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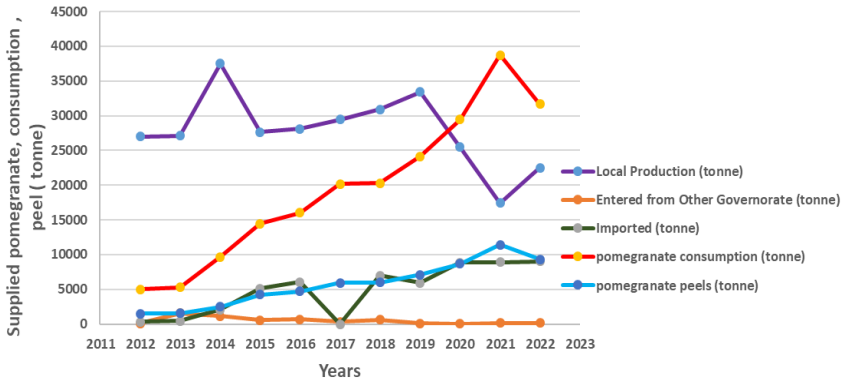


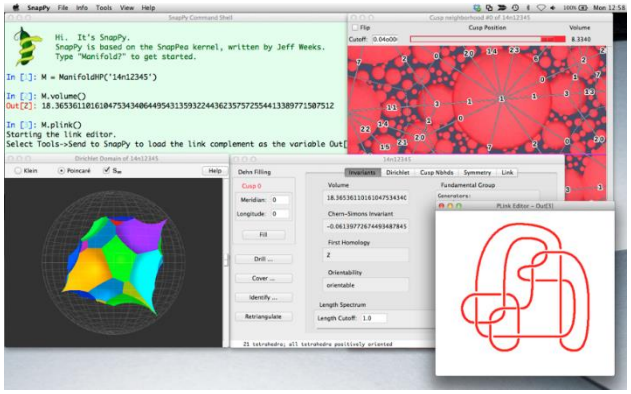


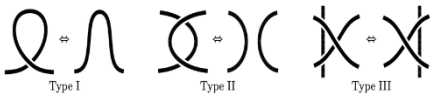

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# Production and consumption of Pomegranate in Sulaimania Governorate, and using their peels as ruminant feed.

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**Abstract**

The agriculture industry holds great importance in Iraq, particularly when it comes to pomegranate cultivation in the Sulaymaniyah governorate. The Halabja district is widely recognized for its expertise in producing and growing pomegranates, making it a prime subject for research. This presents an opportunity to improve the management of waste and by-products. As the industrial sector continues to grow around the world, there has been a significant increase in the amount of corn and soy used to feed livestock. To meet the rising demand for livestock production, it's essential to research alternative feed ingredients. The pomegranate juice processing industry creates a massive quantity of waste in the form of discrafed peels. This waste can cause disposal problems and environmental contamination. However, these discrafed peels could be utilized as a partial replacement for corn and soy in ruminant feed. By using agro-industrial by-products as feed, we can overcome conventional feed shortages and high prices for ruminants and find a sustainable alternative. conventional feed shortages and high prices for ruminants and finds a sustainable alternative. Additionally, this approach helps to mitigate the need for expensive waste management initiatives, when competition for nutrition between humans and animals is reduced, utilizing by-products such as pomegranate for animal nutrition can address related environmental issues.

The current study focuses on 10 years' worth of data of pomegranate production, consumption, and waste (2012–2022).Furthermore, there exist opportunities to improve livestock productivity in the Sulaymaniyah governorate located in Kurdistan, Iraq.

## Introduction

Reducing negative impact of environment, optimizing natural resource use, and minimizing landfill waste are key reasons for exploring waste options, in fruit production and processing (1). Also there is a substantial amount of fruit waste are produced each day which can be feed to ruminants and poultry. Researching alternative feed ingredients is crucial for addressing the rising demand for animal and poultry production. Utilizing fruit waste in animal and broiler diets as a partial substitute for corn or soy is one potential solution (2). Pomegranate peel and seed are considered by-products in the agro-industrial sector These compounds contain many bioactive

ingredients, including Anthocyanins, polyphenols, and tannins. These compounds have been linked to beneficial health well-being (3,4). The peel serves as the primary by product subsequent to the production of juice, functioning as a functional food and nutraceutical (5,6). Reducing and recycling waste is a pressing matter as it can improve food security, lessen the environmental impact of food production, lower waste management expenses and create possibilities for new products like animal feed. Tilts crucial to make efficient use of feed resources expand the range of feed resources available, and find new resources that don't, compete with human food in order to meet the demand for animal feed. reduce the environmental footprint of the food production chain, decrease waste management costs, and open opportunities for the production of novel products including animal feed (7).
As according to (8), this is crucial for the livestock industry's ability to develop sustainability, many developing countries are shifting their cropping patterns from cereals to more profitable fruit, this will result in the future generation of huge quantities of fruit waste, which could potentially be recycled and reintroduced back to the food chain by converting them into livestock feed (8), is an ongoing shift in the cropping pattern from cereals to more remunerative fruit and vegetable crops in a number of developing countries, this will result in the future generation of huge quantities of fruit waste, These could potentially be recycled and brought back to the food chain by converting them into animal feed. Up to 70% of a livestock farmer's costs may go into feeding their animals, utilizing waste products, however, can save these costs as well as increase rearers profits.

## Materials and Methods

### *Study area*

The study was conducted in the Sulaymaniyah governorate, where is a mountainous area located in the KRI, north-east of Iraq. Sulaymaniyah has a hot dry summer and a rainy cold winter climate. Sulaymaniyah governorate's total area is about 1,844,884 hectares, with 607,972 hectare of arable lands. It hosts the two major fertile plains in the region (namely, Sharazur and Bitwen plains), and has abundant water resources (9). This can give it a great capacity for agricultural production and self-sufficiency in agri-food products in the future if the resources are properly and sustainably utilized.

### *Data Collection*

The data on the cultivated area and production pomegranate in were obtained from the General Director of Sulaymaniyah governorate, (9,10).

### *Data analysis and calculation*

Fruit samples of pomegranate were collected from local markets in Sulaimania Governorate / Iraq and which imported from Turkey, Iran, and Egypt. The data that was gathered analyzed using Microsoft Office Excel 2019. This study employed four variables to ascertain the extend of planted area; consumption, peel production or Growth Percentage (%), Growth Rate, and Average of Annual Growth Rate.
The growth percentage was determined by subtract the original from the new value and divide the results by the original value. To turn that into a percent increase, multiply the results by 100.
Change percentage can be calculated from the following equation (11):

$$\text{Change \%} = (\text{Ending Value} - \text{Beginning Value}) / (\text{Beginning Value}) \times 100$$

Where:
Change % = Change percentage between the start and end periods
GR = Growth Rate, GR was calculated from the following equation (11):

$$GR = \left(\frac{\text{Ending Value}}{\text{Beginning value}} - 1\right) \times 100$$

The calculation of The average annual growth rate (AAGR) involved determining the average growth rates across multiple periods of equal duration, with each period being annualized (measured in years). AAGR was determined using the following mathematical calculation (11):

$$AAGR=(\sum GRn)/N$$

Where:
AAGR = Average of annual growth rate
GR n = Growth rate in a period (e.g. year 1, year 2, etc.)
N = Number of Years

## Results and Discussion

One of the most important crops grown in the Halabja district is the pomegranate crop. Instead, this fruit is of economic importance in the study area, mainly as it produces the finest types of pomegranates in Iraq, and it has a different taste. It is used in the manufacture of pomegranate molasses and juices, and in the manufacture of some remedies used in the treatment of some diseases (12). The pomegranate industry possesses substantial potential and plays a crucial role in the Kurdistan Region of Iraq's (KRI) attainment of food security and agricultural economic growth. It significantly contributes to enhancing the income of rural households and proves to be a profitable venture for farmer (13). Since 2009, the Kurdistan Regional Government (KRG) - Ministry of Planning had established a forward-looking vision with the aim of reconstructing the infrastructure Kurdistan Region of Iraq's (KRI). This plan has placed significant emphasis on the advancement of the agriculture sector, particularly the pomegranate production industry (14, 15,16).
Table 1 showed that instability in the cultivation area (Donum), Number of trees and, production rates (tonne) were observed during 2020-2022. Generally, Cultivates Area increased from 9600 Donum in 2012 to 10500 Donum in 2022, the number of trees increased from 2950000 in 2012 to 3300000 in 2022 at different percentage rates, and production (tonne) increased till 2019 then dropped to 25500 in 2020, and then declined again to 17450 in 2021, and rose again to 22500 in 2022, this is right for Cultivates Area and trees numbers. The presence of fluctuations and instabilities in local production has the potential to negatively impact the sustainability of agri-food and food security in the Kurdistan Region of Iraq's (KRI), specifically within the sulaymaniyah governorate.

**Table 1.** The annual growth rate and change in cultivated Area (Donum), Trees number, and production (tone) between (2012-2022) in Sulaymaniyah governorate.

| Year | Cultivates Area (Donum) | Increase Cultivates Area % | Trees Number | Increase Trees Number % | Production (Tonne) | Increase Production% |
|---|---|---|---|---|---|---|
| 2012 | 9600 | 100 | 2950000 | 100 | 26975 | 100 |
| 2013 | 9740 | 101.46 | 3075000 | 104.24 | 27120 | 100.54 |
| 2014 | 9858 | 102.70 | 3120000 | 105.76 | 37500 | 139,02 |
| 2015 | 9980 | 103.96 | 3134000 | 106.24 | 27660 | 102.54 |
| 2016 | 10000 | 104.16 | 3150000 | 106.78 | 28100 | 104.17 |
| 2017 | 10130 | 105.52 | 3200000 | 108.47 | 29450 | 109.17 |
| 2018 | 10480 | 109.17 | 3295000 | 111.69 | 30890 | 114.51 |
| 2019 | 10650 | 110.94 | 3337000 | 113.12 | 33425 | 123.91 |
| 2020 | 10220 | 106.46 | 3120000 | 105.76 | 25500 | 94.53 |
| 2021 | 10250 | 106.77 | 3098000 | 105.20 | 17450 | 64.69 |
| 2022 | 10500 | 109.38 | 3300000 | 111.86 | 22500 | 83.41 |
| Change% | 9.375 | - | 11.864 | - | -16.589 | - |
| AAGR% | 0.8345 | - | 1.073 | - | 0.520 | - |

Un published data from General Director of Agriculture in Sulaymaniya governorate

Between 2012 and 2022, the percentage increase in cultivated area was 9.375% and the percentage increase in the number of trees was 11.864%. However, there was a significant decrease in production, which dropped by -16.589%. The primary causes of the local output drop include political unrest, regional economic crises, drought, disease, and deforestation. The decrease in local production has detrimental effects on the overall sustainability of agri-food items in the KRI Kurdistan Region of Iraq's (KRI), with a specific emphasis on Sulaymaniyah governorate.

The average annual growth rate AAGR for the cultivated area و number of trees and production increased by 0.83, 1.07, and 0.52 respectively. While a drop in local pomegranate output AAGR could threaten KRI food security and the long-term viability of the agricultural sector.

Table 2 and figure1 revealed that Pomegranate production (tonne) increased till 2019 dropped to 25500 in 2020, and then declined again to 17450 in 2021, and rose again to 22500 in 2022, while the production inters Sulaimani governorate from other Iraqi governorate (like Diyala province) reduced between 2012-2022, but imported pomegranate from out border increased from 331 in 2012 tonne to 9019 tonne in 2022. Pomegranate consumption increased from 5023 tonne in 2012 to 31689 tonne in 2022, this is due to Pomegranate consumption having noticeably increased in the KRI in the last two decades. The region has seen economic prosperity before the spike in demand for pomegranate consumption. This economic upturn created a substantial disparity between the demand for pomegranates and the local agricultural production, prompting a rise in the importation of pomegranates from foreign sources (17,18). According to (19), the development in household income has a favorable impact on Pomegranate consumption, in the Kurdistan Region of Iraq's (KRI). There has been a decrease of -16.59% in pomegranate production, leading to a reduction in production, However, pomegranate (consumption and waste) has risen fivefold. This increase may be attributed to a growing population, increased awareness of the health benefits of pomegranate, higher levels of education, and greater income. The average annual growth rate for production, consumption, and waste increased by 5.69, 228.34, and 227.68, respectively. The agriculture waste or by-products of the pomegranate is a rich source of bioactive compounds (20).

**Table 2.** Local, entered from other Governorate, imported, consumption, and peels of pomegranate (tons) between 2012-2022.

| Year | Local Production (tonne) | Entered from Other Governorate (tonne) | Imported (tonne) | pomegranate consumption (tonne) | pomegranate peels (tonne) |
|---|---|---|---|---|---|
| 2012 | 26975 | 125 | 331 | 5023 | 1482 |
| 2013 | 27120 | 1550 | 426 | 5307 | 1566 |
| 2014 | 37500 | 1163.4 | 2101.3 | 9645 | 2485 |
| 2015 | 27660 | 572.7 | 5096.7 | 14482 | 4272 |
| 2016 | 28100 | 708.6 | 6069.3 | 16035 | 4730 |
| 2017 | 29450 | 332.2 | 4968,6 | 20164 | 5948 |
| 2018 | 30890 | 631.5 | 6995.7 | 20283 | 5984 |
| 2019 | 33425 | 108 | 5931 | 24153 | 7125 |
| 2020 | 25500 | 50 | 8861.5 | 29467 | 8693 |
| 2021 | 17450 | 158.6 | 8940.6 | 38709 | 11419 |
| 2022 | 22500 | 170 | 9018.9 | 31689 | 9348 |
| Total | 306570 | 5570 | 58741 | 214957 | 63052 |
| Change % | - 16.59 | 36 | 2624.77 | 530.88 | 530.77 |
| AAGR | 5.6973 | -------- | ------ | 228.34 | 227.68 |

Un published data from General Director of Agriculture in Sulaymaniya governorate.

The average pomegranate peel % = 29.5 The measurement was taken by the author.

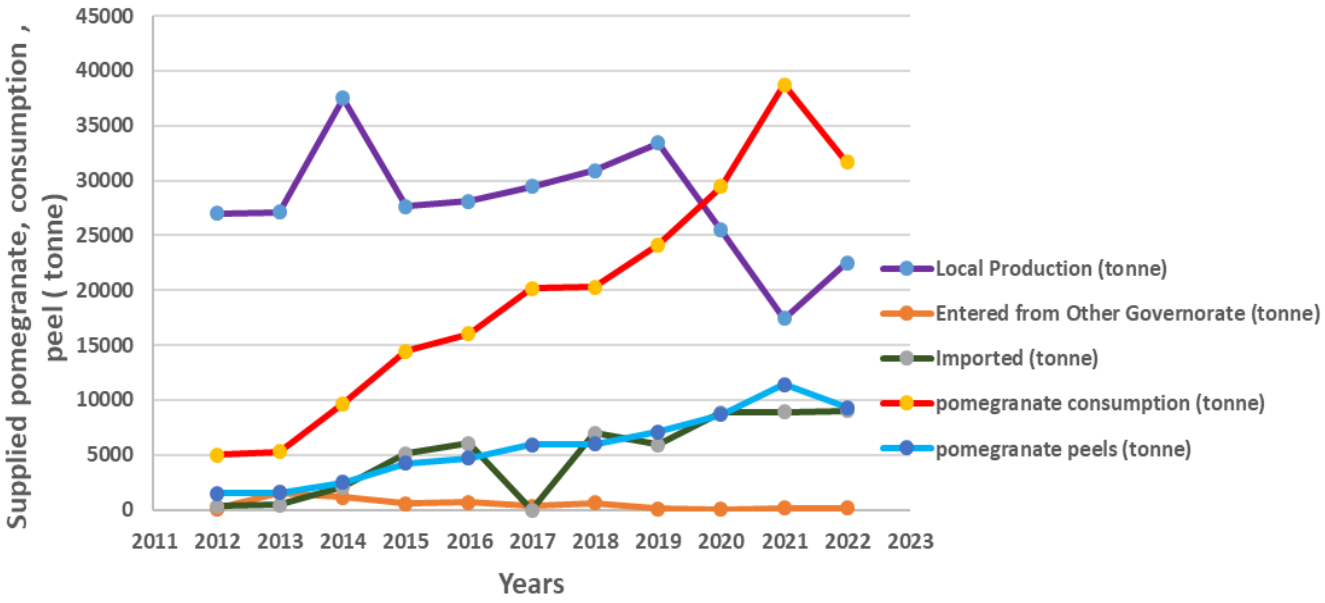


**Figure 1.** Trends of Pomegranates supply, consumption and peel in Sulaimaniyah governorate

### *Pomegranate waste problem*

The problem of pomegranate waste has several environmental, economic and health-related implications (21). Pomegranate waste breaks down anaerobically in landfills, releasing methane gas linked to climate change. Furthermore, Agricultural areas and ecosystems are impacted by pollution, unsuitable disposal, and contaminated soil and water (22). Pomegranate peels are rich in antioxidants, dietary fiber, and other bioactive compounds. Discarding them means losing out on their potential health benefits and nutritional value. Pomegranate waste transforms an underutilized resource into a valuable resource that can be. Recognizing the value of pomegranate waste and developing effective strategies for its utilization and management are essential steps toward addressing this problem.

### *Creative Methods for Making Use of Pomegranate Peels*

In recent years, innovative techniques for utilizing pomegranate peels have gained attention as a way to decrease waste and extract valuable compounds from this byproduct (23). Advanced extraction methods like supercritical fluid extraction (SFE) and microwave-assisted extraction (MAE) are being used to extract bioactive compounds such as polyphenols and flavonoids from pomegranate peels efficiently (24). Ultrasonic-assisted extraction (UAE) is a non-thermal technique that uses ultrasound waves to improve the extraction efficiency of bioactive compounds. Dried and ground pomegranate peels can be used to create dietary supplement that are rich in antioxidants (21), and dietary fiber. For their possible health benefits, pomegranate peel extracts or powders can also be used as feed additives in animal nutrition. (25). With the help of these inventive ways to use pomegranate peels, value-added products that could improve human health and the environment can be produced with less waste. (26). Moreover, these methods support sustainability objectives by optimizing resource use and reducing waste production

### *Pomegranate Peels*

Research conducted by (27) found that the peel percentage ranged from 34.29% to 51.48%. Another study conducted by (4,19) showed that the peel percentage fell around 30–40%, as well as 27%, which is similar to our result of 29.5%. According to (18), pomegranate fruit contains a high percentage of compounds that possess antifungal, antiprotozoal, antioxidant, anticarcinogenic, anti-inflammatory, and antibacterial properties. The

establishment of agricultural industrial facilities aimed at the manufacture of pomegranate juice results in the generation of pomegranate peel as a consequential output (28).

### Nutritional value of pomegranate peel left over

Dietary fiber, which can help with blood sugar regulation, weight management, and digestive health, is rich in pomegranate peels (29). They also include vital minerals like potassium and vitamins like C and K (30). Furthermore, pomegranate waste is a loaded source of phytochemicals with anti-inflammatory and anti-cancer properties, such as punicalagin, ellagic, and anthocyanins (24, 31). Ruminants have a unique ability to utilize fiber through their rumen microbes, which allows for the replacement of cereals with by-products. This can decrease competition between human and animal nutrition. According to (32,33), the inclusion of pomegranate peel in the feedlot calves diet at a level of up to 20% of their total feed intake did not exhibit any desirable beneficial or negative impact effects on their consumption of the fattening ration. nevertheless, as a result of its favorable taste, the consumption of feed rises at this quantity, so contributing to the enhancement of the Average Daily Gain (ADG) through is nutritious content. In contrast (34) discovered that the administration of pomegranate peel to young Calves' during the initial 70 days of their lives results in a reduction in grain consumption and a decrease in the digestibility of fat and crude protein across the entire digestive tract. This outcome is likely due to the elevated tannin levels. Another study, also found that presenting fresh pomegranate peel
improved feed intake and increased the final weight (35,36). Recent research investigation has also demonstrated that the presence of antioxidant in the diet of lambs, specifically in PP, has a positive impact on their overall health and performance (37,38). The presence of tannin in pomegranate is considered an anti-nutritional factor that can have detrimental effects on animal performance (39;40). This result is consistent (41,42,43)) who showed that using 5% PP as feed additives resulted in higher body weight gains than the 10% pomegranate peel group on Turkey-bred sheep. This may be because pomegranate peel contains a significant amount of tannin, which may alter the diet's taste. In addition, it was shown that lactating goats' feed intake and nutrient digestibility (Crude Protein, Crude Fiber, Dry Matter and Organic Matter) were increased by pomegranate peel consumption (44). Based on the current study findings, it can be concluded that increasing the amount of pomegranate peel powder supplementation linearly decreased average daily gain, total gain, and feed conversion ratio in local Iraqi goat kids fed a diet supplemented with two levels of PP powder. This decrease is most likely caused by the possibility that the structure of pomegranate peel contains significant amounts of tannin. The feed conversion ratio and total gain were decreased because tannin was discovered to bond with diet nutrients such as protein and carbohydrates post-ruminally limiting the animal body's ability to utilize these nutrients (45). Pomegranate peels work best when used at 1%–1.5%; concentrations higher than this showed no noticeable effects. (35 ,46, 47,48). It is noteworthy that the utilization of pomegranate waste may present certain challenges because of problems with transportation, storage, and processing. To effectively extract and use these nutritional components, though, new techniques and technologies are being developed. Acknowledging the pomegranate waste's nutritional worth is consistent with the ideas of sustainability and decreasing food waste. By utilizing its nutritional potential for a range of applications in the food, pharmaceutical, and cosmetic industries, pomegranate waste offers a chance to minimize food waste. The environment and general public's health benefit from this tactic (49).

## Conclusions

An innovative method of feeding ruminants has been found by utilizing agro-industrial by-products in place of traditional feed, especially to the yearly increase in pomegranate peels. The high cost of conventional feed and shortages are mitigated by this alternate technique. Pomegranate peel waste also lowers waste management expenses and environmental risks while opening up new product prospects, such as animal feed. It's ideal to gradually introduce different foods and see how your animals react to them.

## Conflict of Interest

I confirm no conflicts of interest associated with this manuscript.

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## انتاج و استهلاك و قشرة الرمان و التركيز على استخدام قشرة الرمان في تغذية المجترات

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**الخلاصة**

**حظى الصناعة الزراعية بأهمية كبيرة في العراق، خاصة عندما يتعلق الأمر بزراعة الرمان في محافظة السليمانية. تشتهر منطقة حلبجة على نطاق واسع بخبرتها في إنتاج وزراعة الرمان، مما يجعلها موضوعًا رئيسيًا للبحث. وقد ارتفع استهلاك الرمان من 5023 طناً عام 2012 إلى 31689 طناً عام 2022، فيما ارتفعت كمية قشور الرمان من 1482 طناً عام 2012 إلى 9348 طناً عام 2022. وتكشف هذه الأرقام أن لدينا كميات كبيرة من قشور الرمان التي تذهب سدى. ومع ذلك، هناك طرق مستدامة وفعالة من حيث التكلفة لإدارة وتقليل هدر قشور الرمان على المستوى الصناعي. إحدى هذه الإستراتيجيات هي استخدام قشور الرمان في الأنظمة الغذائية للحيوانات المجترة، وهو ما يمكن القيام به بكفاءة. وهذا يمثل فرصة لتحسين إدارة النفايات والمنتجات الثانوية. مع استمرار القطاع الصناعي في النمو في جميع أنحاء العالم، كانت هناك زيادة كبيرة في كمية الذرة وفول الصويا المستخدمة لتغذية الماشية. لتلبية الطلب المتزايد على الإنتاج الحيواني، من الضروري البحث عن مكونات علفية بديلة. تنتج صناعة معالجة عصير الرمان كمية كبيرة من النفايات على شكل قشور مهملة. يمكن أن تسبب هذه النفايات مشاكل في التخلص منها تلوثًا بيئيًا. ومع ذلك، يمكن استخدام هذه القشور المهملة كبديل جزئي للذرة وفول الصويا في علف الحيوانات. ومن خلال استخدام المنتجات الثانوية الصناعية الزراعية كعلف، يمكننا التغلب على نقص الأعلاف التقليدية وارتفاع أسعار الحيوانات المجترة وإيجاد بديل مستدام. نقص الأعلاف التقليدية وارتفاع أسعار الحيوانات المجترة وإيجاد بديل مستدام. بالإضافة إلى ذلك، يساعد هذا النهج على تخفيف الحاجة إلى مبادرات إدارة النفايات باهظة الثمن، وتقليل المنافسة على التغذية بين البشر والحيوانات، واستخدام المنتجات الثانوية مثل قشور الرمان الثانوية لتغذية الحيوانات يمكن أن يعالج القضايا البيئية ذات الصلة. تركز الدراسة الحالية على سجلات عشر سنوات (2012 إلى 2022) لإنتاج واستهلاك و قشور الرمان، والهدف هو تحليل اتجاهات إنتاج واستهلاك وهدر الرمان في مدينة السليمانية. بالإضافة إلى ذلك، هناك آفاق لتعزيز الإنتاج الحيواني في محافظة السليمانية، كردستان، العراق**