OPEN ACCESS JOURNALS
Indiana Journal of Agriculture and Life Sciences
Abbriviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/ 10.5281/zenodo.8195354

INDIANA PUBLICATIONS
PRODUCTIVE AND QUALITY RESEARCH

Review Article

Volume-03|Issue-04|2023

Importance of Utilization of Citrus By-Product Waste in Ruminant Animal Nutrition

Alsaied Alnaimy Mostafa Habeeb*

Egyptian Atomic Energy Authority, Nuclear Research Center, Biological Applications Department, Inshas, Cairo, Egypt

Article History
Received: 05.07.2023
Accepted: 20.07.2023
Published:26.07.2023

Citation
Habeeb, A. A. M. (2023). Importance of Utilization of Citrus By-Product Waste in Ruminant Animal Nutrition. *Indiana Journal of Agriculture and Life Sciences*, *3*(4), 1-9.

Abstract: Utilizing agro-industrial byproducts as feedstuffs may be economically beneficial because conventional feedstuffs are frequently pricey. Because the rumen microbial ecosystem can use by-product feedstuffs, which frequently contain high levels of structural fiber to meet their nutrient requirements for maintenance, growth, reproduction, and production, by-product feedstuffs are frequently a practical alternative for ruminant feeding systems. Citrus by-products, which vary according to the original crop and production method, are a significant part of many regions of the world's ruminant feeding systems and contain a variety of by-product feedstuffs. The waste product of the canning of citrus juice is citrus pulp. For this, oranges, tangerines, lemons, or grapefruits are used, but in other parts of the world, orange fruit is the usual raw material for the juice business. The solid substance left over after fresh fruits are crushed to make juice is known as citrus pulp. The dried leftovers of orange, grapefruit, and other citrus fruit peel, pulp, and seeds are known as citrus pulp. Citrus pulp has a high nutritional value because it includes a lot of easily fermentable carbohydrates and a range of energy substrates for ruminant microorganisms, including both soluble carbohydrates and an easily digested neutral detergent fiber fraction. As a result, the digestibility coefficients of both neutral and acid detergent fiber are raised when starchy diets are replaced with citrus byproduct feeds. In addition to being a great feed for beef and developing cattle, dried citrus pulp may substitute energy sources in rations to the extent that it can be added to up to 40% of the dry matter without endangering the health of the animals. Citrus pulp can be dried to maximize its utility. Heifers up to 45% can be fed as the major energy source for beef cattle; however, milking cows shouldn't be fed citrus pulp at high levels since it tends to reduce milk supply. Furthermore, citrus waste liquid that contains 9 to 15% soluble solids, of which 60 to 75 percent are sugars, may be condensed to create citrus molasses.

Keywords: Citrus By-Product, Ruminants, Physiological Parameters, Growth, Milk Yield

INTRODUCTION

In Egypt, there is an annual demand for around 13.0 million metric tons of total digestible nutrients, but only 9.6 million metric tons are generated, meeting approximately 75% of the livestock's energy needs (Baraghit *et al.*, 2009). It has been determined that a lack of animal feeds has a detrimental effect on the expansion of animal output in Egypt. To reduce reliance on traditional feed source feed lower feeding costs, nontraditional feed alternatives such crop leftovers and agro-industrial byproducts must be investigated (Zaza, 2005). The main issue with animal production in Egypt is the country's relatively expensive pricing for concentrates and their constituents. Increased amounts of waste from the feed business are also being found in human waste, including potato waste and waste from the feed industry from several companies, pea pod wastes, tomato pulp, and citrus pulp (Habeeb *et al.*, 2011). The anticipated local yearly output of these goods is 4.0 million metric tons, with 1.9 million metric tons of trash comprising 747 mega tons of total digestible nutrients and 88 mega tons of crude protein, respectively (Nour, 1988). This quantity and other agro-industrial by-products might help fill the nutritional gap in animal feeds and prevent human and animal consumption of edible grains from competing with one another. One of the most significant fruit crops globally is citrus. Oranges produced 82 million metric tons, or 61%, of the world's citrus production in 2010. There are significant amounts of by-products produced during the processing of citrus fruits (and 40% of the production of oranges), which accounts for around 30% of the production (USDA–FAS, 2010). In this paper, a brief discussion of the prospective application of citrus industrial byproducts for cattle nutrition is covered. This study also reviews the overview of citrus by-products in ruminant feeding, analyses the nutritional content, nutrient digestion and animal performance effects of citrus by-product wastes.

IMPORTANCE OF UTILIZATION OF CITRUS BY-PRODUCTS WASTE IN RUMINANT ANIMAL NUTRITION

The Value of Citrus By-Products in Animal Feeding

Since conventional feedstuffs are frequently costly, using agro-industrial by-products may be economically advantageous. Because the rumen microbial ecosystem can use by-product feedstuffs, which frequently contain high levels of structural fiber, to meet their nutrient requirements for maintenance, growth, reproduction, and production, ruminant feeding systems based on locally accessible by-product feedstuffs are frequently a practical alternative (Mirzaei-

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

Aghsaghali & Maheri-Sis, 2008). Citrus by-products are used as a low-cost dietary addition to cow diets, and it has been shown that supplementing with citrus by-products may reduce the development of Salmonella and Escherichia coli in mixed microorganism fluid medium in the rumen (Duoss-Jennings *et al.,* 2013). Citrus by-product feedstuffs are becoming more popular as an alternative to traditional feeds for ruminants because of rising disposal prices in many regions of the world. Fresh citrus pulp, citrus silage, dried citrus pulp, citrus meal and fines, citrus molasses, citrus peel liquor, and citrus-activated sludge are the principal citrus by-product feeds fed to ruminants. Culls or extra fruit are two minor citrus by-product feedstuffs. When compared to starch-rich feeds, citrus by-product feedstuffs can be employed as a high-energy feed in ruminant diets to support development and lactation (Bampidis & Robinson, 2006).

Manufacturing of Citrus By-products

Citrus pulp is a by-product of the canning of citrus juice. For this, citrus fruits like oranges, tangerines, lemons, or grapefruits are used. Orange fruit is a common raw material for the juice business, especially in nations not just in the Mediterranean basin but also elsewhere in the world. Between 2000 and 2003, inclusive, the total global citrus output averaged 69.4 million metric tons per year. The Mediterranean nations of Spain, Italy, Greece, Egypt, Turkey, and Morocco produce around 24% of the world's citrus fruits, with Brazil accounting for the largest share[5]. Numerous significant fruits belong to the genus Citrus, with the sweet orange accounting for 67.8% of the world's citrus output, followed by tangerine (17.9%), lemon (6.3%), and grapefruit (5.0%) (USDA–FAS, 2010). Humans mostly consume citrus fruits as fresh fruit or as processed juice that is either fresh chilled or concentrated. After the fruit's juice has been removed, skin, pulp, rag, and seeds make up the residue. These elements serve as the raw ingredients from which citrus by-product feedstuffs are created, either alone or in various combinations. The primary citrus by-product feedstuffs from citrus processing are fresh crude protein, which is the entire residue left over after juice extraction and weighs between 492 and 692 g/kg of fresh citrus fruit with 600-650 g dry matter/kg peel, 300-350 g/kg pulp, and 0-100 g/kg seeds; and by-product feedstuffs, which are created by shedding, liming, pressing, and drying the peel, pulp, and seed residues to about 80g/kg moisture (RCREC, 2009). Depending on the kind of fruit, the processing techniques, and environmental circumstances, citrus pulp, this is made up of a mixture of peels, inner parts, seeds, and culled fruit, makes up around 50–65% of the weight of the entire fruit (Figure 1) (Arthington *et al.,* 2002).

Figure 1. Citrus By-Product

Citrus Molasses

Citrus molasses may be produced by concentrating the liquid obtained by pressing citrus trash, which contains 9 to 15% soluble solids, of which 60 to 75% are sugars. The liquor has a high biological oxygen requirement without any further processing, and dumping it into lakes or streams might result in a waste problem. As a matter of fact, it can make up more than half of the overall quantity of garbage. Normal citrus molasses is a thick, viscous liquid with a bitter flavor that ranges in color from dark brown to practically black. However, its flavor has no bearing on how effective it is for feeding cattle; in fact, it may be utilized in the same way as sugarcane molasses. Prior to drying, it can be used with pressed pulp to boost the product's energy content without compromising the pulp's preservation properties. When fed to cattle at their discretion, up to 3 kg per day can be consumed (Devendra, 1988). The quantity of animal feed produced locally may be significantly increased by using by-products from the citrus sector. Because dried citrus pulp is simple to handle, transport, and include into complex feeds, drying is typically the favored method of conservation in nations where the quantity of peel and rag from canning companies is significant. These dried citrus pulps are manufactured in the United States on an annual basis in amounts close to 700 000 tones. The price of drying is around US $ 40 per ton of dry meal (including 10% moisture) (Figure 2&3) (Gohl, 2007).

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

OPEN ACCESS JOURNALS
Indiana Journal of Agriculture and Life Sciences
Abbriviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/ 10.5281/zenodo.8195354
INDIANA PUBLICATIONS
PRODUCTIVE AND QUALITY RESEARCH

Figure 2. Molasses Citrus Byproduct

Figure 3. Pellets Dried Citrus By-Product

Citrus Pulp Explanation

After freshly squeezed fruit juice is produced, citrus pulp is the solid byproduct that is left behind. The dried remnant of orange, grapefruit, and other citrus fruit peel, pulp, and seeds is known as citrus pulp. It weighs between 50 and 70 percent of the original fruit's fresh weight and includes the skin (60–65 percent), interior tissues (30–35 percent), and seeds (0–10 percent) (Crawshaw, 2003). The by-products of other citrus fruits, most notably grapefruit and lemon, may also be found in citrus pulp, which is typically manufactured from oranges. Fresh orange pulp has a natural acidity, but because of its high water and soluble sugar content, it is still a perishable commodity that can easily soured, ferment, and generate environmentally toxic sludge (Crawshaw, 2003). One of the most desirable energy feeds is dried or pelleted citrus pulp, which can be used in feeding programs as a dry carbohydrate concentrate with a high total digestible nutrient content, which averages around 74%, a bulk energy feed with a high degree of water absorption, and above-average palatability for cattle. Dried citrus pulp or pellets may often replace 40–45% of the crushed, broken maize in a dairy ration (Arthington *et al.*, 2002). It has been shown that using citrus pulp for animal feeding is an efficient strategy to reduce waste production. A thorough study should also consider the expenses of alternative disposal solutions for citrus pulp as well as the environmental costs of replacement feeds. For ruminants, the dried citrus pulp is used as a grain alternative and energy concentrate feed. It includes significant amounts of highly-dried citrus pulp components (10–40% dry matter), water-soluble sugars, and neutral detergent fiber (approximately 20% dry matter). Due to the lime that was added during the drying process, which may quadruple the original calcium content, it is also high in calcium (1-2% dry matter). It has a low level of phosphor (approximately 0.1% dry matter), ether extract (about 2% dry matter), and citrus pulp (5-10% dry matter). In comparison to citrus pulp without molasses, citrus pulp with molasses has higher sugar content and less fiber. It is basically a feed for ruminants that can readily digest

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

fiber because of the high fiber content (Arthington *et al.*, 2002).

The Nutritional Composition of Citrus By-Products

The majority of citrus by-product feedstuffs have been given a special international feed number, and the chemical make-up of diverse citrus by-product feedstuffs from various sources has been compiled. Citrus fruit's composition is influenced by the environment, variety, rootstock, and growth circumstances. The origin of the fruit and the technique of processing have an impact on the nutritional value of citrus by-products as well. The source of the fruit and the method of processing are two other factors that affect the nutritional content of citrus by-product feedstuffs (Ammerman & Henry, 1991). Citrus pulp has a high level of quickly fermentable carbohydrates, which contributes to its high nutritional value. Citrus pulp has a high moisture content (80%), is heavy, and is consequently difficult to store or transport; hence, the protein level is low and of low digestibility and biological value (Fegeros *et al.*, 1995). It is low in nitrogen but high in rapidly fermentable substrates such as sugars, non-starch polysaccharides, and organic acids. Citrus pulp is an excellent byproduct to ensile with high-dry-matter cereal-crop wastes like wheat straw due to these properties (Migwi *et al.*, 2001).

Digestibility and Energy Value

Citrus pulp includes a range of energy substrates for rumen bacteria, including soluble carbohydrates and a fiber component that is easily digested by nature and contains nutrients (Bath *et al.*, 1980; & ADAS, 1992). Citrus byproducts have been utilized in the past as a high energy feed in rations to enhance cow lactation and growth (Lanza *et al.*, 2001). Due to ruminants' capacity to digest high-fiber feeds in the rumen, several citrus by-products are acceptable for inclusion in ruminant diets. Animal feeding can employ citrus byproducts, either fresh or after they have been ensiled or dehydrated, due to their relatively high organic matter disappearance rate (85–90% range) and energy value (2900 kcal/kg dry matter, equivalent to barley and maize in terms of metabolized energy) (Bueno *et al.*, 2002). In concentration diets, citrus by-products are substituted for cereal. In contrast to grains, its energy is derived from soluble carbohydrates and digestible fiber rather than starch. Acetic acid, which is produced when citrus pectin is broken down widely and quickly, is less likely than lactic acid to lower pH levels and lead to acidosis. Citrus by-products' prolonged rumination creates a lot of saliva that lowers the pH of the rumen due to its high fiber content. For animals fed high-concentrate, low-roughage diets in high-yielding dairy cows, citrus by-products are consequently viewed as a safer feed than grains (Crawshaw, 2003). Citrus by-products appear to have a favorable impact on fiber digestibility in regimens comprising poor digestibility forages (hay or straw) or roughages like maize silage or sorghum silage. This may be because they increase rumen retention time (Arthington *et al.*, 2002).

Essential Variables to Take Note of While Feeding Citrus Byproducts to Animals

Citrus by-products' low and variable protein digestibility (between 37 and 70 percent) may result in a general decline in protein digestibility if substantial volumes of citrus by-products are included in diets with forages high in protein. Its low soluble nitrogen concentration might cause the rumen's ammonia level to drop. As citrus by-products include highly fermentable carbohydrates that may encourage more effective nutrition utilization by rumen bacteria, supplementation with urea or ammonia can be a beneficial technique (Rihani, 1991). True protein sources, however, may be more effective. Phosphorus supplementation is a crucial factor to take into account for balanced meals containing citrus by-products because of the low phosphorus content and the imbalance between calcium and potassium. Green leafy roughage is a crucial component in diets with high amounts of citrus by-products due to the low vitamin A content of citrus by-products (Arthington *et al.*, 2002).

The Nutritional Digestibility of Citrus By-Products

Dry matter and organic matter digestibility coefficients often do not change when citrus byproduct feeds are substituted for starchy feeds, but crude protein digestibility drops and neutral detergent fiber and acid detergent fiber digestibility coefficients rise (Lanza, 1984). Because of their beneficial effects on rumen microflora, citrus by-product feedstuffs increase the utilization of dietary fiber components. Additionally, when straw is utilized as the main source of nutrition for ruminants, the diet is enhanced by the addition of citrus by-product feedstuffs to make up for any nutritional inadequacies in the straw and to promote better nutrient absorption (Villarreal *et al.*, 2006). Providing large amounts of citrus by-products to beef cattle may limit fodder intake but improve overall calorie intake, according to a study that found supplementation with increasing volumes of battered citrus by-products tended to increase the digestibility of the entire diet's dry matter and organic matter. Supplementing with a significant quantity of citrus byproducts along with rumen-degradable protein-rich forages may be advantageous (Jong-Kyu *et al.*, 1996; & Heuzé *et al.*, 2012).

How Citrus Byproducts Influence On Ruminant Animal's Physiological Body Functions

Fed untraditional ration in comparison to traditional ration decreased albumin and increased globulin concentrations while total protein values were unaffected by the type of feeding, and it was concluded that untraditional ration increased immunity, especially during the hot summer season (Habeeb *et al.*, 2011). The use of agro-industrial by-product mixtures as feed components for ruminants is reasonable and is not anticipated to change the enzymatic activity in the ruminants, according to a study that found that feeding crossing calves unconventional rations decreased liver enzyme activities and may have decreased the heat load on animals during the hot summer season. When compared to calves fed conventional diets, calves fed untraditional feed had considerably lower urea-N and glucose concentrations, with percentage drop values of 30.0 and 16.0, respectively. Crossing calves fed the usual feed had considerably greater amounts of total lipids, total cholesterol, and triglycerides than those fed the unconventional ration (Habeeb *et al.*, 2011). Thyroid, cortisol, and parathormone hormone concentrations were not significantly affected by the kind of diet (Habeeb *et al.*, 2011). The same authors came to the conclusion that the daily body weight gain of crossing calves was not affected by feeding the unconventional ration, and concentrations of most blood components were in the normal range, indicating the importance of unconventional feeding, especially during the hot summer season, and particularly that ration without any additional cost aside from their use of factory byproducts from agro-industrial operations on farms. In groups fed 50% concentrate feed mixture plus 50% vegetable and fruit market wastes with silage treated formic acid, and groups fed 50% concentrate feed mixture plus 50% vegetable and fruit market wastes with silage treated with lactic acid bacteria, plasma cholesterol significantly increased and blood plasma glucose slightly increased when compared to the group fed concentrate feed mixture, and the roughage source was Darawa (Peacock & Kirk, 1959). Triglyceride levels in the blood did not significantly vary from control diet-fed cows, although cholesterol levels were greater in the serum of cows fed dried citrus pulp than in cows fed the control diet (Khattab, 2008). Liver enzyme activities were comparable to those of control rations and mixes of agro-industrial byproducts (El-Sayed, 1994). There were no appreciable variations in the blood levels of total protein, albumin, or globulin in cows given dry citrus pulp compared to those fed the control diet (Belibasakis & Tsirgogianni, 1996).

How Citrus By-products Influence on Growing Ruminat Animail

The impact of feed types on crossbred calves throughout both the cool and hot seasons of the year was studied (Habeeb, 2011). The waste items from the food businesses were fed to the second group, while the concentrate feed mixture was provided to the first group (conventional ration). Citrus pulp made up 20% of the combination, followed by potato effluent (30%), pea pods (30%), and tomato pulp (30%). The findings showed that the daily body weight gains of crossover calves fed conventional or nontraditional diets were not statistically different; however, nontraditional diets dramatically reduced the activities of liver enzymes and greatly raised globulin concentrations. The authors came to the conclusion that unconventional feeding was preferable to standard rations, particularly during the heat, and they discovered that rations stimulate calves' appetites due to their varied ingredients and high levels of water (Scerra *et al.*, 2001). The latter authors reported the effects of orange pulp silage on lamb development and carcass parameters. Citrus pulp was ensiled with chopped wheat straw in an 80:20 dry matter ratio to reduce ensiling losses brought on by the citrus pulp's high moisture content. A diet of oat hay plus concentrate and a diet of citrus pulp silage plus concentrate were given to twenty lambs, respectively. The authors came to the conclusion that using citrus pulp silage to raise lambs with good carcasses and meat was economically favorable. The average daily body weight gain for the buffalo calves fed rations, in calves fed concentrates feed mixture and hay, in calves fed citrus wastes and pea pods and hay, and in calves given artichoke wastes and pea pods and hay, respectively, was 841, 810, and 741 g throughout the feeding trials (Lashin *et al.*, 1995). With the substitution of citrus byproduct for yellow maize, feed efficiency increased, daily feeding costs dropped, and daily body weight growth improved, leading to an improvement in relative economic efficiency (Omer & Tawila, 2009). When Friesian heifers from 6 to 18 months old were given dry orange pulp concentrates in place of maize grain, the body weight did not suffer (Lanza, 1984). When coupled with enough protein and other critical elements in a diet for young, developing steers, citrus pulp, corn feed meal, and crushed snapped corn did not significantly affect the gain of the steers (Peacock c& Kirk, 1959). Additionally, dried citrus pulp is an excellent feed for beef and developing cattle, and it can substitute for some energy sources. Higher values are possible, although 20–30% of the dry matter is an acceptable inclusion rate. Cattle being fed to gain weight might have up to 40% dry citrus pulp in their meals without any negative effects on their health. Young bulls' live weight growth and carcass yields were unaffected when up to 55% dry pulp (replacing 86% of maize grain) was included in their meals (Peacock c& Kirk, 1959). Adding more dried citrus pulp to beef calves given low-quality stargazes-up to 2.5 kg per day per animal (as fed), or 30% of the diet's dry matter-led to decreased fodder consumption but increased calorie intake. Citrus pulp at a 30% level seems to be recommended in diets for calves older than two months, but not for younger ones due to acceptability issues. Additionally, a 45% incorporation rate in calf feeds was noted. Citrus condensed molasses soluble was examined as a ruminant energy source (Chen *et al.*, 1981). Citrus condensed molasses soluble was given to diets based on dried citrus pulp and corn grains in two feeding tests with steers, the first at 0, 70, 140, and 210 g/kg to replace maize or dry citrus pulp and the second at 0, 25, 50, and 100 g/kg to replace sugarcane molasses. There were no differences between treatments in terms of body weight increase, feed effectiveness, or carcass features. In a different trial with lambs, maize grain was replaced with citrus condensed molasses soluble at levels of 0, 100, and 200 g/kg dry matter. Body growth was decreased for the high citrus condensed molasses-soluble diet, but dry matter consumption was comparable across treatments. Overall the data point to

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

an equivalent increase in ruminant development when maize and wheat grains are replaced with citrus by-product diets.

How Citrus By-products Influence on Lactating Ruminants

Dairy cows can benefit from the valuable feed that is citrus pulp. When forage is sparse (low fiber diet) or when high energy is needed (as a cereal replacer, for example), the considerable acetic acid synthesis in the rumen permits the maintenance of milk output and milk fat content. The feasibility threshold has been set at 40% of the entire ratio. However, inclusion rates of less than 20% (diet dry matter) are advised since greater levels may adversely affect diet digestibility, milk parameters, and dry matter intake. Dry matter intake, milk output, or milk protein content were unaffected by the addition of 20% dry matter dried citrus pulp as a concentrate replacement in a 50–60% maize or sorghum silage-based diet (Devendra & Gohl, 1970). Both digestibility and rumen metrics are unaffected by concentrations below 20%. The characteristics of the ruminant remain unchanged when 20% to 24% of it is added to mixed dairy diets, although milk output and milk protein content may go down while milk fat content stays the same or goes up. Dried citrus pulp reduced the total amount of dry matter consumed and the total amount of dry and organic matter digestible if it reached 24% of the overall diet (Belibasakis & Tsirgogianni, 1996). When dried orange or dry lemon pulp was substituted for maize or barley grain in concentrates given to Friesian dairy cattle, neither the milk's fat content nor flavor were adversely affected. The performance and milk composition of lactating dairy cows in relation to the effects of high maize grain (80 g/kg dried citrus pulp) and high dried citrus pulp (431 g/kg dried citrus pulp) as total mixed ration feed are studied (Van Horn *et al.,* 1975). Feed consumption, milk yield, and milk protein content were discovered by the authors to be comparable among treatments. The same authors discovered that milk fat content was 42.2 g/kg against 35.4 g/kg and milk solids not-fat content was 90.3g/kg compared to 88.4g/kg in high dry citrus pulp versus high corn total mixture ration, respectively. The effects of feeding lactating Holstein dairy cows a total mixed ration with high starch (corn grain; 22.0 kg dry matter/cow/day; 204 g/kg dry matter) or high pectin (dried citrus pulp; 20.8 kg dry matter/cow/day; 93 g/kg dry matter and 207 g/kg dry matter) on performance and milk composition are investigated (Solomon *et al.,* 2000). The scientists discovered that treatment had no effect on milk output or fat content; however, the high starch Total mixed ration increased milk protein content. The performance of dairy cattle fed dry citrus pulp or maize products is evaluated (Leiva *et al.,* 2000). The scientists discovered that diet had no impact on intakes of dry matter, crude protein, neutral detergent fiber, milk yield, milk fat content and yield, or milk protein yield. The effects of feeding orange slices that have been ensiled to dairy sheep that are nursing are also being investigated (Volanis *et al.,* 2004). Daily, the animals were given three kilograms (79.5%) of sliced orange silage mixture in place of some of the maize grain/soybean meal/oat hay ration given to the control group. Corn products or dried citrus pulp are given to dairy animals, and their performance is evaluated (Leiva *et al.,* 2000). The scientists discovered that diet had no impact on intakes of dry matter, crude protein, neutral detergent fiber, milk yield, milk fat content, or milk protein yield. The effects of feeding orange slices that have been ensiled to dairy sheep that are nursing are also being investigated ((Volanis *et al.,* 2004)). Daily, the animals were given three kilograms (79.5%) of sliced orange silage mixture in place of some of the maize grain/soybean meal/oat hay ration given to the control group. The authors observed that milk yield was 12% higher for controls and that ewes fed orange silage had milk with 16% more fat. The same authors also demonstrated that the addition of sliced oranges reduced milk yield and milk protein concentration, likely as a result of decreased microbial protein synthesis and flow to the intestine, and increased milk fat concentration, likely as a result of a concentration effect. When wet lemon pulp was given as a supplement to late-lactation ewes grazing on natural pastures, milk yield increased (0.89 kg/d versus 0.72 kg/d), milk protein content decreased (to 52 g/L from 55.7 g/L), and milk fat concentration, nitrogen fractions, or milk coagulation properties were unaffected (Todaro *et al.,* 2004). In the diet of a low-producing dairy ewe, the addition of dried citrus pulp up to a level of 300 g/kg of concentrate dry matter (roughly 110 g/kg of dietary dry matter) as a replacement for grains, soybean meal, and wheat middling did not affect milk yield or the concentrations of milk fat, protein, or lactose, but it did change the milk's fatty acid profile (Vasta *et al.,* 2008). Citrus pulp is a dietary supplement that may be utilized for dairy animals and other animals in general. According to the findings, substituting citrus by-product feeds for maize grain and other high-starch diets leads to identical milk output and composition in lactating ruminants (Sinclair, 1984).

Principal Obstacles to Employing Agro-Industrial by Product Waste in Animal Nutrition

By-products produced in an industry as a result of the manufacturing of primary goods are referred to as agro-industrial by-products. In comparison to agricultural residues, by-products are less fibrous, more concentrated, very nutritious, and less expensive (Zaza, 2008; & Alnaimy *et al.,* 2017). The restricted usage of some agro-industrial by-products may be attributed to major restrictions on the use of particular feed supplies. The primary challenges of using agro-industrial waste in animal feeding are as follows:

- The composition of agroindustrial byproducts is fre quently unpredictable.
- Limited duration of use, such as seasonality and loc al production.
- A lot of wetness.
- Exorbitant handling and shipping costs from the fac tory to the farm.

- Some feed supplies' nutritional value is unknown to farmers.
- Competition from other users.
- The existence of ant-nutritional elements.
- Protein value may be lost due to dehydration.
- The high-fat content of the olive cake's lipids.
- The development of mould (aflatoxins) may be hazardous.
- Additionally, the inability to use this by-product as fresh material for extended periods of time and the lack of practical ways to include it in feeding schedules may contribute to their underutilization.

CONCLUSION

Fresh citrus pulp, citrus silage, dried citrus pulp, citrus meal and fines, citrus molasses, citrus peel liquor, and citrus activated sludge are the principal citrus by-product feeds fed to ruminants. The rumen ecology and, consequently, cellulolytic, are often less negatively impacted by the supplementation of forages with citrus by-product feeds that are high in pectin or highly degradable neutral detergent fiber than by the supplementation of forages with starch- or sugar-rich feeds. There are several different energy substrates for ruminant microorganisms present in citrus byproduct feedstuffs, including both soluble carbohydrates and quickly digested neutral detergent fiber. Crude protein digestibility drops, neutral detergent fiber and acid detergent fiber digestibility increase, and dry matter and organic matter digestibility coefficients tend to stay unaltered when citrus by-product diets are used in place of starchy feeds. Due to possible benefits to the rumen microbiota, citrus by-product feedstuffs enhance the utilization of other dietary neutral detergent fiber. Additionally, giving citrus by-product feedstuffs to ruminants when straw is utilized as their main source of nutrition improves their diet by addressing any nutritional shortages in the straw and increasing the digestion of its contents. When added to ruminant diets, citrus byproduct feedstuffs as high-pectin energy sources tend to enhance the molar percentage of acetic acid while decreasing the molar proportion of propionic acid, increasing the acetate/propionate ratio. Citrus byproduct feedstuffs can be utilized in diets for ruminants to boost lactation and development as a high energy feed.

REFERENCES

1. Baraghit, G. A., Ahmed, B. M., & El-Mahy, M. A. (2009). Digestibility, nutritive value and rumen fermentation of rice straw and sugar cane bagasse treated with a commercial bacterial culture. *Egypt J Nutr Feed*, *12*(3), 511-522.
2. Zaza, G. H. M. (2005). Effect of incorporation of biologically treated sugar beet pulp as non-conventional feedstuffs in the diets of growing rabbits. In *Proceeding of the 4th International Conf. on Rabbits Prod. In hot Climates. Sharm El-Sheik, Egypt* (pp. 267-274).
3. Habeeb, A. A. M., Gad, A. E., & El-Tarabany, A. A. (2011). Effect of two climatic conditions and types of feeding on body weight gain and some physiological and biochemical parameters in crossing calves. *Zagazig Vet. J*, *39*, 34-48.
4. Nour, A. M. (1988). Agricultural industry wastes in animal nutrition. *In Proceeding of the 1st National Conf. on Role of scientific research and Technology*. Cairo, Egypt.
5. USDA–FAS. (2010). Citrus: World Markets and Trade. *Citrus Update* (pp. 1–9.). Foreign Agriculture Service–USDA. USA.
6. Mirzaei-Aghsaghali, A., & Maheri-Sis, N. (2008). Nutritive value of some agro-industrial by-products for ruminants-A review. *World J. Zool*, *3*(2), 40-46.
7. Duoss-Jennings, H. A., Schmidt, T. B., Callaway, T. R., Carroll, J. A., Martin, J. M., Shields-Menard, S. A., ... & Donaldson, J. R. (2013). Effect of citrus byproducts on survival of O157: H7 and non-O157 Escherichia coli serogroups within in vitro bovine ruminal microbial fermentations. *International journal of microbiology*, *2013*.
8. Bampidis, V. A., & Robinson, P. H. (2006). Citrus by-products as ruminant feeds: A review. *Animal feed science and technology*, *128*(3-4), 175-217.
9. Range Cattle Research and Education Center (RCREC). (2009). Citrus Pulp: *New information for an old feed byproduct*. University of Florida, IFAS, USA.
10. Grasser, L. A., Fadel, J. G., Garnett, I., & DePeters, E. J. (1995). Quantity and economic importance of nine selected by-products used in California dairy rations. *Journal of Dairy Science*, *78*(4), 962-971.
11. Arthington, J. D., Kunkle, W. E., & Martin, A. M. (2002). Citrus pulp for cattle. *Veterinary Clinics: Food Animal Practice*, *18*(2), 317-326.
12. Devendra, C., & Gohl, B. I. (1970). The chemical composition of Caribbean feedingstufis. *Tropical Agriculture, Trinidad and Tobago*, *47*(4), 335-42.
13. Devendra C (1988). Non–conventional feed resources and fibrous agricultural residues. *Strategies for expanded utilization. International Development Research Council (IDRC), Ottawa, Canada and Indian Council of Agricultural research.* New Delhi, India.
14. Gohl BI. (2007). Ruminant nutrition: selected articles from the World Animal Review. Citrus by–products for animal feed. FAO Corporate Document Repository, *Produced by Agriculture and Consumer Protection. Animal Nutrition*. FAO, Rome, Italy.
15. Crawshaw, R. (2003). Co-product feeds: Animal feeds from the food and drinks industries R Crawshaw Nottingham University Press, Nottingham, 2001 pp 285, price£ 30.00 (paperback) ISBN 1-897676-35-2. *Journal of the Science of Food and Agriculture*, *83*(4), 362-362.
16. Ammerman, C. B., & Henry, P. R. (1991). Citrus and vegetable products for ruminant animals. *Proceedings, Alternative Feeds for Dairy and Beef Cattle, St Louis, MO*, 103-110.

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

17. Fegeros, K., Zervas, G., Stamouli, S., & Apostolaki, E. (1995). Nutritive value of dried citrus pulp and its effect on milk yield and milk composition of lactating ewes. *Journal of Dairy Science*, *78*(5), 1116-1121.
18. Migwi, P. K., Gallagher, J. R., & Van Barneveld, R. J. (2001). The nutritive value of citrus pulp ensiled with wheat straw and poultry litter for sheep. *Australian Journal of Experimental Agriculture*, *41*(8), 1143-1148.
19. Bath, D. L., Dunbar, J. R., King, J. M., Berry, S. L., Leonard, R. O., & Olbrich, S. E. (1980). By-products and unusual feedstuffs in livestock rations. *WREP-Western Region Extension Publication-Cooperative Extension Service (USA)*.
20. ADAS (1992). Dried citrus pulp. ADAS Nutrition Chemistry Feed Evaluation Unit. *Technical Bulletin No, 92/8*, 1–22.
21. Lanza, M., Priolo, A., Biondi, L., Bella, M., & Salem, H. B. (2001). Replacement of cereal grains by orange pulp and carob pulp in faba bean-based diets fed to lambs: effects on growth performance and meat quality. *Animal Research*, *50*(1), 21-30.
22. Bueno, M. S., Ferrari Jr, E., Bianchini, D., Leinz, F. F., & Rodrigues, C. F. C. (2002). Effect of replacing corn with dehydrated citrus pulp in diets of growing kids. *Small Ruminant Research*, *46*(2-3), 179-185.
23. Rihani, N. (1991). Feed value and use of citrus by-products in animal feed. *Mediterranean Options Seminar Series* , *16* , 113-117.
24. Lanza A. (1984).Dried citrus pulp in animal feeding. In J. Hollo (ed.). *In Proceedings of the International Symposium on Food Industries and the Environment Budapest* (Pp.189–198). Hungary, New York, USA..
25. Villarreal, M., Cochran, R. C., Rojas-Bourrillón, A., Murillo, O., Muñoz, H., & Poore, M. (2006). Effect of supplementation with pelleted citrus pulp on digestibility and intake in beef cattle fed a tropical grass-based diet (Cynodon nlemfuensis). *Animal Feed Science and Technology*, *125*(1-2), 163-173.
26. Jong-Kyu, H. A., Kim, S. W., & Kim, W. Y. (1996). Use of Agro-Industrial by-Products as Animal Feed in Korea. *Suweon: Animal Science and Technology College of Agriculture and Life Science, Seoul National University*, 441-744.
27. Heuzé, V., Tran, G., & Hassoun, P. (2012). Citrus pulp, dried. *Feedipedia*.
28. Peacock, F. M., & Kirk, W. G. (1959). *Comparative feeding value of dried citrus pulp, corn feed meal and ground snapped corn for fattening steers in drylot* (No. 616). Gainesville, FL, USA: University of Florida Agricultural Experiment Station.
29. Khattab, M. S. (2008). *Preparation of silage from vegetable and fruits market wastes treated with some additives and its effect on the productive performance of lactating animals* (Thesis). Faculty of Agric. Ain-Shams University, Egypt.
30. El-Sayed, I. M. (1994). *Nutritive value evaluation of some crops, vegetable and fruit residues* (Doctoral dissertation, M. Sc. Thesis, Fac. Agric., Cairo University).
31. Belibasakis, N. G., & Tsirgogianni, D. (1996). Effects of dried citrus pulp on milk yield, milk composition and blood components of dairy cows. *Animal Feed Science and Technology*, *60*(1-2), 87-92.
32. Scerra, V., Caparra, P., Foti, F., Lanza, M., & Priolo, A. (2001). Citrus pulp and wheat straw silage as an ingredient in lamb diets: effects on growth and carcass and meat quality. *Small Ruminant Research*, *40*(1), 51-56.
33. Lashin ME, EA Saad, HA Salama (1995). Use of citrus wastes, pea pods and artichoke as silage for feeding buffalo calves. Proc. 5th Sci. Conf. *Animal Nutrition*, *1*, 137–144.
34. Omer, H. A. A., & Tawila, M. A. (2009). Response of Baladi goats to diets containing different levels of citurs by product. Egypt. *J. Nutr. and Feeds*, *12*(1), 75-88.
35. Chen, M. C., Ammerman, C. B., Henry, P. R., Palmer, A. Z., & Long, S. K. (1981). Citrus condensed molasses solubles as an energy source for ruminants. *Journal of Animal Science*, *53*(1), 253-259.
36. Van Horn, H. H., Marshall, S. P., Wilcox, C. J., Randel, P. F., & Wing, J. M. (1975). Complete rations for dairy cattle. III. Evaluation of protein percent and quality, and citrus pulp-corn substitutions. *Journal of Dairy Science*, *58*(8), 1101-1108.
37. Solomon, R., Chase, L. E., Ben-Ghedalia, D., & Bauman, D. E. (2000). The effect of nonstructural carbohydrate and addition of full fat extruded soybeans on the concentration of conjugated linoleic acid in the milk fat of dairy cows. *Journal of Dairy Science*, *83*(6), 1322-1329.
38. Leiva, E., Hall, M. B., & Van Horn, H. H. (2000). Performance of dairy cattle fed citrus pulp or corn products as sources of neutral detergent-soluble carbohydrates. *Journal of Dairy Science*, *83*(12), 2866-2875.
39. Volanis, M., Zoiopoulos, P., & Tzerakis, K. (2004). Effects of feeding ensiled sliced oranges to lactating dairy sheep. *Small Ruminant Research*, *53*(1-2), 15-21.
40. Todaro, M., Cacciatore, T., Ferrantelli, M., Iraci, C., Leto, L., Modica, R., ... & Sardina, M. T. (2004). Influenza del pastazzo di limone sulle caratteristiche qualitative e quantitative del latte di pecora. *Proc. 16th Natl. Congr. SIPAOC, Siena, Italy*, 331.
41. Vasta, V., Nudda, A., Cannas, A., Lanza, M., & Priolo, A. (2008). Alternative feed resources and their effects on the quality of meat and milk from small ruminants. *Animal Feed Science and Technology*, *147*(1-3), 223-246.
42. Sinclair, W. (1984). The biochemistryand physiology ofthe lemon and other citrus

***Corresponding Author:** Alsaied Alnaimy Mostafa Habeeb

fruits. *University of California, Division of Agricultural Sciences, Riverside, California*.

43. Zaza, A. I. A. (2008). Performance of awassi lambs fed citrus pulp and olive cake silage submitted in partial fulfillment of the requirements for the degree of master in animal production. *Faculty of Graduate Studies at An-Najah National University*.
44. Habeeb, A. A. M., Gad, A. E., Mustafa, M. M., Atta, M. A. A., & Basuony, H. A. M. (2017). Using of citrus by-products in farm animals feeding. *Open Access Journal of Science*, *1*(3), 58-67.

Conflict of Interest

Author declares that there is no conflict of interest