,6-glucans from *Saccharomyces cerevisiae*, the inflammatory milieu associated with obesity was suggested as a possible factor potentiating the pro-inflammatory effects of β -glucans [31]. However, individual susceptibility was also considered, as only one obese animal among the evaluated subjects developed an adverse reaction.

This individual variability in immune responses was also considered in the present study. The authors hypothesized that some dogs with IBD may not have developed the expected immunomodulatory response due to immunological particularities that are not yet fully elucidated. In this context, it is plausible that β -glucans may, under certain conditions, act as pro-inflammatory immunological stimuli, potentially exacerbating allergic responses in immunologically predisposed individuals.

This hypothesis is supported by the fact that β -glucans are classified as pathogen-associated molecular patterns (PAMPs) and are recognized by innate immune system receptors, including C-type lectin receptor 1 (Dectin-1), Toll-like receptor 2 (TLR-2), and complement receptor 3 (CR3) [32]. Activation of these receptors may amplify Th2-type immune responses associated with allergic processes, as demonstrated by Hadebe et al. [33], who observed exacerbation of allergic pulmonary inflammation in mice following administration of purified β -glucan.

In the present study, dogs already exhibited signs of cutaneous allergy, initially characterized by mild ear pruritus, which became generalized and worsened following prebiotic administration. According to the findings of Municio et al. (2013) [23], who demonstrated that the immunological effects of β -glucans depend on the pre-existing inflammatory environment, we believe that the exacerbated cutaneous allergic response observed in these dogs was likely potentiated by the overall inflammatory state characteristic of IBD, particularly in animals that already presented dermatological manifestations.

However, the authors of this study believe that the reported allergic reaction may be partially explained by the fact that IBD is characterized by a loss of intestinal selective permeability [34,35] and, consequently, a loss of oral tolerance. This disruption may lead to an altered immune response to multiple antigens and represent an initial step in the

development of food hypersensitivity [36]. This mechanism also helps explain why the CCECAI includes “itching” as one of the variables used to quantify disease severity and why hypoallergenic diets are recommended for dogs with IBD [11].

Despite these findings, the adverse reactions observed were unexpected, as β -glucans have also demonstrated beneficial effects in patients with atopic dermatitis. In a study by Kim et al. (2018) [37], rats with experimentally induced atopic dermatitis received oral yeast-derived β -glucan at a dose of 10 mg/kg, resulting in significant reductions in vasodilation, pruritus, edema, and serum histamine concentrations.

In addition, prebiotics may promote the growth of short-chain fatty acid-producing bacteria, which serve as an energy source for intestinal epithelial cells and contribute to tissue repair, restoration of gut junction integrity, and improvement of intestinal permeability [38]. However, microbiota modulation generally requires a longer period (about 60 days in healthy subjects or more in the diseased) [39] to produce measurable changes in fermentative profiles. Therefore, acute allergic reactions may occur before the beneficial effects of microbiota modulation become evident.

However, this study is limited by the identification and potential reporting of adverse reactions in only two of the 18 animals subjected to prebiotic supplementation. Given that this type of adverse reaction is still rarely reported in the literature, explanations were proposed to account for the occurrence of cutaneous allergy associated with the use of β -glucans. Nevertheless, although these findings indicate the need for greater caution and clinical monitoring, it is important to emphasize that the recognition of adverse reactions in specific cases does not contraindicate the use of β -glucans, considering the substantial body of evidence supporting their beneficial effects.

4. Conclusions

Based on the reported cases and the responses observed after the administration of beta-glucan-based prebiotics, this study identified significant cutaneous manifestations indicative of adverse reactions to this compound under conditions that favor an altered immunomodulatory response, that is, in inflammatory contexts associated with loss of oral tolerance, such as in IBD, in which the beneficial effects of beta-glucans may be converted into adverse responses. However, the authors acknowledge that further studies are needed to deepen the understanding of this condition and to confirm the proposed mechanisms, which at this stage should be interpreted as hypotheses grounded in the observations obtained.

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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Abbreviations

IBD	Inflammatory bowel disease
PAMPs	pathogen-associated molecular patterns
ACVIM	American College of Veterinary Internal Medicine
EPI	Exocrine pancreatic insufficiency
CCECAI	Canine Chronic Enteropathy Clinical Activity Index
BCS	Body condition score
MMS	Muscle mass score
CIBDAI	Canine Inflammatory Bowel Disease Activity Index
CD	Chron's Disease

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