

## Leafy Foods are Functional Feed Ingredients for Improved Animal Nutrition

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### Abstract

There are significant environmental, economic and social factors favouring the reutilization of fruit and vegetable processing co-products in farm animal nutrition. Current evidence shows that fruit and vegetable processing co-products can be effectively used in farm animal nutrition as functional feed ingredients for the production of food products of improved quality. These ingredients comply with consumer requests for the production of "clean," "natural" and "eco/green" label food products. The main parameters affecting extensive application of fruit and vegetable processing by-/co-products as functional feed ingredients in livestock nutrition are related to animal factors, logistics, and commercial value. Further research is needed to enable the commercial application of these products to livestock nutrition.

**Keywords:** Fruit and vegetable co-products; Farm animals; Nutrition; Product; Quality

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### Introduction

Recently, there has been great social and environmental pressure for the efficient reutilization of agricultural industry residues due to the global intensification of food production that has led to the creation of large quantities of food co-products and wastes. Utilization of agro industrial by-/co-products in farm animal nutrition reduces the environmental impact of the food industry and improves profitability and valorisation of the agricultural by-products since feeding food residue to livestock is an efficient way to upgrade low quality materials into high quality foods [1]. This is compliant with the current legislation that strongly encourages the food industry to find new end-uses for by-products. Furthermore, these undesirable materials pose increasing disposal and potentially severe pollution problems and represent a loss of valuable biomass and nutrients. In addition, industrial ecology and circular economy are considered the leading principles for eco-innovation focusing on a "zero waste" society and economy where wastes can be used as raw materials. On the other hand, consumers that demand the production of "clean," "natural" and "eco/green" label food products are also willing to pay significant premiums for such products. Consumers also request natural ingredients, which consumers expect to be safe and health promoting due to their increasing awareness of diet related health problems. Finally, feed additives can also affect other major determinants of food quality for the modern consumer such as shelf life, sensory characteristics (appearance and eating quality), nutritional value, and health enhancers [2].

Industrialization of food production has resulted in a generation of large quantities of food waste that can be classified into the following six categories: (a) crop waste and residues; (b) fruit and vegetables by-products; (c) sugar, starch and confectionary industry by-products; (d) oil industry by-products; (e) grain and legume by-products; and (f) distilleries' and breweries' by-products. Processing of fruit, vegetable and oilseed (considered fruits) generates various quantities and types of by-products depending on the raw material and the applied processing procedure. For most fruits and vegetables, the production of likely waste is estimated to be approximately 30% of the processed material [3]. Furthermore, the global market for feed ingredients is expected to grow at the compound annual rate of 3.8% in the coming years and is projected to reach approximately \$20 million by 2018 as a result of the rising per capita incomes and urbanization in developing countries. Additionally, developments in the bio refinery industry and novel extraction methods have led to the production of phytochemicals and other target compounds that can be used as functional additives in different products.

Fruit and vegetable processing by-/co-products are promising sources of valuable substances such as phytochemicals (carotenoids, phenolics, and flavonoids), antioxidants, antimicrobials, vitamins, or dietary fats that possess favourable technological activities or nutritional properties. The applications and the functions of fruit and vegetable residues or their valuable extractable compounds in the food industry are presented in key

review studies. Fruit and vegetable processing residues have traditionally been used in animal nutrition as the main feed ingredients and their effect on animal performance has been extensively studied [4]. However, fruit and vegetable processing by-/co-products as sources of phytochemicals constitute a relatively new class of feed ingredients and there is limited knowledge on their applications and functions as well as their bioactivity, bioavailability, and interactions with other feed ingredients. The aim of this study is to provide a brief overview of the recent knowledge on the application of fruit and vegetable co-/by-products as functional feed ingredients in farm animal nutrition for the production of food products with improved characteristics. Current limitations as well as targets for future research work are also discussed.

This overview highlighted the current developments on the application of fruit and vegetable processing co-products in farm animal nutrition as functional feed ingredients. The relevance of this topic is supported by the zero-waste society target set by the European Union until 2025 and the environmental burden arising both from fruit and vegetable processing and livestock production. In recent years, a number of studies have shown that fruit and vegetable processing co-products can be effectively used in livestock nutrition for the production of animal products of improved quality [5]. Nevertheless, fruit and vegetable processing co-products still remain an underexploited source for the dietary supplementation of farm animals with functional compounds and the production of value-added

products. Commercial application of fruit and vegetable industry co-products as functional feed ingredients provides challenges and opportunities for field scientists. However, targeted multidisciplinary (food scientists, animal scientists, chemists) research on the efficacy, bioavailability, individual functions, and optimum supplementation levels of fruit and vegetable co-products as feed additives is needed.

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