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Effect of Brewer's Dried Grain on the Serum Biochemical Indices of Grower Rabbits

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ABSTRACT

This study investigated the effects of varying levels of Brewer's Dried Grain (BDG) on the serum biochemical indices of grower rabbits (*Oryctolagus cuniculus*). With the increasing demand for animal protein, particularly in developing regions like Nigeria, finding sustainable and cost-effective feed sources is crucial. The research was conducted at the Livestock Teaching and Research Farm of Joseph Sarwuan Tarka University, Makurdi, over an eight-week period. A total of 20 growing rabbits, aged 3 to 4 months, were randomly allocated to five dietary treatments containing 0%, 5%, 10%, 15%, and 20% BDG. The results indicated significant variations in total protein and cholesterol levels among the dietary treatments. Total protein levels increased from 5.33 g/dl in the control group (0% BDG) to 7.67 g/dl in the 20% BDG group, suggesting that BDG positively contributes to the nutritional intake of rabbits. Cholesterol levels varied as well, with the highest recorded at 108.33 mg/dl in the 15% BDG group, while remaining within acceptable limits across all treatments. Other biochemical parameters, including albumin, urea, and creatinine, showed no significant differences, indicating that the inclusion of BDG did not compromise health and kidney function. These findings underscore the potential of BDG as a nutritious and economically viable feed ingredient for rabbit farming, particularly in resource-limited settings. Incorporating up to 20% BDG into rabbit diets is feasible without adverse health effects, thus supporting sustainable livestock management practices. The study highlights the importance of utilizing agricultural by-products to enhance food security and improve the livelihoods of smallholder farmers. Future research should focus on the long-term impacts of BDG on growth performance and overall health in rabbits, as well as exploring other agricultural by-products that could further diversify feed sources.

INTRODUCTION

The ever-increasing human population and the consequent insufficiency in animal protein intake remain major challenges in developing countries, including Nigeria (Okachi & Ani, 2016). The per capita daily intake of animal protein in these regions falls far below the recommended level (Ajayi *et al.*, 2007). Rising demand for animal protein, coupled with economic constraints, has increased interest in fast-growing livestock species characterized by short generation intervals, low-cost management requirements, high fecundity, and adaptability to diverse ecological conditions (Omolade Ebun, 2016).

Among such animals, rabbits (*Oryctolagus cuniculus*) have gained prominence for their high-quality meat, which is rich in protein and low in fat and cholesterol (Abdel-Rahman & Ashour, 2023). Rabbit production offers great potential for bridging the animal protein gap and providing sustainable income for smallholders. However, the high cost of conventional feed ingredients - accounting for up to 70% of production costs - remains a major limiting factor (Ajayi *et al.*, 2007). Therefore, identifying alternative, cost-effective feed resources is critical to enhancing rabbit productivity.

Brewer's Dried Grains (BDG), a by-product of the brewing industry obtained from grains such as barley,

wheat, maize, rice, and sorghum, have shown promise as a sustainable feed ingredient. BDG typically contains 19-37.9% crude protein on a dry matter basis, along with considerable fiber and non-starch polysaccharides that influence nutrient digestibility (Parpinelli *et al.*, 2020; Lynch *et al.*, 2016). Its inclusion in livestock diets has been reported to improve growth performance and economic returns, particularly in rabbits and small ruminants (Lima *et al.*, 2017). With a crude protein content of approximately 28% and 18% crude fiber, BDG can potentially meet the nutrient requirements of grower rabbits (Ekpenyong, 2016).

Blood and serum biochemical parameters serve as reliable indicators of the physiological, pathological, and nutritional status of animals (Aderemi, 2004; Opara, 2006). They provide useful insights into how dietary components and feed additives affect animal health and metabolism. Evaluating these parameters is therefore essential when introducing alternative feed ingredients such as BDG into animal diets.

Given these considerations, this study was designed to evaluate the effects of graded levels of Brewer's Dried Grains on the serum biochemical indices of grower rabbits, with the aim of determining its potential as an economical and nutritionally viable feed ingredient.

The use of unconventional feed ingredients such as

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Brewer's Dried Grains (BDG) offers a practical solution to the rising cost of livestock production in developing countries. By incorporating BDG into rabbit diets, feed costs can be substantially reduced while maintaining adequate nutrient intake and growth performance. Understanding its effects on serum biochemical indices will provide insight into the physiological responses and overall health status of rabbits fed BDG-based diets. This knowledge is essential for determining safe inclusion levels and optimizing feed formulations that promote efficient, healthy, and sustainable rabbit production. Moreover, the outcome of this study could contribute to improved food security and protein availability, particularly in resource-limited settings.

LITERATURE REVIEW

Origin and Distribution of Rabbit

The domestic rabbit originated from wild rabbits found in Mediterranean countries and was introduced to England between the 11th and 12th centuries (Adukwu and Olukosi, 1990). Different breeds of domestic rabbits began to evolve as early as the 18th century. Rabbits were transported to various parts of the world by sailors who sought a continuous meat supply during their voyages. It is likely that this was the method of introducing rabbits to Nigeria. European rabbits were also brought to Australia and New Zealand, and the European hare became established in several areas of North America. In Nigeria, wild hares, which are mostly greyish-brown, are still common and are usually seen at night. The term "rabbit" originally referred to small, fast animals with short ears that gave birth to blind and naked offspring. Rabbits have a sharp sense of smell and hearing and feed on a wide variety of plants. They belong to the Lagomorpha order and the Leporidae family. Rabbits have some traits similar to ruminants, such as consuming large amounts of forage and harboring bacteria for fermentation, allowing them to produce B-vitamins in the caecum. However, unlike ruminants that chew cud, rabbits re-ingest fermented products directly from the anus, which has led to their classification as "pseudo-ruminants" (Adukwu and Olukosi, 1990).

Taxonomical Classification, Characteristics, and Importance of Rabbits Breeds

Rabbits are classified as follows: Kingdom *Animalia*, Phylum *Chordata*, Class *Mammalia*, Order *Lagomorpha*, Family *Leporidae*, Genus *Oryctolagus*, Species *cuniculus* (Aduku & Olukosi, 1990).

There are now hundreds of rabbit breeds worldwide, varying in coat type and size (Aduku & Olukosi, 1990). Rabbits are diverse animals, with each breed exhibiting distinct characteristics in terms of growth, genetics, and adaptability to different environments. Understanding these differences is important for improving breeding and meat production practices.

Growth performance in rabbits is greatly influenced by breed. Research shows that larger breeds, such as

the Flemish Giant, and medium breeds like Argenté de Champagne grow faster than smaller breeds. A study found that the giant MB breed grew significantly faster than the hybrid Hyplus, while smaller breeds such as MW and CB exhibited slower growth rates (Tümová *et al.*, 2014). This supports the idea that larger breeds generally have better growth performance due to their size and genetic makeup (Tümová *et al.*, 2014; Wang *et al.*, 2016). Medium and large rabbit breeds have distinct traits that are important for classification and breeding. Medium breeds typically weigh between 3.5 and 5.5 kg, while large breeds can exceed 5.5 kg, with some giant breeds reaching over 10 kg. Classification is often based on size, growth rate, and reproductive traits, which are influenced by genetics and environmental factors. Medium and large breeds, such as Jabali and Tianfu Black, have been shown to have superior growth rates and carcass characteristics compared to smaller breeds. For example, Jabali rabbits have higher dressing percentages and overall body weight, which are important for meat production (Zigo *et al.*, 2020; Wang *et al.*, 2016).

Additionally, certain gene polymorphisms, such as in the MC4R gene, are linked to growth efficiency, highlighting the genetic factors that affect rabbit size and weight (Radwan *et al.*, 2023; Jiang *et al.*, 2009). Reproductive traits also differ between medium and large breeds. Smaller breeds reach puberty earlier (4–6 months) compared to larger breeds (5–8 months) (Onuoha, 2020). These differences can affect breeding strategies, as medium and large breeds may require different management practices to optimize production. Reproductive traits, including litter size and frequency, are key to sustainable meat production (Zigo *et al.*, 2020).

In terms of physical appearance, medium and large breeds differ in body conformation and external traits. Studies show that medium breeds tend to have a more compact body structure compared to larger breeds (Zigo *et al.*, 2020). This compactness can influence their adaptability to different environments and their overall health. Moreover, skin and fur characteristics can vary between medium and large breeds. For instance, heavier breeds like Tianfu Black have a higher skin percentage, which may offer advantages in meat yield and heat dissipation (Wang *et al.*, 2016). These traits are important for farmers when selecting breeds for specific production goals.

Medium and large rabbit breeds have multiple characteristics, including growth performance, reproductive physiology, and physical traits. Understanding these characteristics is essential for effective breeding and management practices aimed at enhancing meat production and ensuring the sustainability of rabbit farming.

Roles of Rabbits in the Livestock Industry

Rabbits are increasingly recognized for their vital role in the livestock industry, particularly in developing regions, where they can improve food security and alleviate poverty. Rabbit farming is a low-cost, high-output practice that offers a sustainable protein source,

especially in areas where traditional livestock farming may be impractical due to limited resources. Rabbits are efficient at converting feed into meat, which is critical as global demand for animal protein rises due to population growth and urbanization (Sikiru *et al.*, 2020; Kemunto *et al.*, 2022; Meyer *et al.*, 2021).

Rabbit meat is a valuable nutritional source, known for its high protein content, low fat, and beneficial fatty acid composition. This makes it a healthy alternative to more conventional meats like beef and pork (Siddiqui *et al.*, 2023; Cullere *et al.*, 2022). Additionally, rabbit farming has a lower environmental impact compared to larger livestock, producing fewer greenhouse gas emissions and exhibiting better feed conversion ratios (Meyer *et al.*, 2021; Sanah *et al.*, 2022). Given the increasing environmental concerns associated with livestock farming, rabbits are an appealing choice for sustainable meat production (Sampels & Skoglund, 2021).

Economically, rabbit farming supports rural livelihoods by creating jobs and stimulating local economies. It is often integrated into smallholder farming systems, serving as a supplementary income source alongside other agricultural activities (Baviera-Puig *et al.*, 2017; Mutsami & Karl, 2020). The rapid reproductive cycle of rabbits offers quick returns on investment, making them attractive for small-scale farmers (Lestari *et al.*, 2019). Nonetheless, rabbit production is considered the most suitable means of producing high-quality animal protein that could make a substantial contribution to meeting the demand for animal protein in Ghana (Osei *et al.*, 2012).

Cultural acceptance and demand for rabbit meat vary globally. While rabbit meat is a staple in Mediterranean countries, it is less common in other regions (Honrado *et al.*, 2022; Zotte, 2014). Promoting rabbit meat as a functional food, emphasizing its health benefits and culinary flexibility, can increase its consumption (Petrescu & Petrescu-Mag, 2018). As consumer preferences shift toward healthier, sustainable options, rabbit meat has the potential to expand significantly (Tufarelli *et al.*, 2022).

Rabbits contribute to food security, economic development, and environmental sustainability. Integrating rabbit farming into agricultural systems, particularly in developing countries, offers solutions to challenges related to poverty, nutrition, and environmental sustainability.

Hematology

Hematological studies are valuable for disease prognosis and for monitoring therapeutic interventions and feed-related stress (Togun & Oseni, 2005). Such studies are important because blood is the major transport system of the body, and evaluations of hematological profiles typically provide vital information on the body's response to injuries of all forms, including toxic injuries (Ihedioha *et al.*, 2004).

Hematology is the branch of medicine concerned with the study of blood, the blood-forming organs, and blood diseases. The term "heme" derives from the Greek word

for blood. This field involves investigating the causes, prognosis, treatment, and prevention of diseases related to blood. Hematology includes studying conditions that affect the production and components of blood, such as blood cells, hemoglobins, blood proteins, bone marrow, platelets, blood vessels, spleen, and the mechanisms of coagulation. Such conditions may include hemophilia, blood clots, other bleeding disorders, and blood cancers such as leukemia, multiple myeloma, and lymphoma.

Blood volume is composed of approximately 55% plasma and 45% cells. Plasma consists of 91–92% water and 7–9% solids. The solid component of plasma includes proteins such as albumin, globulins, and fibrinogens; inorganic constituents, primarily electrolytes including sodium, potassium, calcium, magnesium, phosphorus, chloride, iodine, iron, copper, and zinc; organic constituents such as urea, uric acid, creatine, amino acids, neutral fats, cholesterol, and glucose; and internal secretions, including hormones, antibodies, and various enzymes (Aka & Adikpe, 2014).

Cholesterol

Cholesterol is a waxy steroid metabolite found in cell membranes and transported in the plasma of both animals and humans. It is a vital structural component of mammalian cell membranes, required for proper membrane fluidity and permeability. Cholesterol is also essential for the synthesis of steroid hormones, fat-soluble vitamins, and bile acids. However, excessive dietary cholesterol can lead to high blood pressure, heart failure, and other medical complications. Maintaining a low-cholesterol diet is therefore important to reduce harmful cholesterol levels (Aka & Adikpe, 2014).

Creatine and Creatinine

Creatine is synthesized in the kidney, liver, and pancreas and is transported to other organs such as muscle and brain, where it is phosphorylated to phosphocreatine, a high-energy compound. The interconversion of phosphocreatine and creatine is a key metabolic process in muscle contraction. Some creatine in muscle spontaneously converts to creatinine, an anhydride. Between 1 and 2% of muscle creatine is converted to creatinine daily. Endogenous creatine production is proportional to muscle mass and varies with age and sex. Creatinine is a heterocyclic nitrogenous compound produced from creatine in muscle at a rate dependent on muscle bulk. It is excreted unchanged by the kidneys, mainly via glomerular filtration, with a small contribution from active secretion. Approximately 10% of creatinine is derived from dietary sources, particularly cooked meat (Aka & Adikpe, 2014).

Albumin

Albumin is the major plasma protein with a molecular weight of approximately 66.3 kDa. It is synthesized exclusively in the liver at a rate of approximately 120 mg/kg body weight per 24 hours. Synthesis can increase up to

twofold in response to decreased plasma oncotic pressure and decrease in response to certain cytokines. The plasma half-life of albumin is approximately 20 days.

Albumin is also present in interstitial fluid; although its concentration is lower, the larger volume of this compartment results in more total albumin compared to plasma. Disruption of endothelial function, such as occurs in sepsis, allows albumin to move into the interstitial fluid, causing rapid changes in plasma albumin concentration. Albumin acts non-specifically as a transport protein for numerous substances, including free fatty acids, ions (e.g., Ca²⁺, Zn²⁺), bilirubin, and many drugs. It contributes to plasma oncotic pressure and maintains the distribution of extracellular fluid between vascular and extravascular compartments. Albumin also functions as a minor hydrogen ion buffer (Aka & Adikpe, 2014).

Total Protein

Dietary proteins of plant or animal origin are large macronutrient biomolecules consisting of one or more long chains of amino acid residues (polypeptides) essential for life support including catalysis of metabolic reactions, DNA replication, response to stimuli and transportation of molecules (Genton *et al.*, 2010). Serum biochemical analysis is commonly used to measure total protein, with levels in New Zealand White rabbits consistent with established reference values (Özkan *et al.*, 2012). Protein quality in feeds can also be monitored through serum biochemical indices (Ilo & Egu, 2018).

Urea

Urea metabolism in rabbits is complex and influenced by diet and gut microbiota. It serves as a nitrogen source, supporting protein synthesis and microbial growth in the cecum. Studies indicate that dietary urea can improve nitrogen retention and growth (Li *et al.*, 2012), although excessive supplementation may lead to toxicity (Abdel-Rahman & Ashour 2023). The gut microbiome plays a role in urea utilization, complicating interpretation of plasma urea levels (Kovács *et al.*, 2013).

MATERIALS AND METHODS

Study Area

The research was conducted at the rabbit section of the Livestock Teaching and Research Farm of the College of Animal Science, Joseph Sarwuan Tarka University, Makurdi, Benue State. Makurdi is located at a latitude of 7°43'N and a longitude of 8°53'E. The town lies within the Guinea Savannah region of Nigeria and experiences two distinct seasons: the wet season, which lasts from April to October with an annual rainfall ranging from 1,105 mm to 1,600 mm, and the dry season, which lasts from November to March. The area has a warm climate with an annual temperature range of 22.8°C to 40°C and relative humidity ranging from 4.8% to 64% (TAC, 2009).

Source of Brewers Dried Grain

The Brewers dried grains (BDG) were obtained from a local brewery within Makurdi metropolis. The sundried grains were sampled for analysis and subsequently stored in feed bags until incorporated into the experimental diets.

Experimental Animal, Design and Management

A total of 20 growing rabbits aged three to four months were used for the study. The rabbits were stabilized for one week, weighed, and randomly allocated to five dietary treatments, with four rabbits per treatment. Each treatment was replicated four times, with one rabbit per replicate. The experiment lasted for eight weeks.

Upon arrival, the rabbits were given an anti-stress supplement (Vitalyte) and housed in well-ventilated hutches equipped with feeders and drinkers. Clean water and feed were provided for one week to allow acclimatization to the new environment. Subsequently, the experimental diets were administered. All rabbits received ivermectin and tetracycline injections for the treatment of endo- and ecto-parasites.

Experimental Diets

Five experimental diets were formulated using Brewers dried grain at inclusion levels of 0%, 5%, 10%, 15%, and

Table 1: Ingredient and Proximate Nutrient Composition of Grower Rabbit Diets Containing Graded levels of Brewers dried Grain

Ingredient	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)
Maize	30	30	30	30	30
Soya beans	19	19	19	19	19
Maize bran	47	44.65	42.3	37.95	37.8
BDG	0.00	2.35	4.7	7.05	9.2
Bone meal	3	3	3	3	3
Methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Premix	0.3	0.3	0.3	0.3	0.3
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Calculated analysis (%)					

CP	14.90	15.05	15.27	15.43	15.63
CF	7.59	7.75	7.76	7.85	7.55

Premix provided per kg diet: vitamin A, 12,000 IU; vitamin D3, 1,000 IU; vitamin E acetate, 50 mg; vitamin K3, 2 mg; biotin, 0.1 mg; Fe, 100 mg; Cu, 20 mg; Mn, 50 mg; Co, 2 mg; I, 1 mg; Zn, 100 mg; Se, 0.1 mg; Robenidine, 66 mg

20%, corresponding to treatments T1, T2, T3, T4, and T5, respectively.

Hematological Indices

At the end of the eight-week study period, 3 mL of blood was collected randomly from three rabbits per treatment by severing the jugular vein. The blood samples were transferred into labeled sterile sample bottles containing anticoagulant and subsequently used to determine serum biochemical indices, including total protein, albumin, cholesterol, urea, glucose, and creatinine.

Chemical Analysis

Proximate composition of brewer's dried grains and the experimental diets were analyzed using the methods described by AOAC (2006).

Data Analysis

All data generated from experiment were subjected to one-way analysis of variance (ANOVA) in a completely randomized design (CRD) according to Steel and Torrie (1980). Treatment means were separated using Duncan's multiple range test (DMRT) (Duncan, 1995).

RESULTS AND DISCUSSION

Effect of Brewers Dried Grain on the Biochemical Parameters of Grower Rabbits

The findings of this study provide valuable insights into the effects of varying levels of Brewers Dried Grain (BDG) on the biochemical parameters of grower rabbits. Significant variations were observed in total protein and cholesterol levels among the different dietary treatments. Total protein levels ranged from 5.33 g/dl in the control group (T1) to 7.67 g/dl in the T5 group, which included 20% BDG. Although these values are below the 10 g/dl threshold reported by Jonathan (2013), they indicate that protein from BDG contributes positively to the rabbits' nutritional intake. This observation aligns with the findings of Abdel-Rahman and Ashour (2023), who emphasized the importance of high-quality protein sources for optimal growth and health in rabbits.

Cholesterol levels also varied significantly, with the highest value of 108.33 mg/dl recorded in the T4 group (15%

BDG), closely followed by 108.00 mg/dl in the T2 group (5% BDG). The lowest cholesterol level of 94.33 mg/dl was observed in T5 (20% BDG). These results suggest that BDG inclusion can influence lipid metabolism, consistent with the findings of Sikiru *et al.* (2020), who reported that dietary modifications can affect serum cholesterol levels in rabbits. Importantly, all cholesterol values remained within acceptable ranges, indicating no adverse health effects from the dietary treatments, as corroborated by Kokore *et al.* (2021).

The biochemical parameters measured in this study serve as important indicators of the rabbits' physiological and nutritional status. Notably, albumin, urea, and creatinine levels did not show significant differences across the treatment groups, suggesting that BDG inclusion did not compromise kidney function or overall health. Albumin levels ranged minimally from 4.00 g/dl in T2, T3, and T4 to 5.00 g/dl in T1 and T5. Urea levels varied from 38.00 mg/dl in T4 to 42.00 mg/dl in T5, while creatinine remained constant at 1.00 mg/dl across all treatments. These findings are consistent with Aka and Adikpe (2014), who highlighted the importance of stable biochemical parameters in maintaining homeostasis in livestock.

The implications of these findings are significant for the economic viability of rabbit farming, particularly in developing regions where feed costs are a major concern. The ability to incorporate up to 20% BDG into diets without detrimental health effects demonstrates that by-products can be effectively utilized in animal nutrition. Lima *et al.* (2017) similarly reported that alternative feed ingredients can enhance growth performance and sustainability in rabbit farming.

Overall, the results of this study highlight the potential of Brewers Dried Grain as a nutritious and cost-effective feed ingredient for grower rabbits. The observed differences in total protein and cholesterol levels, along with stable indicators of health such as albumin, urea, and creatinine, suggest that BDG can be safely included in rabbit diets. These findings contribute to the growing body of evidence supporting the use of by-products in animal nutrition, offering promising strategies for improving livestock management and enhancing food security in developing regions. Future research should

Table 2: Effect of Graded Levels of Brewers Dried Grains on the Biochemical parameters of Grower rabbits

Parameters	T1	T2	T3	T4	T5	SEM
Total protein g/dl	5.33 ^b	4.33 ^{ab}	6.00 ^{ab}	5.00 ^a	7.67 ^{ab}	0.44
Albumin g/dl	5.00	4.00	4.00	4.00	5.00	0.19
Creatinine mg/dl	1.00	1.00	1.00	1.00	1.00	0.00
Urea mg/dl	40.00	40.67	39.67	38.00	42.00	0.997
Cholesterol mg/dl	102.00 ^{ab}	108.00 ^a	98.00 ^{bc}	108.33 ^a	94.33 ^c	1.710

explore the long-term effects of BDG on growth performance, overall health, and its broader implications for sustainable agricultural practices.

CONCLUSION

This study examined the effects of varying levels of Brewer's Dried Grain (BDG) on the serum biochemical indices of grower rabbits. The findings indicate that incorporating up to 20% BDG into rabbit diets does not adversely affect health, as evidenced by stable biochemical parameters such as total protein, albumin, cholesterol, urea, and creatinine.

Notably, total protein levels increased with higher BDG inclusion, highlighting its positive contribution to nutritional intake. Cholesterol levels fluctuated but remained within safe limits, suggesting that dietary adjustments can influence lipid metabolism without negative health impacts. These results underscore the economic viability of using BDG as a sustainable, cost-effective feed option for rabbit farming, particularly in developing regions where feed costs are critical. Overall, the study supports the safe integration of BDG into rabbit diets, contributing to improved livestock management and sustainability. Future research should further explore the long-term effects of BDG on growth performance and health in rabbits.

Based on the findings of the study, several recommendations can be made to enhance rabbit farming practices. Firstly, farmers should consider incorporating Brewer's Dried Grain (BDG) into the diets of grower rabbits, with levels up to 20%, as this has been shown to boost protein intake without compromising health or biochemical parameters. Additionally, it is advisable to regularly monitor serum biochemical indices, such as total protein and cholesterol levels, to ensure the health and nutritional status of rabbits when utilizing alternative feed ingredients like BDG. Furthermore, future research should focus on the long-term effects of BDG on growth performance, reproductive health, and overall sustainability in rabbit farming. This will provide deeper insights into its benefits and potential limitations. Educating smallholder farmers about the economic advantages of using by-products like BDG is also crucial, as it can help reduce feed costs and improve livestock productivity. Finally, further investigations into other agricultural by-products suitable for rabbit nutrition should be pursued to diversify feed sources and enhance the sustainability of rabbit farming practices.

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