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CITRUS PULP AS AN INNOVATIVE FEED INGREDIENT IN RUMINANT NUTRITION. A REVIEW

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SUMMARY

Over the last fifty years, the Egyptian population increased from approximately 34 million in 1969 to more than 101 millions in November, 2019 based on Worldometers survey of the latest United Nations data (Worldometers 2019). As a result of this substantial growth, demand on food supply should have been more than the double. This means that agricultural scientists must work vigorously to increase food production, both plant and animal, to meet the increased needs of future generations.

In Egypt, there is a serious gap between available and required amounts of animal feed supplies, which have been calculated to be 4.2 million tons of total digestible nutrients (TDN) per year (Shoukry 2019). The shortage in concentrate feed resources represents a major constraint to animal production in Egypt.

Continued rise in prices of corn grains that are locally produced in Egypt, or that imported from abroad reflected on increasing the price of concentrate feed mixture (CFM) because corn grains represent a high percentage (approximately 50±10%) of the CFM of ruminants. Egypt's import of corn grains increased from 64000 tons in 1969 to 10 million tons during 2018/2019 (USDA 2019), representing approximately 156 fold increase during the last 50 years. The importation of the yellow corn grains annually depletes a huge amount of foreign currency (estimated about 2 Billion dollar/year in 2018). A recent study (Shoukry 2019) showed that more than 70% of poultry and fish nutritional requirement are imported. Those reasons led the specialists in animal nutrition to search for alternative feedstuffs that may partially or completely replace traditional feed ingredients as a source of energy in animal rations.

Citrus by-products may play an important role in solving this critical issue. There are many forms of citrus by-products feedstuffs fed to ruminants (Bampidis and Robinson 2006). The present review will be focused on fresh, silage and dried orange pulp because these are the most available forms of citrus by products in Egypt.

The fresh citrus pulp (FCP) is the raw by-product of citrus juice industry, which includes all contents of the citrus fruit, except the expressed citrus juice (Hutton 1987). It is palatable for the animals, low price compared to other feed materials that have the same nutritional value and provides good digestible nutrients. Also, it is rich in vitamin C and antioxidants, which is positively reflected in the health and productivity of the animal. However, the disadvantages of FCP are bulkiness, spoils quickly and is fly-breeding nuisance if allowed to rot, and provides an unbalanced Ca: P ratio. Because of its high moisture content (76-87%), usefulness of citrus pulp can be enhanced by ensiling or drying it and converting it to dry citrus pulp (Bakr 2015).

Ensiling citrus pulp is a good method to make it available for year-round feeding (Fuller, 2004). The silage has a pleasant odor and is readily acceptable by cattle. Citrus pulp enhances overall silage quantity and quality (more sugars, more acidic bacteria, lower pH) and reduces the need for acid additives (Crawshaw, 2004). Fresh citrus pulp silage can be preserved in good condition without an additive (Revuelta Llano et al., 2008). Moreover, citrus pulp ensiled without additives gives better results in energy conversion efficiency measured by production of volatile fatty acids (Itavo et al., 2000).

The dried citrus pulp is a by-product produced after extraction of the juice from citrus fruits and drying of the residues. It is classified as an energy concentrate by-product feed. The DCP was used at different percentages of substitution of grains (corn, barley, and wheat), beet pulp, and sometimes as an antioxidant feed supplementation.

Keywords: Citrus pulp, citrus silage, dried citrus pulp, ruminant's nutrition, growth rate, milk yield, milk composition

INTRODUCTION

In Rome 2009, the high level expert forum was held entitled "How to feed the world 2020" and there was some important information in this forum. The World population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050 and nearly all of this growth is forecast to take place in the developing countries (FAO 2009). These trends mean that market demand for food would continue to grow. Demand for cereals, for both food and animal feed uses is projected to reach some 3 billion tonnes by 2050, up from today's nearly 2.1 billion tones (FAO 2009).These trends mean that market demand for food would continue to grow. Production in the developing countries would need to almost double.

The Egyptian population increased during the last 50th years from approximately 34 millions in 1969 to more than 101 millions in November, 2019 based on Worldometers elaboration of the latest United Nations data (Worldometers 2019). that's This means that the Egyptian population increased by double during the last 50 years. Therefore, agricultural scientists must work vigorously to increase food production, both plant and animal, to meet the needs of future generations.

Recently, and according to result from Egyptian animal production market, the nutritional cost increased and represents approximately 75% of variable costs of animal production projects and the cost of CFM represents approximately 75% of the total nutritional cost of beef and dairy animal's projects in Egypt.

In Egypt, there is a serious gap between available and required amounts of animal feeds and it was calculated to be 4.2 million tons of total digestible nutrients (TDN) per year (Shoukry 2019). This led the specialists in animal nutrition to search for alternative feedstuffs or agro-industrial by-products that may replace corn grains as a source of energy in animal rations.

The shortage in concentrate feed resources represents a major constraint to animal production in Egypt. Corn grains represent a high percentage (approximately 50±10%) of concentrate feed mixture (CFM) of ruminants, plus continued rise in prices of concentrate feed, especially corn grains that are locally produced in Egypt, or that imported from abroad. Egypt's import of corn grains increased from 64000 tons in 1969 to 10 million tons during 2018/2019 (USDA 2019) representing approximately 156 fold during the last 50th years. The importation of the yellow corn grains annually depletes a huge amount of foreign currency (estimated about 2 Billion dollar/year in 2018). In a recent study Shoukry (2019) calculated that more than 70% of poultry and fish nutritional requirements are imported.

These reasons led the specialists in animal nutrition to search for alternative feedstuffs that may partially or completely replace traditional feed ingredients in animal rations.

Citrus by-products may play an important role in solving this critical issue. There are many forms of citrus by-products feedstuffs fed to ruminants (Bampidis and Robinson 2006).

The objective of the present review will be focused on fresh, silage and dried orange pulp because these are the most available forms of citrus by products in Egypt.

Benefits of proper use of citrus by products as a source of energy in ruminant rations:

The increase of proper using of huge amount of citrus by products annually produced in Egypt as an alternative source of energy in ruminant's rations have some important advantages:

(1) Decreases dependence of livestock on grains, hence, reduces the depletion of foreign currency spent on the importation of yellow corn year by year.
(2) Utilization of non-conventional (non-traditional) feedstuffs especially those materials that don't compete with human consumption.
(3) Decreases the environmental pollution because fresh materials are difficult to handle due to its bulkiness, fermentation and quick spoilage that can be a fly-breeding media if allowed to stay.
(4) Decreases the cost of animal feeding that recently represent more than 75% of variable costs of animal production projects.
(5) Use of unconventional feed ingredients as a functional feed that add bioactive molecules which improve the productive performance of ruminant for their content of antioxidant capacity, and some antibacterial activity.
(6) Ameliorates the harmful effects of heat stress on production and animal health; hence get ready for the upcoming global warming
(7) Produces high quality-low price meat and milk (functional feed for functional food).
(8) The use of these materials can help in establishing small and medium industries run labor and thus realizes sustainable development through the achievement of economic goals, improves the social situation and increases person's level living in Egypt.

Citrus pulp as an innovative feed ingredient in ruminant nutrition:

The main target of produced citrus fruit is consumption by humans as fresh fruits or processed juice. There are about 70 species of citrus, only two, the grapefruit *(Citrus paradise* Macf.) and the sweet orange *(C. sinensis* Pers.) are industrially processed on a large scale, mainly for juice (Gohl 1978). After juice extraction from the citrus fruits, the remained residues are citrus industrial by-products (Bampidis and Robinson 2006).

The main forms of citrus by-products feedstuffs fed to ruminants are fresh (wet) citrus pulp (FCP), citrus silage, dried citrus pulp (DCP), citrus meal and fines, citrus molasses, citrus peel liquor, and citrus activated sludge. Other minor BPF from citrus include cull or excess fruit (Bampidis and Robinson 2006). This review will be focused only on orange pulp (fresh, silage and dried) because these are the most famous and available forms of citrus by products in Egyptian market plus small amount of lemon pulp.

Fresh citrus pulp (FCP):

Fresh citrus pulp (FCP) is the raw by-product of citrus juice manufacture which includes everything from the citrus fruit except the expressed citrus juice (Hutton 1987). The FCP contains around 20% DM, representing about 50% of the weight of fresh oranges, but this can vary from 50 - 70% depending on species, variety, husbandry and processing techniques. The DM comprises mainly from peel (60-65%) and segment pulp (30-35%) with some residual seeds (0-10%). This variation largely depends on species and varieties within species (Hutton 1987).

The advantages of FCP are acceptable taste for animals (palatability) and the mature cow can consume about 10 kg per day (Gohl 1978), low price compared to other feed materials that have the same nutritional value (250 LE /ton price market in 2018), good nutritional value. It contains approximately 13-24% DM, 7-8.5% CP, 2-5% EE based on DM), rich in its content of vitamin C and antioxidants, which are positively reflected on the health and productivity of the animal and good nutrient digestibility.

The disadvantages of FCP are difficulty to handle because of bulkiness, where citrus pulp bulk density was estimated to be 303 kg/ m^3 - 324 kg/ m^3 (Ammerman*et al*., 1965 and Kammel 1991). It ferments and sours quickly leading to being a fly-breeding nuisance if allowed to spoil. It is unbalanced in Ca:P ratio. Also, storage of the fresh by-product is difficult due to its high moisture content (76-87%). So, to increase the usefulness of citrus pulp it can be preserved by ensiling or drying and converting it to dried citrus pulp (Bakr 2015).

Citrus pulp silage (CPS):

Ensiling citrus pulp is a good method to make it available for year-round feeding (Fuller, 2004).The silage has a pleasant odor and is readily eaten by cattle. Citrus pulp enhances overall silage quantity and quality (more sugars, more acidic bacteria, lower pH) and reduces the need for acid additives (Crawshaw, 2004).The CPS can be preserved in good condition without an additive (Revuelta Llano *et al*., 2008). Additives (formic, acetic or propionic acid or enzyme inoculate) do not improve CPS quality (Itavo et al., 2000a). Moreover, citrus pulp ensiled without additives gives better results in energy conversion efficiency measured by production of volatile fatty acids (Itavo et al., 2000b).

In different studies, the CPS can be preserved in good condition by mixing with sugarcane bagasse (Montejo et al., 2008), mixed with grass or hay (Göhl, 1978) in order to increase DM content. However, and according to the author opinion, these methods are not economic for Egyptian market for the recent increase in the price of roughages feed ingredients. Also, if the orange pulp mixed with hay, the price of mixed silage will be more expensive than corn silage. If the orange pulp mixed with low quality roughages, the nutritive value of mixed silage will be less than corn silage. In my opinion and according to my practical experience in producing a huge amount of orange silage in different farms in Egypt, the appropriate method for making orange silage is the distribution of rice straw on the floor of the banker in a layer ranging from 5 to 10 cm according to the quantity to be manufactured. Preparing suitable place for receiving the FCP and then transferring the fresh pulp to the banker by loader bucket and pressing it only by the loader bucket and do not allow to the loader climb up the fresh pulp. After transporting all fresh pulp to the banker, 2 kg of salt and 3 kg of limestone should be added per every $1m^2$ of the banker top layer to prevent fungal growth and mold in these layer. After 45 days the banker will be ready to use as good quality orange silage. With this suggested method the price of orange silage will represent 35-40% of the price of corn silage according to the price of these material in Egyptian market in 2019.

The average chemical composition of orange pulp silage was 19.6% DM, CP 7.7%,CF 14.3%, EE 2.6%, ash 5.1%, and gross energy 18.1 MJ/ kg DM (Feedipedia 2012).

Dried citrus pulp (DCP):

Dried citrus pulp is the suitable form that can maximize the use of citrus pulp as animal feed throughout the year after sun drying or mechanically. The DCP is used as a cereal substitute in ruminant feeds, due to its high energy content and good digestibility by ruminant species. The benefits of DCP are the most versatile of the citrus feeds, palatable, rich in nutrients, easily mixed with other feed ingredients and exerts a mildly laxative effect. It can be stored all-year around for feeding, and deteriorates less in storage than many other feeds. Rodents and birds are not particularly attracted to it and it is slightly hygroscopic and should therefore be stored in dry place (Gohl 1978).

The chemical composition of citrus by-products is influenced by factors that include the source of the fruit, proportion of seeds and peel, type of processing, variation in production site, citrus variety, the harvesting season and citrus species (Hutton 1987; Arthington *et al*., 2002; and Wadhwa *et al*., 2013). Dried citrus pulp is usually made from oranges (60 %), grapefruits and lemons. It contains 10- 40 % soluble fiber (pectin) and 54 % water soluble sugars, 1−2 % calcium due to the addition of lime and 0.1 % phosphorus (Crawshaw 2004; Wadhwa *et al*., 2013).

Chemical composition of DCP, summarized from several sources, is shown in Table (1). According to data in Table 1, the DCP contains in average: 85.8% - 94.5% DM, 83.15 - 96.2 % OM, 5.41 - 8.68 % CP, 10.33 – 15.69 % CF, 0.9 – 4.92 % EE, 3.8 – 16.85% Ash, 59.33 – 70.1% NFE, 18.9 – 29.7% NDF, 12.8 – 24% ADF and 0.9 – 5 ADL.

Calcium and phosphorus contents were 0.79% and 0.16%. respectively in whole fresh grapefruit, 0. 47% and 0.23% in whole fresh orange and were 1.3% and 0.12% in fresh orange pulp (Gohl 1978). So that, when DCP is included in the ration, it is necessary to ensure that Ca and P levels are adequate and are in the right ratio because citrus pulp is not balanced in calcium and phosphorus ratio. Moreover citrus pulp has a lowvitamin A content (Gohl 1978) so, green leafy roughage should be an important ingredient in rations with high levels of the pulp or added as a premix (minerals and vitamins mixing).

Santos *et al*. (2014) found that DCP contained 78.4 mg/ 100 g, DM of polyphenols and 16.1 mg/ 100 g, DM of flavonoids.

Table 1. Chemical composition of dried citrus pulp summarized from several sources

Author	Chemical composition (%)							Cell wall constituents (%)		
	DM	OM	CP	CF	EE	Ash	NFE	NDF	ADF	ADL
Copeland and Shepardson (1944)[1]	91.59	84.4*	5.41	10. 33	1.81	7.16	66.88	-	-	-
Gohl (1978)[1]	91.8	92.9*	6.9	13.1	2.8	7.1	70.1	-	-	-
Hutton (1987)[1]	91.4	86.8*	6.2	12.3	3.7	4.7	64.6	27	24	1.5
NRC (1988)[4]	88	96.2	8.5	-	1.7	3.8*	-	21	16	-
Fegeros*et al.* (1995)[1]	90.4	83.15	7.71	11.15	4.92	16.85	59.33	19.4	12.8	-
Belibasakis and Tsirgogianni (1996)[1]	90.4	-	6.2	13.1	-	-	-	25.9	23.1	-
NRC (2001)[4]	85.8	92.8	6.9	-	4.9	7.2	-	24.2	22.2	0.9
Bampidis and Robinson (2006)[4]	90.2	90.9	7.2	-	3.0	9.4*	-	19.3	16.9	5
Caparra *et al*. (2007)[2]	86.4	90.7*	8.6	-	2.9	9.3	65.1	29.7	21.1	2.5
Aghsaghali and Maheri-Sis (2008)[1]	89.7	93.7	6.9	-	2.3	6.3*	-	22.0	19.7	2.1
Allam *et al*. (2011)[4]	85.8	92.95	7.2	12.2	4.5	7.05	69.05	27.73	20.96	2.92
Palangi *et al.*, (2013)[3]	88.73	94.9	8.68	-	0.9	5.1	-	21.4	18.3	-
Lima *et al.* (2014)[1]	88.75	-	5.84	-	1.77	-	-	18.93	16.02	-
Santos *et al*.(2014)[3]	94.5	94.7	6.0	-	1.9	5.3*	-	19.1	14.6	0.8
Wang *et al.*, (2017)4.	90.75	-	6.17	15.69	3.51	-	-	23.37	21.49	-
Sharif *et al.*, (2018)	90.5	94.46	6.49	-	-	5.43	-	20.59	14.29	-
Allam *et al*. (2020)[4]	89.66	92.51	8.48	13.85	4.66	7.49	65.51	26.36	23.8	2.2

[1]dried citrus pulp, [2]solar dried citrus pulp, [3]Pelleted citrus pulp, [4]dried orange pulp,* calculated, - : not detected.

The content of vitamin C (ascorbic acid) in citrus pulp is higher than yellow corn grains; and also varies by different citrus species. Generally, Vitamin C content in orange pulp is higher than in lemon pulp (Bakr 2015, Allam *et al*., 2020).

Energy content in citrus pulp

The International feed number of DCP without fines is 4-01-237 (Bampidis and Robinson 2006) and it is known that fourth group in the international feed number represents feedstuffs used as an energy source. Harris *et al*. (1982) mentioned that citrus pulp is a good source of energy in animal rations. However, unlike cereals, its energy is not based on starch but on soluble carbohydrates and digestible fiber. Kemmere *et al*. (1948) found that the energy value of dried grapefruit meal was 74.5 therms per 100 pounds.

The ME availability of DCP was 85- 90 % that of maize and comparable to barley (NRC, 2001 and Bampidis and Robinson, 2006). The DCP is used as a cereal substitute in concentrate diets due to its high OMD (85- 90%) and energy availability (2.76 - 2.9 Mcal ME/kg DM and 1.66 -1.76 Mcal NE/kg DM) for lactating dairy cows (Wadhwa *et al*., 2013).

Bampidis and Robinson (2006) mentioned that DCP contains 22- 40% of pectin and that may be considered high concentration. Citrus pulp contains both pectin and cellulose, with pectin comprising approximately 450 g/kg of cell wall. Pectin is degraded very rapidly and extensively in the rumen but, unlike starch, it yields little lactate, causing less decline in rumen pH. Citrus by products feed stuffs, as high pectin energy sources, when included in rations for ruminants, tended to increase the molar proportion of acetic acid and decrease the molar proportion of propionic acid, resulting in an increased acetate/propionate ratio (Bampidis and Robinson 2006). Similarly, Wing (2003) found that citrus pectin's were easily and extensively degraded, producing acetic acid, which is less likely than lactic acid to cause a pH drop and result in acidosis.

The energy value of DCP as a TDN % ranged from 82 to 86% (Arthington *et al*., 2002 and Santos *et al*., 2014) compared to 86.2 TDN in ground corn. The GE (MJ/kg DM) in DOP ranged from 16.23 (Bampidis and Robinson 2006) to 17.49 (Allam *et al*., 2020) compared to 17.69 in yellow corn grains. Bampidis and Robinson 2006) found that DE and ME in sheep were 5.35 and 12.8 (MJ/kg DM). The energy value as a NEl (7.36 to 8.37), NEg (4.89 to 8.87) and NEm (7.36 to 10) MJ/kg DM (Bath *et al*. 1980, NRC 1988, NRC 2001, Bampidis and Robinson 2006 and Arthington *et al.,* 2002).

Replacement levels of dried citrus pulp in ruminant rations

Dried citrus pulp is widely used in ration of lactating animals (cows, ewes and goats), fattening calves, steers, lambs, and goats kids at different percentages of substitution with energy source like, grains (corn, barley, and wheat), dried or pelleted beet pulp and as a part of CFM and, sometimes, DCP is used as feed supplementation to study its effect as an antioxidant. The replacement levels of DCP in formulated feeds varies according to availability and relative cost effectiveness of alternative raw materials (Hutton 1987). The replacement levels ranged from 8% to 100% with energy source (Copeland and Shepardson 1944; Kemmere *et al*., 1948; Van Horn *et al*., 1975; Harris *et al*., 1982; Belibasakis and Tsirgogianni 1996; Leiva*et al*., 2000; Miron*et al*., 2002; Assis *et al*., 2004; Caparra*et al*., 2007; Jaramillo *et al*., 2009; Allam *et al*., 2011; Shdaifat *et al*., 2013; Santos *et al*., 2014 and Allam *et al*., 2020).

Effect of using dried citrus pulp in animal rations on:
Milk yield:

Dried orange pulp (DOP) showed to be equivalent to beet pulp in milk production (Reagan and Mead 1927; Copeland and Shepardson 1944; and Belibasakis and Tsirgogianni 1996). Similarly, Belibasakis and Tsirgogianni (1996) found that, mean daily milk yield and 4% fat-corrected milk (FCM) were higher by 0.5 kg and 1.8 kg/day, respectively, with lactating Friesian cows fed ration containing DCP (20% from dried beet pulp, ground maize and CFM). Arnold *et al*. (1941) found that slightly more milk and butterfat were produced from cows fed grapefruit pulp than from those fed beet pulp. Davis and Kemmerer (1948) found that the daily addition of 4 lb of dried grapefruit peel to an alfalfa hay ration increased milk production of dairy cows and they concluded that dried grapefruit peel contains factors which stimulate milk production by dairy cows.

Assis *et al*. (2004) evaluated the replacement of corn by pelleted DCP in lactating cow's rations at levels 33%, 67% and 100% and insignificant differences were found on milk production or FCM. The same trend was reported by Santos *et al*. (2014) who studied the effect of 9% and 18% replacement with pelleted DCP in ration of dairy cows and found insignificant effect on milk production and 4% FCM yield (kg/d). Also, milk yield (kg/d), protein, TS and lactose were insignificantly affected by dietary treatments.

As a source of antioxidant, with soybean oil as a source of PUFA, and in ruminally fistulated lactating Holstein cows, Lima *et al.* (2014) studied the effect of supplementation of citrus pulp on milk yield and reported that treatments did not have any significant effect on average daily milk yield.

Recently, Allam *et al*. (2020) found an improvement in DMY of Holstein cows fed rations containing DOP compared to control cows which were fed a ration containing yellow corn grains especially under heat stress conditions. Citrus peel and pulp when fed in moderate quantities under extremely hot weather had a beneficial effect on the appetite of dairy cows (Copeland and Shepardson 1944) or for the effect of vitamin C as antioxidant or anti heat stress (Allam *et al.,* 2020).

In lactating ewes, Fegeros *et al*. (1995) found that milk or FCM yields were insignificantly affected by the replacement of some grains, soybean meal, and wheat middlings by DCP for up to 30% of the concentrate, or at 10% of the total ration, on DM basis. In the same trend, Shdaifat *et al*. (2013) replaced 20% barley grains by DCP in the ration of lactating Awassi ewes and reported insignificant differences in DMY.

In contrast, in 1944, five experiments had been conducted with lactating dairy cows comparing a concentrate ration containing 50% citrus peel and pulp with a similar concentrate ration containing 50% ground corn and cob meal without shuck. The results of milk production showed a slight difference in milk yield favoring the ground corn ration (Copeland and Shepardson). Also, Gohl (1978) recommended that the citrus pulp should not be used at high levels for milking cows as milk production tends to decrease. Leiva *et al.* (2000) found that cows fed 19.5% cornmeal (ration CMD) yielded more milk (3.9 kg/d), 3.5% fat- and protein-corrected milk (2.6 kg/d) compared to cows fed ration containing 20.5% citrus pulp (DCP).

Milk composition:

Researchers had different findings about the effect of DCP on milk composition of lactating animals especially its effect on milk fat parentage. Using of citrus pulp in dairy cow feeds significantly affected milk composition, and also citrus taint may be passed into the milk under certain conditions (Hutton 1987). However, the same author observed no problem when 25% DCP were added as feed supplement (around 2 kg/ cow/ day). Also, Copeland and Shepardson (1944) suggested that no citrus taint was detected in milk composition from cows fed up to 3.6 kg daily of dried citrus peel and pulp.

Major components:

Some experiments revealed that inclusion of DCP in rations of lactating cows insignificantly affected milk composition. Authors evaluated replacement of energy source by DCP on lactating cow's rations at different levels (Wing 1975; Belibasakis and Tsirgogianni 1996 and Assis *et al*., 2004 and Santos *et al*., 2014) or studied the effect of supplementation of DCP as a source of antioxidant (Lima *et al*., 2014) or in lactating ewes rations (Fegeros *et al.,* 1995 and Shdaifat *et al*., 2013) and insignificant differences were found on milk composition (CP, Fat, SNF and total solid).

On the other hand, some experiments reported that inclusion of DCP in lactating cow's rations significantly affected milk composition specially by increasing milk fat % or yield (Van Horn *et al*.,1975 and Belibasakis and Tsirgogianni 1996). The authors suggested three explanations for the increase in fat content and yield as a benefit for fed ration containing DCP: First it may probably be due to the higher cholesterol concentration, which possibly leads to an increase in the cholesterol level of milk fat. Second explanation might be that the citrate contained in the citrus pulp is taken up by the mammary gland and the increased cytoplasmic citrate will provide a substrate for lipogenesis and possibly some activation of acetyl-CoA carboxylase. The third explanation might be that an increase in the molar concentration of rumen acetic acid and the ratio of acetic to propionic acids, which is the precursor of short and medium chain fatty acids in milk fat. Finally it may be that, although DCP is not described as roughage feedstuff, it may help - but cannot entirely prevent- in case of cows fed rations lacking in roughages, because DCP keep acetate levels and pH in the rumen high, and this tends to prevent low milk fat and metabolic problems on fiber-deficient rations (Harris *et al*. 1982).

Other experiments demonstrated that the inclusion of DCP in lactating cows rations (Leiva *et al*., 2000; Santos *et al*., 2014 and Bakr 2015, Allam *et al.*, 2020) or in lactating ewes rations (Shdaifat *et al*., 2013) significantly affect milk composition by decreasing milk fat.

Profile of fatty acids (FAs), profile of amino acids and milk total plate count:

The information about the effect of the inclusion of DCP in lactating cow's rations on fatty acids profile in milk is limited (Santos *et al*., 2014).The replacement of some grains, soybean meal, and wheat middlings with DCP at 30% of the concentrate or at 10% of the total ration of lactating ewes significantly ($P<0.05$) decreased butyric, caproic, caprylic, and capric FAs. However, the long-chain FAs were unaffected by the dietary treatment (Fegeros *et al*., 1995).

Santos *et al*. (2014) found that milk fat of cows fed diets that contained pelleted DCP tend to be less in 4:0, 6:0, 14:0 and 20:0 Fas, and differences were insignificant, but the proportion of 8:0 and 11:0 FAs were higher in milk fat of cows fed diets with DCP, while milk fat of cows fed control diet had higher 10:0 and 17:0 FAs. Higher proportion of cis7-16:1 FA and lower proportion of 18:0 FA were found in milk fat from cows fed diet contained 3% soybean oil and 18% pelleted DCP. In general, cows fed 3% soybean oil and 18% pelleted DCP showed higher MUFA and lower SFA than cows fed the other diets. Bakr (2015) found that DCP rations may help to produce functional milk rich in MUFA, PUFA, especially CLA C18:2 and lower in its content of SFA and total plate count compared to milk produced from control group. So, DOP may be containing some components that increase milk quality. It is clear that the effect of inclusion of DCP in lactating cow’s rations on milk fatty acids, amino acid profile and milk total plate count needs further research.

Growth and beef cattle performance:

In beef cattle and heifers rations: DCP has been used as the main energy source and up to 45 % has been used in calf rations (Gohl, 1978). Hadjipanayiotou and Louka (1976) studied the nutritional value of DCP as a barley grain replacement in British Friesian male calves diets. The first concentrate consisted of barley grains (820 g/kg) and soybean meal (SBM) 150 g/kg, and the second of barley (200 g/kg), DCP (600 g/kg) and SBM (180 g/kg). The BW gain, feed intake, FCR and dressing proportion were similar among diets. The authors concluded that replacement of barley grains with DCP had no depressing effect on growth and that the nutritive value of DCP approached that of barley grain.

Schalch *et al*. (2001) partially, or totally, replaced ground corn and wheat grains with DCP in the starter concentrate of 28 Holstein calves fed one of four treatments with each having a different level of DCP in the concentrate (i.e., 0, 150, 300 and 450 g/kg). The BW gain, DM intake and FCR were similar among treatments and the authors concluded that DCP can successfully substitute cereals in the starter diet of calves.

The DCP can also be used in starter diets of calves as a substitute for an NDF rich feed, such as bermuda grass hay, and have similar BW gain, DM intake and FCR (de Castro and Zanetti, 1998).Vijchulata et al. (1980) suggest that DCP, when properly fed, is a similar energy source to corn grain for steers. In the low concentrate TMR, corn grain or DCP was incorporated at 70 g/kg DM of the concentrate, and in diets with a high concentrate level, corn or DCP was incorporated at 650 g/kg DM. No differences occurred among treatments in BW gain, DM intake or FCR (Henrique *et al*., 1998).

CONCLUSION

Citrus by-products (fresh, silage and dried orange pulp) may be playing an important role in solving problem of energy gap in ruminant ration in Egypt. These by products are palatable for the animals, low price compared to other feed materials that have the same nutritional value, and provides good digestible nutrients. Also, it is rich in pectin, vitamin C and antioxidants, which is positively reflected on the health and productivity of the animal. The silage has a pleasant odor and is readily acceptable by cattle. The dried citrus pulp (DCP) is classified as an energy concentrate by-product feed. The DCP was used at different percentages of substitution of grains (corn, barley, and wheat), beet pulp, and sometimes as an antioxidant feed supplementation. Overall, results suggest that substitution of corn grain in ruminants ration, as well as several other high starch feeds with DCP results in improving milk yield, composition, growth rate, digestibility, animal health and feed efficiency. It is clear that the effect of inclusion of DCP in lactating cow’s rations on milk fatty acids, amino acid profile and milk total platecount, anti heat stress needs further research.

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