A Seminar Paper

On

Effects of Feeding Fruit and Vegetable By-products in Livestock

Course Title: Seminar
Course Code: ASN 598

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ABSTRACT

The increasing consumption of animal products will give rise to a vast demand of animal feed. Meeting this demand will be a challenge, given the scarcity of natural resources such as land and water. There are major environmental, economic and social factors favoring the re-utilization of fruit and vegetable processing by-products in farm animal nutrition. Current evidence shows that fruit and vegetable processing by-products can be efficiently used in farm animal nutrition for the production of improved quality food products and maximize production. Simultaneously it will help justifying environmental problems that arise due to disintegration of such wastes in the environment. The nutritional value, conservation methods and feed inclusion level must be maintained, for the incorporation of these unconventional feed resources in the diet of farm animal. The fruit and vegetable processing by-products is an exceptional source of nutrients which can potentially be used after drying as an animal feed to reduce animal feeding cost and consequently increase farmers' profits. Equally important is to conduct risk evaluation given the presence of these contaminants in the animal diets. Researchers and poultry nutritionists have become interested in developing multi-prolonged technologies and processing methods. This chapter reviews the effects of proper utilization of fruit and vegetable by-products in livestock feed.

Key words: Fruit and vegetable by-products, Inclusion level, Conservation, Livestock.

Title of the seminar paper presented as a part of course ASN 598 during Summer 2020

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Chapter I

INTRODUCTION

Livestock play an integral role in the livelihood of poor farmers by providing economic, social and food security. Taking 2010 as the base year, the world would need 73 percent more meat and 58 percent more milk in 2050, while these values for developing countries will be 109 percent and 116 percent, respectively (FAO, 2011). To meet this demand, huge quantity of feed resources will be required. Already there is a considerable shortage of feed availability in most developing countries. The scarcity of feed sources often imposes a major challenge in livestock production in these countries (Aregeore *et al.*, 2000). The challenge can be alleviated by the use of unconventional feedstuffs in animal feeding depending on their nutrient content, availability and acceptability to animals; and provided it is economical compared to conventional feed ingredients (Elbashier & Omer 2013).

Recently, there has been great social and environmental pressure for the efficient reutilization of agricultural industry residues (Pfaltzgraff *et al.*, 2013; Santana-Méridas *et al.*, 2012) due to the global intensification of food production that has led to the construction of large quantities of food by-products and wastes (Waldron 2007). Utilization of agro-industrial by-products in farm animal nutrition reduces the environmental impact of the food industry and improves profitability and valorization of the agricultural by-products since feeding food residue to livestock is an efficient way to promote low quality materials into high quality foods (Elferink *et al.*, 2008).

The three main parameters affecting the application of unconventional feed ingredients in animal nutrition are related to animal factors and the presence of anti-nutritional factors, production logistics and profit that is extended from the food processing industry to the feed industry and, finally, to the farmer (Williams & Agri 2014).

Fruit and vegetable processing by-products are promising sources of expensive substances such as photochemical (carotenoids, phenolics, and flavonoids), antioxidants, antimicrobials, vitamins, or dietary fats that possess favorable technological activities or nutritional properties (Schieber *et al.*, 2001; Fernández-López *et al.*, 2008). However, to find out the optimum processing and utilization of such residues as animal feed, the seasonal availability and nutritive value of these by-products should be identified. Therefore, by-product could serve as an excellent source of nutrients for ruminants and can economize the production of animals (Wadhwa *et al.*, 2006).

OBJECTIVES

- ✓ To get familiar with fruit and vegetable by-products used in feed industry.
- ✓ To highlight the beneficiary effects of fruit and vegetable by-products.
- ✓ To get information of safe inclusion levels of fruit and vegetable by-products.

Chapter II

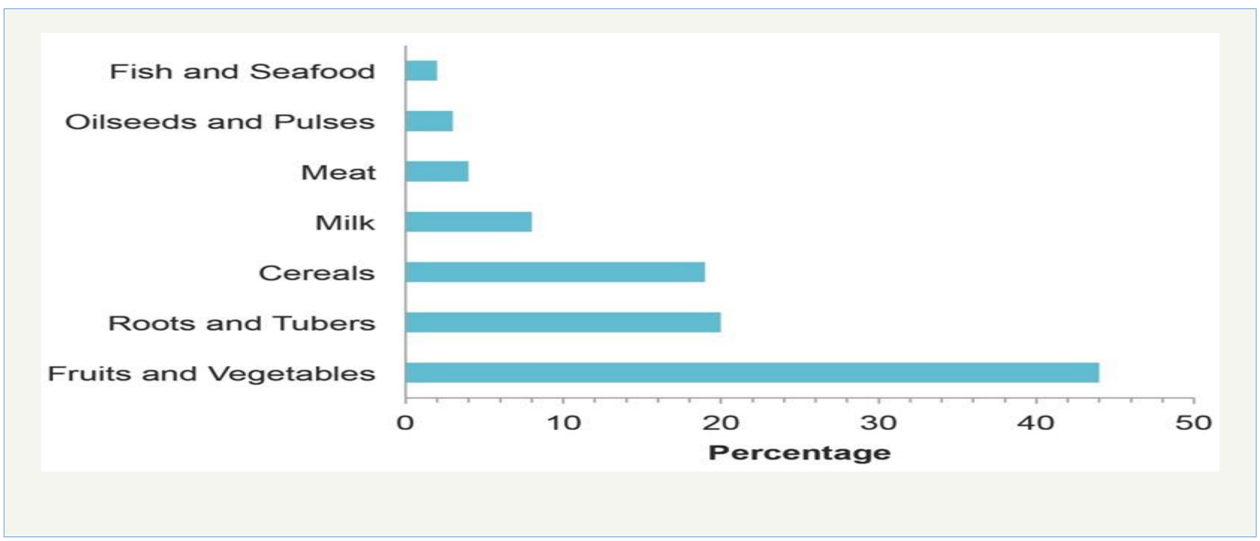
MATERIALS AND METHODS

Scientific approach requires a close understanding of the subject matter. This paper mainly depends on the secondary data. Different published reports of different journals chiefly supported in providing data in this paper. This paper is completely a review paper. Hence, no specific method has been followed in preparing this paper. It has been prepared by browsing internet, studying comprehensively several articles published in different journals, books, proceedings. The author would like to express his deepest sense of gratitude to his major professor and course instructors for their efficient and scholastic guidance, precious suggestions to write this manuscript from its embryonic stage. All the information collected from the secondary sources have been compiled systematically and chronologically to enrich this paper.

Chapter III

REVIEW OF FINDINGS

The fruit and vegetable by-products includes all products derived from the various stages of fruit and vegetable processing that are suitable for animal consumption and promote welfare and health, as well as human health and safety. According to the European Union Regulation EC 767/2009, feed materials are defined as: products of vegetable or animal origin, whose principal purpose is to meet animals' nutritional needs, in their natural state, fresh or preserved, and products resulting from the industrial processing thereof, and organic or inorganic substances, whether or not containing feed additives, which are intended for use in oral animal-feeding either directly as such, or after processing, or in the preparation of compound feed, or as carrier of premature (Kasapidou *et al.*, 2015).



(Source: FAO, 2011)

Figure 1. Global food waste by commodity.

Table 1: Quantities of various fruit and vegetable processing by-products

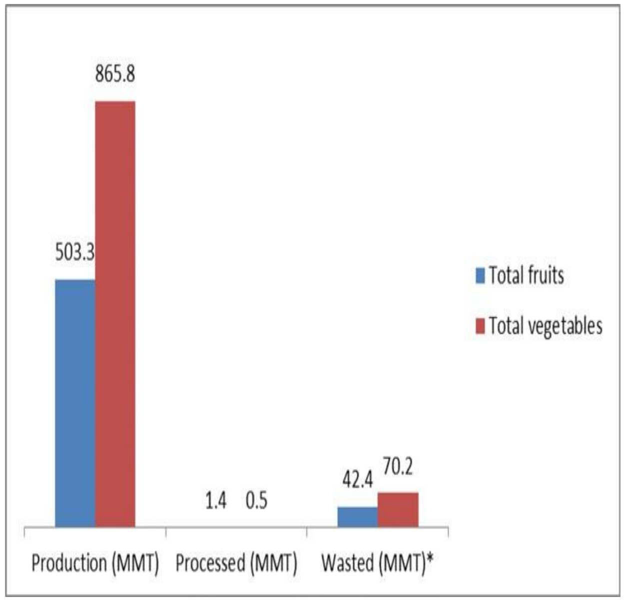
Commodity	Percent weight basis
Apple	12-47
Apricot	8-25
Grape fruit	3-58
Orange	3
Peach	11-40
Pear	12-46
Asparagus	3.2-30
Bean, green	5-20
Beet	7-4
Broccoli	20
Cabbage	5-25
Carrot	18-52
Cauliflower	8
Peas	6-79
Potatoes	5
Spinach	10-40
Sweet potato	15
Tomato	5-25

Source: (Joshi *et al.*, 2012)

3.1. Factors for the application of fruit and vegetable by-products in farm animal nutrition

- ✓ Seasonal and/or local supply
- ✓ Sufficient product quantity to support a supply chain
- ✓ Collection, transportation and processing cost
- ✓ Inadequate knowledge of processing, storage and handling conditions
- ✓ Unknown effects on nutrient digestibility related to processing situation and/or different feed formulations (matrices)
- ✓ Product bio-security and safety
- ✓ Feed palatability and animal reaction to the diet
- ✓ Variable product composition

- ✓ Limited or no knowledge of inclusion levels—Application of “best guess” theory for feed formulation



(Source: Sagar *et al.*, 2018)

Figure 2.Global production of fruits and vegetables, processed and wasted quantities (million metric tons, MMT).

3.2. Requirements for the application of fruit and vegetable by-products in farm animal nutrition

- ✓ Product standardization and precise description
- ✓ Nutritional evaluation
- ✓ Product compliance with legislation
- ✓ Product handling and storage
- ✓ Knowledge of the action mode
- ✓ Active compounds and bioavailability
- ✓ Knowledge of the presence of anti-nutritional factors
- ✓ Low cost

Table 2: Composition of different fruit by-products(per 100g)

Fruit	Moisture(g)	Protein(g)	Fat (g)	Minerals(g)	Fibre(g)	Carbohy-drate(g)
Apple pomac	-	2.99	1.71	1.65	16.16	17.35
Mango seed core	8.2	8.50	8.85	3.66	-	74.49
Jack fruit seeds	64.5	6.60	0.40	1.20	1.50	25.80
Banana peel	79.2	0.83	0.78	2.11	1.72	5.00
Sweet orange seeds	4.00	15.80	36.90	4.00	14.00	-
Watermelon seeds	4.3	34.10	52.60	3.70	0.80	4.50
Muskmelon seeds	6.8	21.00	33.00	4.00	30.00	-
Pumpkin seeds	6.0	29.50	35.40	4.55	12.00	12.53

Source: (Mani and Sethi, 2000)

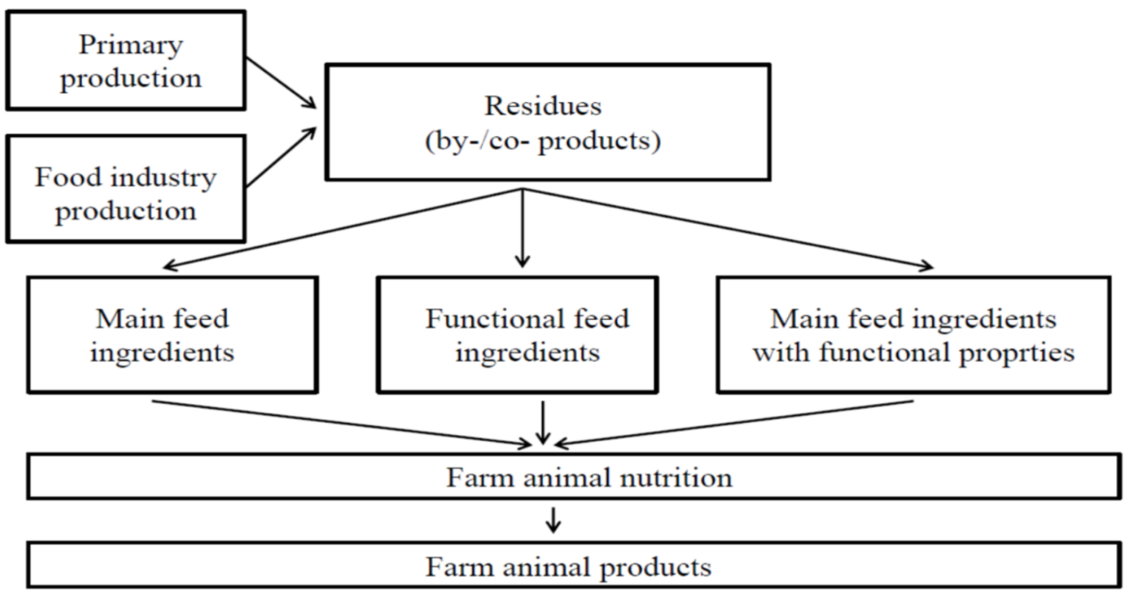
Table 3: Chemical Composition % of the Studied Vegetable by-products

Samples	DM (Dry matter) %	CP (Crude protein)%	EE (Ether extract)%	CF (Crude fiber)%	Ash%	NFE (Nitrogen Free Extract)%
Beet	90.4	16.28	0.8	9.2	11.3	52.82
Beet leaves	96	23.32	1.6	16	11.67	43.41
Carrot	83.9	7.04	1.2	15.4	10.73	49.53
Carrot leaves	95.5	9.35	2.8	7.8	21.16	54.39
Onion peel	91.3	8.66	1	44.5	15.56	21.58

(Source: Elbashier *et al.*, 2013)

3.3. **Food–Feed–Food System Description**

The present food–feed–food system is shown in Figure 3. Fruit and vegetable industry by-products are collected either from primary production fields, such as in the case of olive leaves, or from the processing factories, such as with pomaces; they are then used either as unprocessed residue or are subjected to processing. Processing procedures may involve drying, since most of these materials have a high moisture content that leads to product spoilage, or they may be subjected to advanced processing/biorefinery techniques for the collection of specific compounds such as phenols, vitamins, fatty acids, or carotenoids. The moisture content of citrus fruits lies in the range of 76%–83% (Crawshaw 2003), olive cake moisture stands around 30%–50% (Lopez *et al.*, 2001), and the average moisture content of grape pomace is approximately 64% (Makris *et al.*, 2007).



Source: (Kasapidou *et al.*, 2015)

Figure 3. Simplified schematic presentation of the food–feed–food system.

The produced by-products can be included in animal feed formulations either as main feed ingredients to provide crude protein and energy, such as citrus pulp, as dietary supplements to achieve a particular function. The food-feed-food cycle is completed by the production of primary (milk, meat, eggs) livestock products (Kasapidou *et al.*, 2015).

Table 4.Proximate composition of fruit by-products (fresh matter) and feeds used for in-vitro cultivation experiment

Items	GP	VP	Concentrate	Itarian ryegrass
DM (g/kg)	335	445	931	905
CP (g/kg)DM	95	145	180	95
NDF(g/kg)DM	250	340	220	680
NFC(g/kg)DM	495	448	735	85
TEPH(g/kg)DM	113	103	210	NA
CT(g/kg)DM	71	85	85	NA

GP, grape pomace; VP. wild grape pomace; DM, dry matter; CP, crude protein; NDF; neutral detergent fiber; NFC, non-fiber carbohydrate; TEPH, total extractable phenolics; NA, not available; CT, condensed tannins

Source: (Mousa *et al.*, 2019)

Table 5. Chemical composition of Napier silage, VWP, C-mix and VWP-mix

Parameters	Napier Sailage	VWP	C-mix	VWP-mix
DM (g kg−1fresh)	182	900	916	917
OM (g kg−1DM)	915	858	897	860
CP (g kg−1DM)	77	127	164	161
NDF(g kg−1DM)	650	450	311	366
ADF(g kg−1DM)	450	340	178	297
TDN(% Calculated)	-	63.8	-	-
GE(MJ kg−1DM)	-	14.3	-	-

VWP, vegetable wastes processed feed; C-mix, concentrate mixture with conventional ingredients; VWP-mix, concentrate mixture with VWP and conventional ingredients; DM, dry matter; OM, organic matter; CP, crude protein; NDF; neutral detergent fiber; ADF, acid detergent fiber; TDN, total digestible nutrients; GE, gross energy.

Source: (Das *et al.*, 2018)

3.4. Conservation of fruit and vegetable by-products (Drying method)

- ✓ Fruit and vegetable by-products such as fresh apple pomace, tomato pomace, bottle gourd pomace (muddy in texture), pineapple bran and carrot pulp contain about 90 percent water.
- ✓ Keep the fresh by-products in a heap on a slant till the excess water is drained out.
- ✓ Press mechanically by using filter press.
- ✓ Dry the by-products by thermal drying: by blowing hot air or by using a solar drier.
- ✓ In case a mechanical press or thermal drying facilities are not available, then the by-products may be spread in a 5–7 cm thick layer on a concrete floor under direct sunlight for sun drying. By-products such as chaffed banana foliage, pea pods, tomato pomace and snow peas can be easily sun dried.
- ✓ Turn the material upside down with a fork, 2−3 times a day, till the dry matter reaches around 90 percent. In peak summer (40−45 °C)the desired dry matter is achieved within 2−3 days.
- ✓ Ground the dried by-products in a Willey mill using 1−2 mm screen.
- ✓ Store the ground by-products in polythene bags and use as and when required.

Table 6: Macro mineral content (percent DM basis) of fruit and vegetable by-products

Commodity	Calcium	phosphorus	Magnesium	Potassium
Banana peels	0.29	0.18	0.30	1.11
Muskmelon peels	0.62	0.44	0.43	0.44
Watermelon peels	0.47	0.43	0.36	0.74
Sugar beet leaves	0.88	0.20	0.82	0.54
Cauliflower leaves	2.17	0.34	0.44	0.60
Cabbage leaves	2.38	0.23	0.68	0.44
Pea vines	1.28	0.22	0.49	0.45

Source: (Mani and Sethi, 2000)

Table 7: Micro mineral content (ppm) of fruit and vegetable by-products

Commodity	Iron	Copper	Zinc	Manganese
Banana peels	2947.0	386.0	1138.0	522.0
Muskmelon peels	226.0	54.4	40.0	20.40
Watermelon peels	185.0	4.8	39.3	14.36
Sugar beet leaves	677.0	8.8	32.5	67.8
Cauliflower leaves	387.0	4.0	40.8	40.8
Cabbage leaves	894.0	9.4	48.3	54.6
Pea vines	1587.0	10.9	53.6	49.8

Source: (Mani and Sethi, 2000)

3.5. Fruit by-products as livestock feed with safe inclusion level

3.5.1. Apple (*Malus domestica*)

Apple pomace, a mixture of skin, pulp and seeds left after the extraction of apple juice or after production of jam and sweets by the apple processing industry, constitutes approximately 25% of the apples taken for the processing (Ajila *et al.*, 2012). It is a rich source of insoluble carbohydrates, such as cellulose and hemicellulose as well as of reducing sugars, such as glucose, fructose and sucrose. But it is low in protein, essential amino acids and vitamin C (Albuquerque *et al.*, 2006; Villas-Bôas *et al.*, 2002; Joshi & Sandhu 1996).

Figure 4: Apple By-products

3.5.1.1. **Ruminants**: Apple pomace can be utilized in ruminant feed after drying or ensiling (Joshi & Sandhu 1996; Ahn *et al.*, 2002; Kafilzadeh *et al.*, 2008). The nutritive value of apple pomace was determined by sole feeding to crossbred (Karan Swiss) male calves (Singhal *et al.*, 1991) and to buffalo calves (Sharma & Sharma 1984). Its addition up to 60% in the diets of goats did not induce any adverse effect on DM intake, nutrient digestibility and nitrogen retention (Joshi & Sandhu 1996).

3.5.1.2. **Non-ruminants:**In broiler ration 10% of maize can be replaced by apple pomace without affecting production. A replacement level >10% produced wet litter and depressed feed efficiency probably because of higher fibre content (Zafar *et al.*, 2005). Inclusion of apple pomace did not affect intake, growth and feed: gain ratio up to 30% level of incorporation, deleterious effects on feed protein utilization were observed. Optimum level of apple pomace, on the basis of regression equation, was estimated as 11.3% in rabbit diet (Sawal *et al.*, 1995).

3.5.2. **Banana (*Musa acuminata*)**

There are two main types of bananas: (i) soft, sweet, dessert bananas consumed as a fruit, and belong to Musa acuminate; and (ii) plantains, hybrid of M. acuminate x M. balbisiana, are firmer, starchier, less sweeter fruit and eaten cooked rather than raw or used for making beer, vinegar, chips or starch. These represent 56 and 44% of the world banana production, respectively. About 30–40% of the total banana production is rejected for failing to meet quality standards and is potentially available for feeding to livestock (Babatunde 1992).

Figure 5: Banana By-products

3.5.2.1. **Ruminants:** Whole banana plant after removal of fruit bunch were chopped, sundried and fed to six crossbred (OngoleHolstein) bulls (6–7 years old; 422kg BW) as unique feed without any supplement for 30 days. The whole banana plant contained 6.4% DCP and 75.0% TDN on DM basis. Bullocks maintained their BW and met maintenance requirements; however, incidences of diarrhea were observed. Banana leaf meal (leaves chopped and sun dried) up to 40% in the forage-based ration on DM basis increased weight gains and feed efficiency of Zebu cattle and sheep (Garcia *et al.*, 1973)

3.5.2.2. **Non-ruminants**: Banana leaf meal when used up to 15% in the diet of growing pigs resulted in satisfactory average daily gain and feed conversion efficiency (García & Domínguez 1991).Rabbits can be fed up to 40% banana leaves without adverse effects on growth, feed intake and digestibility (Rohilla & Bujarbaruah 2000).

3.5.3. **Guava (*Psidium guajava*)**

In the tropics it is commonly known as the poor man's apple. After extracting pulp for making beverages, juice, syrup, ice cream, and jams. Ajila *et al.*, 2012 reported only 10% as waste or byproduct (pomace) after processing. Guava pomace has 61% CF and 12% EE. Guava seeds contain 9.7% protein and 8.9–9.4% oil (Habib 1986), which is a good source of linoleic acid. The pulp and peel have a high content of dietary fibre (48.6–49.4%).

Figure 6: Guava By-products

3.5.3.1. **Non-ruminants:** However, Lira et al., 2009 reported that guava pomace can be used in broiler (1–42 days) ration up to 12%, with no effect on the productive performance of the birds or the economic viability of the production. Sundried guava pomace could be included at 15% in diets of laying hen during 32–48 weeks of age without adverse effect on productive performance and egg quality (El-Deek *et al.*, 2009).

3.5.4. **Mango (*Mangifera indica L.*)**

India is the highest producer of mango pulp, contributing 42.7% to the world production . The left over after the extraction of pulp is called mango waste (peel and seeds), which constitutes 45% of processed mango (Ajila *et al.*, 2012).

Figure 7: Mango By-products

3.5.4.1. **Ruminants**: The DM digestibility of dried seed kernels in sheep was 70%, but intake was rather low (1.2% BW). The mango seed kernels had low palatability, probably due to the tannin content. However, a limited amount of kernels (<10%) with mango peels, rice straw and urea gave good results (Sanon & Kanwe 2010).

3.5.4.2. **Non-ruminants:** Raw mango seed kernel meal included at 5–10% in the diet depressed feed intake and growth in broiler chicks (El Alaily *et al.*, 1976).

3.6. Vegetable by-products as livestock feed with safe inclusion level

3.6.1. Carrot (*Daucus carota*)

Feed carrots are typically cull (grade-out) or surplus carrots obtained during glut season of production. These can be fed clean (whole/chopped), ensiled or dehydrated. Other carrot products that irregularly are fed to livestock include the carrot tops and carrot pomace after extraction of juice.

Figure 8: Carrot By-products

3.6.1.1. **Ruminants:** Carrots are highly palatable and readily consumed by cattle. Carrots are a rich source of ME (3.29 Mcal/kg DM) and NE (1.94 Mcal/kg DM) for lactating dairy cows (NRC, 1989). Clean carrots can be fed up to 20 and 25 kg/day to young bulls and dairy cows (Morel d'Arleux, 1990). Goats can be fed up to 2−4 kg/day of clean carrots (Morel d'Arleux, 1990).

3.6.1.2. **Non-ruminants**: Carrot is a staple diet of horses. Dry carrots and carrot flakes are common commercial treats for horses. Clean carrots are used in low amounts (2−3 kg/day) for working horses, and these are mostly used to maintain appetite and facilitate the consumption of dry feeds. Clean and well-preserved carrots can be fed up to 10 kg/day to resting or recuperative horses (Wolter, 1999).

3.6.2. Potato (*Solanum tuberosum L.*)

The fresh potatoes include 65−75 percent starch (depending on the variety), 9.5 percent CP and 0.4 percent EE on dry matter basis. Potatoes contain negligible quantities of fibrous fractions like NDF, ADF and cellulose.

Figure 9: Potato By-products

3.6.2.1. **Ruminants:** Potatoes have high ME (3.16 Mcal/kg DM) and NE (1.87 Mcal/kg DM) for lactating dairy cows (NRC, 1989). Dairy and beef cows can be fed up to 15−20 kg/day of raw potatoes without any adverse effects on the health of the animals (De Boever *et al.*, 1983).

3.6.2.2. **Non-ruminants**: Pigs are usually given only cooked potatoes, which are efficiently used by fattening and breeding animals. Pigs can be fed up to 6 kg a day. Potatoes produce firm pork. Cooked potatoes can be used for poultry up to 40 percent of the total ration (Edwards, Fairbairn and Capper, 1986).

3.6.3. **Sugar beet (*Beta vulgaris var. altissima*)**

The sugar beet leaves contain 22 percent CP and 3.5 percent EE. The leaves are rich in total soluble sugars (24.9 percent). The leaves are a rich source of both macro- and micro-elements, except that the Mg and Na contents were higher than the maximum tolerance limit for ruminants (Mani & Sethi 2000).

Figure 10: Sugar Beet By-products

3.6.3.1. **Ruminants**: Cattle and sheep appreciate the wilted leaves and crowns of sugar beet. However, due to the presence of oxalic acid, which may cause scouring, fresh leaves and crowns should not be fed at levels >10 kg/day, while ensiled leaves should not be fed at levels >15 kg/day to cattle and >2 kg/day to sheep (Mani & Sethi 2000).

3.6.4. **Tomato (*Lycopersicon esculentum Mill.*)**

Tomato waste is made up of culled tomatoes and tomato pomace. The culled fruits may be spoiled, diseased, too small, deformed etc. and do not meet the grading values for sale in the fresh market or for processing. Fresh culled tomatoes contain 14−20 percent CP, 4−5 percent EE and 22 percent ADF. Tomatoes surround 40−60 percent non-structural carbohydrates; 90−95 percent of them are soluble sugars and 5−10 percent pectins (ANSES, 2008; Ventura, Pieltin and Castanon, 2009).

Figure 11: Tomato By-products

3.6.4.1. **Ruminants**: Fresh cull tomatoes can be fed up to 1.5 kg to male goats with ad libitum ryegrass hay without digestive disorders (Ventura, Pieltin and Castanon, 2009).

3.6.4.2. **Non-ruminants**: Dried cull tomatoes adequately replaced alfalfa meal at 3 percent of the diet for broilers.

Table 8. Effects of fruit and vegetable processing by-products on farm animal product quality

By-Product or Extract	Animal Species	Effect
Grape pomace	Broilers	Antioxidant
Grape seed extract	Broilers	Antioxidant
Tomato extract	Broilers	Antioxidant
Hesperidin	Broilers	Antioxidant
Citrus pulp	Broilers	Improved fatty acid composition
Hesperidin	Laying hens	Antioxidant
Grape pomace	Laying hens	Antioxidant
Grape seed	Laying hens	Antioxidant
Tomato pomace	Ewes	Improved milk fatty acid composition
Olive leaves	Ewes	Improved milk fatty acid composition
Tomato waste	Goats	Improved milk fatty acid composition
Pomegranate seed pulp	Goats	Improved milk fatty acid composition
Citrus (orange) pulp	Goats	Improved appearance, taste and texture
Pomegranate seed pulp	Kids	Antioxidant
Pomegranate by-product silage	Lambs	Improved milk fatty acid composition
Olive cake	Lambs	Antioxidant
Dried citrus pulp	Lambs	Antioxidant
Pomegranate peel extract	Cows	Improved milk fatty acid composition
Dried stoned olive pomace	Water buffaloes	Improved milk fatty acid composition

Source: (Kasapidou *et al.*, 2015)

Chapter IV

SUMMARY & CONCLUSION

Fruit and vegetable by-products can be fed as livestock feed without effecting the palatability, digestibility, nutrient content, health or performance. After observing different research works or findings from books or journals both beneficiary and harmful effects are found due to addition of fruit and vegetable by-products in livestock diet. The effective and efficient utilization of fruit and vegetable by-products will reduce the feed cost and the farmer will be profitable. Animal performance, production yield and end product quality will be improved by feeding fruit and vegetable by-products. The use of wastes and by-products has the potential to bridge the gap between feed demand and feed availability & will also decrease food–feed competition. Furthermore, these unconventional feed resources are good alternative source of energy. It helps in waste management and reduction of environmental pollution.

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