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Review

The Inclusion of Jujube By-Products in Animal Feed: A Review

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Abstract: Given the increasing demands for the quality and safety of animal-derived foods and the strict regulations on the use of antibiotics in animal feed, the use of functional feed additives has attracted increasing research and development. Jujube fruit is an energy-rich food with antioxidant, antibacterial, and antidiarrheal properties. With the expanding areas of cultivation to jujube trees and the intensive processing of jujube in Asia, especially in China, a large number of jujube by-products are produced. These by-products are used widely in animal feed for pigs, chicken, cattle, goats, and fish, as they improve growth performance, promote digestive tract health, and enhance the quality of animal products. This article reviews the nutritional components and benefits of jujube by-products and their potential incorporation in animal feed. The aim of this review is to introduce jujube by-products as a novel supplement or partial dietary replacement in the animal feed industry.

Keywords: jujube by-product; feed additive; nutrient; biological function

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1. Introduction

The jujube (*Ziziphus jujuba* Mill.), a member of the Rhamnaceae family, consists of approximately 170 species and 12 varieties in the Ziziphus genus worldwide [1]. Cultivated jujube was domesticated originally from wild jujube in the middle and lower drainages of the Yellow River in China [2]. Jujube was cultivated approximately 7000 years ago and was included in the human diet more than 5000 years ago. The large-scale cultivation of jujube trees has been practiced in China for more than 3000 years [2]. It has now been introduced and cultivated in Asia, Europe, Africa, Oceania, and North America [3,4].

Jujube trees are resistant to drought and tolerant of salt-alkaline conditions [4]. The fruit contains a high level of sugars and is rich in vitamin C, iron, and calcium [3]. It also contains active substances such as polyphenols, polysaccharides, and trienoic acid [5], which have been proven to be beneficial, as they possess antioxidant, immunity enhancement, and antitumor properties [3]. Jujube is reported to have a high nutritional value, and its production has earned substantial income for farmers in recent years.

China is the main producer of jujube fruit in the world [3,6]. Jujube trees in China covered 1.3 million ha in 2006 and expanded to approximately 3 million ha in 2019, while the output of jujube increased concomitantly, from 2.46 million tons in 2006 to more than 7.46 million tons in 2019. Based on the field-picking price of 0.8 to 1.3 USD per kilogram in the past five years [7,8], the annual value of the jujube industry in China is estimated at approximately 6 to 10 billion USD.

With the large expansion of jujube production and the development of the jujube processing industry [3], a number of jujube by-products are produced and are used in animal feed [9–11]. Research on the nutritional components and active substances of jujube has increased, and the use of jujube as a feed additive or replacement has received