

Characteristics of the Recycling Channels for Apple Pomace

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1. Introduction

The apple industry is one of Aomori Prefecture's major industries and the apple juice processing sector is an important part of the industry. A large amount of food processing waste (apple pomace) is discharged from this sector in the manufacturing process. Making full use of this by-product is an important issue confronting the apple industry and Aomori Prefecture. Previously, it has been mainly used as livestock feed; however, recently, there have been changes in its use.

In such a situation, there is pressure to develop new technologies to make full use of the by-product. For instance, there are new techniques to produce polylactic acid (PLA), hydrogen and acetic acid from apple pomace.

However, there has been little research investigating how apple pomace is currently used and what factors inhibit its use. With the situation for unused resources rapidly changing it is especially important that the factors influencing utilization (recycling channels) be elucidated.

In this paper the following two points are clarified by case studies of apple juice processing companies in Aomori Prefecture. First, the characteristics of the channels currently used for recycling apple pomace in Aomori Prefecture. Second, the elucidation of factors limiting its uses.

2. The Amount of Apple Pomace Produced in Aomori Prefecture

The production, use and disposal of apple pomace from 1989 to 2003 in Aomori Prefecture are shown in Table 1.

The variation in the annual discharge of apple pomace is large with production varying more than twofold, ranging from a minimum of about 15,000 tons to a maximum of 37,000 tons. Moreover, the variation in annual use is also large, ranging between 10,000 tons and 20,000 tons. The supply of apple pomace depends on the amount of apple juice processing, which in turn is influenced by apple crop yields. Apple crop yields vary widely from year to year, so the annual production of apple pomace is also large.

In addition, not only is there an annual variation in production but there is also a seasonal variation. Because apple juice is produced from autumn to the following spring, the apple pomace supply is concentrated in this period also. The unstable annual and seasonal supply gives rise to problems in planning for the use of apple pomace.

Furthermore, changes in the utilization of apple pomace have occurred with time, with the amount and the proportion of the total production used as livestock feed decreasing since 1993. Use as a livestock feed accounted for about 50 % or more of the amount of discharge until 1993, for about 40 % during the period 1994 to 2000, and for about 30 % more recently. The proportion of apple pomace recycled decreased up to

Table 1 Amount of discharge and utilization of apple pomace in Aomori Prefecture (units: ton, %)

Year	Annual production				Utilization			
	Apple Crop	Processed Apples	Apple Pomace	Disposal	Total	Livestock Feed	Food Material	Others (compost, soil conditioner)
1989	502,800	115,024	22,832	2,637(11.5)	20,195	18,251(79.9)	486	1,458(6.4)
90	501,000	128,784	26,460	9,564(36.1)	16,896	15,169(57.3)	444	1,283(4.9)
91	261,500	183,347	36,795	15,548(42.3)	21,247	20,516(55.8)	531	200(0.5)
92	483,800	103,581	21,493	7,741(36.0)	13,752	13,199(61.4)	553	0(0)
93	482,100	88,672	17,345	4,800(27.7)	12,545	11,932(68.8)	560	53(0.3)
94	504,700	90,360	20,476	8,968(43.8)	11,508	7,737(37.8)	1,426	2,345(11.4)
95	481,300	85,604	17,799	8,228(46.2)	9,571	6,498(36.5)	1,519	1,554(8.7)
96	442,800	71,906	14,992	4,082(27.2)	10,910	6,046(40.4)	1,668	3,196(21.3)
97	488,700	102,342	23,626	7,324(31.0)	16,302	9,903(41.9)	1,552	4,877(20.6)
98	477,300	74,787	15,203	2,694(17.7)	12,509	6,485(42.7)	1,379	4,645(30.5)
99	474,800	82,678	16,775	4,339(25.9)	12,435	6,706(40.0)	1,056	4,673(27.9)
2000	407,200	77,313	16,363	2,803(17.1)	13,570	6,668(40.7)	2,060	4,842(29.6)
2001	491,500	108,672	22,646	1,734(7.7)	20,912	6,375(28.1)	3,207	11,330(50.0)
2002	488,100	92,024	17,631	1,393(7.9)	16,238	5,424(30.8)	637	10,177(57.7)
2003	424,900	61,297	11,657	738(6.3)	10,919	4,381(37.6)	1,378	5,160(44.3)

Source: *Essential Point of Measures to Apple Circulation*. Aomori Prefectural Government, Each annual.

- a) Survey of the main apple juice companies in Aomori prefecture. Aomori Prefectural Government presumes that about 90 percent of the total is covered.
- b) "Disposal" included that apple pomace processed by the industrial waste disposal contractors until 1999. It is presumed that a part of this was recycled as compost. After 2000, making into compost is excluded from "Disposal" and included in "Others".

1995 because of the decrease in use as livestock feed, with usage dropping to 50 % in 1995. However, usage has been on an upward trend again since 1996 as increasing amounts of apple pomace are used in compost or as a soil conditioner (" Others " in Table 1). Thus, the use of apple pomace has changed from being primarily a livestock feed to being primarily a compost or soil conditioner that is spread on the fields.

3. Case Studies of Recycling Channels for Apple Pomace

This chapter aims to characterize the recycling channels for apple pomace in Aomori Prefecture.

There are 11 main apple processing companies in Aomori Prefecture and 5 of these companies have been used as case studies. These companies are located in the Middle-South area, which is the main apple production area, and are on the Japan Sea side of Aomori Prefecture. Hirosaki City is the central city in this area. We researched these companies between 2002 and 2005.

(1) Case report 1: A cooperative society in Hirosaki City

The A cooperative society primarily produces apple juice. A Cs. is the largest buyer of raw processing apples in Aomori Prefecture, accounting for 21.8 % of the total in 1990 (Tsushima and Tamada 2]). A Cs. purchases about 16,000 tons of processing apples and produces 4,000-5,000 tons of apple pomace each year. The apple pomace is chiefly used as livestock feed. A Cs. has 2 channels for using apple pomace as livestock feed, one outside and one inside the prefecture.

First, utilization inside Aomori Prefecture; 3,000-4,000 tons of apple pomace is used as livestock feed in

the dairying area (Shimokita area) on the Pacific Ocean side of the prefecture. The amount used is decreasing in this area. A Cs. bears a cost of 4,000 yen a ton in this channel. A Cs. has the following view of this cost; the cost of making compost is estimated about 10,000 yen per ton, and the fee for commercial disposal (incineration) is estimated at 40,000 yen per ton. It is to A Cs. benefit that the cost for recycling as livestock feed is lower than these costs.

Second, utilization outside of Aomori Prefecture; 1,000 tons per year is used in a dairy farm in central Hokkaido (next prefecture) This channel was started about 2000 and the amount used in this channel is increasing. In this channel, A Cs. bears a cost of 2,700 yen a ton. This cost is lower than that incurred in the recycling channel within Aomori Prefecture.

(2) Case report 2: B Co., Ltd. Branch factory in Hirosaki City

B Co., Ltd. is a major whiskey and wine producing company in Japan. This case study is of a B Co., Ltd. branch factory that primarily produces cider in Hirosaki City. In 2001 3,023 tons of raw processing apples were purchased and about 400 tons of apple pomace were produced. All apple pomace has been made into compost since about 1998.

Two compost-producing companies process apple pomace, one in Hachinohe City on the Pacific Ocean side of Aomori Prefecture and the second in Hirosaki City. B Co. pays 6,000 yen per ton to the Hirosaki company and 8,000 yen per ton to the Hachinohe company. The higher cost at the Hachinohe company being due to higher transportation costs because of the greater distance to the company's premises in Hachinohe.

(3) Case report 3: C Co., Ltd. in Kuroishi City

C Co., Ltd. produces apple juice in Kuroishi City, which is next to Hirosaki City. Apple juice is produced from September to the following April. In 2003, 10,000 tons of raw processing apples were used and 2,000 tons of apple pomace, including 100 tons of damaged fruit, were produced.

The breakdown of total apple pomace use in 2003 was as follows; 1,000 tons were used as livestock feed, 200 tons were used as the raw material for food production, and 700 tons (including the damaged apples) were made into compost.

Apple pomace has been used as a raw material for food production for ten years. The apple pomace is made into a puree and sold to food processing companies in the Kanto area. The price is now falling because of competition from imported puree, so production is limited.

Apple pomace has been used as livestock feed by dairy farmers on the Pacific Ocean side of Aomori Prefecture since 1960. However, the number of dairy farmers carrying apple pomace away has decreased. Therefore, since 1980, it has also gone to Hokkaido through a trading company. In this channel, money is not exchanged.

Of the apple pomace used to make compost, 30 percent is processed by the Rokkasho Villages' compost processing company and 70 percent by the Hachinohe City's company; both companies are located on the Pacific Ocean side of the prefecture. The cost for making compost is 7,500 yen per ton (including a transportation cost of 4,000 yen) at both companies. The reason for the difference in the amount allocated to the two companies is that the Hachinohe company has more trucks than the Rokkasho company. So the Hachinohe company is able to carry away the apple pomace at once when requested by C Co.

Moreover, the reason that C Co. needs to compost the apple pomace, despite the higher cost, is as follows. Apple pomace is packed into flexible containers kept at the plant site until removed. Flexible containers cannot be piled up, because apple pomace is fluid. Therefore, a lot of storage space is necessary, but the plant site is of limited area. In addition, removal by the trading company is not regular because it carries away apple pomace only when transport companies have no other back-haul load to Hokkaido.

Therefore, the storage space for flexible containers is insufficient if removal is not conducted in time. C Co. can do nothing but request the compost processing companies, which can provide a more frequent service, to carry away the apple pomace.

(4) Case report 4: D Co., Ltd. in Hirosaki City

D Co., Ltd. produces apple juice and processed apple goods in Hirosaki City. Thirty percent of the raw apple material becomes apple pomace. This is pureed, heated and converted to apple puree. In addition, the core and the skin, discharged after processing, are made into compost by the compost processing company in Soma Village in the vicinity of Hirosaki City. The puree is sold to the major food processing companies in the Kanto area for use as the raw material base for curry sauce.

(5) Case report 5: E Co., Ltd. Branch factory in Hirosaki City

E Co., Ltd. is a major food processing company in Japan and this case study is of a branch factory in Hirosaki City. In this factory apple juice is the main product. Except for some varieties, the raw processing apples were collected from near this factory. The factory operates chiefly from September to December with 80 percent of production occurring during this period.

In 2004 14,000 tons of raw processing apples were processed, resulting in 2,000 tons of apple pomace. A small amount of apple pomace is processed to "apple fiber" used as the raw material for production of a functional food in Tochigi Prefecture. However, the major part of the apple pomace was made into compost by the K compost processing company in Hirosaki City. However, the cost of making compost is higher than using the apple pomace as livestock feed, therefore, use as livestock feed has been tried and the apple pomace has been sold to the beef cattle industry in the Nasu area of Tochigi Prefecture since 2001.

However, K Co. went bankrupt in September 2004, so since then the apple pomace formerly composted has been incinerated by R Company in Aomori City. The cost of making compost by K Co. was 4,000-5,000 yen per ton, whereas the cost for incineration by R Co. is 32,000-33,000 yen per ton, a six fold increase in cost. So E Co. is interested the full-scale use of the apple pomace as livestock feed. Fortunately, immediately before K Co. went bankrupt, the proportion of the apple pomace processed by the K Co. decreased to 70 percent and sales to the beef cattle industry in Tochigi had risen to 30 percent of total production. In the Tochigi recycling channel, the beef cattle industry bears the transportation cost. In addition, E Co. is paid for the apple pomace, so E Co. has a great advantage in this channel.

After K Co. went bankrupt, and because the cost for incineration is high, E Co. has since October 2004 been organizing a new disposal channel to the Doto area on the east side of Hokkaido. Apple pomace goes to a livestock feed processing company, with E Co. bearing half of the transportation and wrapping costs. As the cost of the Nasu recycling channel is less than that of the Hokkaido channel, E Co. wants to give the Nasu channel priority over the Hokkaido channel. However, the supply of apple pomace from E Co. greatly exceeds the demand from the Nasu channel, so the Hokkaido channel is also indispensable.

4. Conclusions

The major findings of this article are as follows:

First, there is a relationship between the recycling channel, the region and the income involved. These are summarized in Table 2. Recycling of apple pomace is roughly divided into 6 channels by usage and region. The usages are as a raw material for (functional) food, livestock feed, compost production and incineration. The regions are the Japan Sea side (I-J channel), the Pacific Ocean side (I-P channel) of Aomori Prefecture and outside the prefecture (O-P channel) The raw material for food is in the O-P channel, livestock feed is in both the I-P and O-P channels, compost is in the I-J and I-P channels and

Table 2. Recycling Channels of Apple Pomace in Aomori Prefecture

		Income	Inside of Aomori on Japan Sea Side (I-J channel)	Inside of Aomori on Pacific Ocean Side (I-P channel)	Outside of Aomori (Hokkaido, Tohigi, Kanto) (O-P channel)
	Transportation Cost		Low	Middle	High
Resource	Raw Material for Food	+	×	×	
	Livestock Feed	- or 0	×		
Industrial Waste	Compost	- -			×
	Incineration	- - -		×	×

incineration is in the I-J channel. Making compost and incineration are defined as “ Industrial Waste ” in the “ Waste Management Law ” of Japan and transfer between the prefectures is severely limited. Therefore, the O-P channel is not involved in these uses. Livestock numbers in the I-P region are high, so the I-P channel was the main channel for use as livestock feed initially, but recently the O-P channel has expanded.

Examining the cost of each usage; recycling the apple pomace as a raw material for food production is earning an income, recycling as livestock feed is at no, or little, cost, while making compost is a large cost and incineration is the largest cost of all.

Second, the recycling channels have tended to become spread out. The supplier bears the cost in recycling, except when the apple pomace is used as the raw material for food. The recycling cost is different for each use form. Use as livestock feed has the lowest cost, while incineration has the highest. The recycling channels have tended to become spread out because of the action of the supplier in attempting to recycle apple pomace at the lowest cost.

Third, the use of apple pomace as a livestock feed is limited by the lack of transportation and problems in storage. The demand is influenced by transportation and storage problems in the large distribution area and making compost is important in adjusting supply and demand.

Finally, the implications of this article are as follows:

First, lack of transportation and the storage problems limit the effective use of apple pomace. Therefore, it is necessary to strengthen of these functions.

Second, any new uses for apple pomace must have costs that are at least lower than those for making compost. In addition, in the situation where the demand for livestock feed increases, it is essential that the costs be lower than for using apple pomace as a livestock feed.

In improving the recycling channels for apple pomace, it is vital that not only are measures for technological development addressed, but also measures to improve the price and the physical distribution processes such as transportation and storage are considered.

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リンゴジュース製造副産物におけるリサイクル経路の特質

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本論文では、青森県のリンゴジュース製造副産物を対象として、そのリサイクル経路の特質を検討することで、その有効活用の条件を明らかにすることを課題としている。そのために、青森県内の11の主要りんご加工場のうち、5つの加工場を事例に分析を行った。その結果、明らかになったのは、以下の3点である。

第1に、リンゴジュース製造副産物の利用は、処理・用途としては食品素材、飼料化、堆肥化、焼却の4つがあり、処理・利用先の地域としては、近隣の県日本海側、県太平洋側、県外の3つがあり、それぞれリサイクル経路を形成している。

第2に、そのリサイクル経路は、より低い費用負担での処理・リサイクルを求める供給側の行動と需要の地域

的偏在によって、広域化する傾向が強い。

第3に、家畜飼料での利用を阻害している要因の一つとして、リサイクル経路における輸送機能の不足、および需給双方における保管機能の不足という物流機能の不十分さがあげられる。

以下の点から、今後のリンゴジュース製造副産物の有効活用には、第1に、輸送機能と保管機能を強化する対策が必要である。第2に、新規用途に関しては、最低限、供給側にとっては堆肥化よりも低い費用での処理・利用が必要であり、現状のように食品加工副産物の飼料用途での需要が増加する下では、飼料利用よりも低い供給側の負担でのリサイクル利用が必要である。