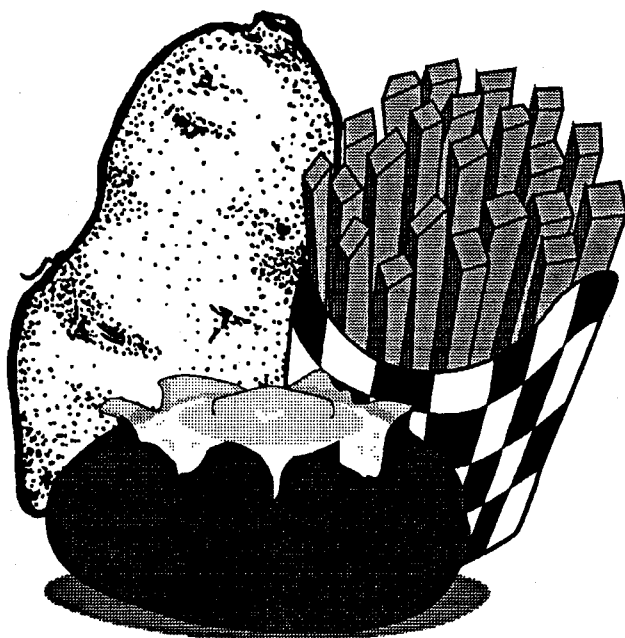


**Potential Food and Nonfood Utilization  
of Potatoes and Related Byproducts  
in North Dakota**



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## **Highlights**

*The overall objective of this report was to identify all food and nonfood uses of potatoes and byproducts and evaluate their market potential. Since 1960, potato production and consumption of potato products have significantly increased due to development of convenience and instant processed potato products. Per capita consumption increased from 106.3 pounds in 1960 to 132.7 pounds (farm weight basis) in 1993. But per capita fresh use declined by 40 percent, while consumption of frozen potato products increased by 600 percent (7.6 lbs. in 1960 to 51 lbs. in 1993).*

*Falling demand for fresh potatoes and rising demand for processed potatoes have resulted in declining numbers of raw potato processors and spatial redistribution of production for both raw and processed forms. Development of new varieties of potatoes has allowed potato production to move into irrigated areas of central North Dakota. Potatoes respond well to irrigation with increased yields and higher, more uniform quality.*

*In 1992, 5.6 percent of U.S. potato production was exported, twice the export volume of 1980. Potato chip exports have increased in the last five years. Canada, Japan, and other Asian countries are leading destinations for U.S. potato products. Mexico is also a leading importer of U.S. potato products.*

*Potential markets exist for North Dakota potatoes in Canada (fresh potato exports), and developing niche markets for new colored varieties and certified organically raised potatoes. Potential exists for increasing exports of frozen potato products to Mexico and Asian Pacific countries.*





## **Potential Food and Nonfood Utilization of Potatoes and Related Byproducts in North Dakota**

Larry D. Stearns, Timothy A. Petry, and Mark A. Krause<sup>1</sup>

Potatoes are a high value crop in North Dakota, where production for 1992 was valued at \$126 million. Acres planted have steadily increased from 115,000 acres in 1950 to 142,000 in 1992 ( North Dakota Agricultural Statistics 1994). Processing capacity in North Dakota will increase with the proposed expansion of an existing plant in Grand Forks and construction of a new plant in Jamestown.

On a global basis, the potato is the fourth most important world food crop. It follows three cereal grains, rice, wheat, and corn, in importance. Potato as a food is most important in the cooler regions of the world. However, technology is being developed that will create new possibilities for production, storage, and processing in the tropical regions of the world (Dhumal et al. 1991). World production, for the past twelve years, has ranged from a high in 1984 of 292 million metric tons to a low in 1991 of 261 million metric tons (Table 1). Historically, the former Soviet Union was the leading potato producer while the United States ranked fourth.

The objective of this report was to identify food and nonfood uses for potatoes and byproducts and to determine their market potential. In the first section, the structure of the potato industry, foreign trade, and markets for potato products are examined. Next, food and nonfood uses for potatoes are discussed. Finally, the potato production and processing industry in North Dakota are updated.

### **Structure of Potato Industry**

External and internal structural changes have completely transformed the U.S. potato industry. External changes of significance include increasing demand for away-from-home food consumption, rapidly expanding fast food sector, changing labor force composition, rising per capita income, and population growth. Important internal changes include falling demand for fresh potatoes, rising demand for processed potatoes, declining numbers of raw potato processors, and spatial redistribution of production for both raw and processed forms (Jones 1985).

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<sup>1</sup>Research associate, associate professor, and assistant professor in the Department of Agricultural Economics, North Dakota State University, Fargo.

Table 1. World Potato Production, 1982-1991

Country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	-----1,000 metric tons-----									
Soviet Union	78,185	82,908	85,515	73,009	87,186	75,908	62,705	72,205	63,700	64,500
China (PRC)	25,700	27,790	38,194	26,750	25,000	26,675	31,620	31,055	32,000	35,500
Poland	31,951	34,473	37,437	36,546	39,037	36,252	34,707	34,390	36,313	29,038
United States	16,109	15,138	16,422	18,443	16,408	17,659	16,168	16,803	18,239	18,970
India	9,912	9,956	12,152	12,571	10,423	12,740	14,046	14,857	14,770	15,254
Germany, Fed. Rep.	7,821	6,299	8,050	8,704	8,127	7,354	7,972	7,948	7,233	7,400
Netherlands	6,219	5,412	6,673	7,150	6,857	7,478	6,742	6,856	7,036	6,735
United Kingdom	6,875	5,885	7,398	6,892	6,412	6,760	6,899	6,262	6,504	6,700
France 6,797	5,731	3,664	7,787	7,149	7,500	6,775	5,417	5,800	6,300	
Spain	5,222	5,163	5,981	5,927	5,125	5,552	4,530	5,366	5,342	5,333
Turkey	3,000	3,050	3,200	4,100	4,000	4,300	4,350	4,060	4,300	4,600
Japan	3,775	3,566	3,707	3,727	4,073	3,955	3,763	3,587	3,552	3,700
Germany, Dem. Rep.	8,883	7,063	11,908	12,350	9,997	12,228	11,546	9,167	6,806	2,825
Canada	2,781	2,556	2,793	2,994	2,761	3,033	2,722	2,811	2,959	2,781
Czechoslovakia	3,608	3,177	3,978	3,450	3,512	3,072	3,659	3,167	2,534	2,713
All others	49,308	47,224	51,511	52,245	51,007	48,969	51,223	52,991	51,020	48,814
World	266,143	265,389	291,882	282,644	287,074	279,436	269,426	276,942	268,107	261,162

Source: Economic Research Service, *Potato Facts*, USDA, Fall/Winter 1992/93.

### External Factors

Increased demand for away-from-home food consumption has increased demand for processed potato products. Growth in demand has been especially rapid at fast food establishments, which has led to increased consumption of frozen potatoes, especially French fries. Growth in away-from-home food consumption is due, in part, to changing composition of the labor force. Increased participation of women in the work force has reinforced demand for away-from-home food consumption and enhanced in-home consumption of processed potatoes. This stems from a direct relationship between female participation in the work force and demand for convenience foods that are easy to prepare quickly. A model developed by Jones (1985) determined that consumers readily switch from fresh to processed potatoes as their income increases; as population increases, the demand for processed potatoes increases while the demand for fresh potatoes decreases. Demand for some processed potatoes is enhanced by income growth as well as income stagnation. This paradox stems from the fact that many customers of upscale restaurants "trade down" to fast food restaurants during less favorable times when income may be constant or decreasing (Jones 1985).

### Internal Factors

There have been significant structural changes in the potato industry. Technological advances in potato processing have significantly increased the size of processing plants, and significantly reduced the number of processing plants. The average size of a potato processing plant increased from an average capacity of 5,000 pounds per hour in 1959 to 45,000 pounds in 1981. During this same period, the number of plants dropped from 446 to 221. Similar size increases occurred in plants processing dehydrated potatoes and potato chips. Smaller firms were placed at a competitive disadvantage as larger firms adopted these scale technologies with their greater efficiencies. This disadvantage was intensified by market share gains and increased advertising by larger processors (Jones 1985).

The chipping industry has experienced internal changes. The number of chipping plants in the United States dropped from 167 in 1982 to 146 plants in 1992. During the same period, the quantity of potatoes used for chipping has increased from 39,993,000 cwt. to 47,763,000 cwt., a 19 percent increase (Table 2).

Table 2. Number of Potato Chipping Plants and Quantity of Potatoes Used for Chips and Shoestring Potatoes, 1982-1991 Crops

Area <sup>1</sup>	1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992	
	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plants	Quant	Plant	Quant	Plant	Quant
		1,000		1,000		1,000		1,000		1,000		1,000		1,000		1,000		1,000		1,000		1,000
	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.	No.	cwt.
New England	12	2,604	12	2,848	11	2,803	11	2,851	11	2,959	9	2,162	9	2,776	9	2,395	9	2,362	9	2,491	9	2,859
Eastern	35	8,427	34	8,241	32	9,424	33	9,416	33	10,535	36	9,673	37	11,033	34	10,035	32	9,905	3	10,060	31	10,549
North Cent.	27	1,194	26	4,229	23	4,003	22	4,327	23	3,890	26	4,120	26	4,197	24	4,456	23	4,589	23	4,397	22	4,296
Mid-Central	10	1,662	11	1,664	10	2,482	12	2,912	13	3,015	11	2,309	11	2,655	9	2,183	8	2,286	8	2,163	8	2,304
Midwest	28	5,433	26	5,509	23	6,106	23	5,914	25	6,509	24	6,659	23	6,458	23	6,773	23	7,844	19	8,244	22	8,269
Southeast	19	6,638	19	7,279	21	6,935	20	7,083	22	7,417	21	6,507	22	7,716	20	7,327	20	6,952	20	7,095	20	8,187
Southwest	10	3,259	8	3,015	8	3,085	9	5,149	9	3,520	9	2,373	8	2,914	7	2,770	7	3,500	6	3,256	6	3,626
Rocky Mts.	7	1,523	7	4,031	7	1,384	6	1,410	7	1,196	7	1,389	7	1,819	8	2,138	9	2,050	10	2,388	9	2,113
West Coast	19	5,953	20	5,968	20	5,530	20	4,635	22	6,334	23	5,018	21	4,390	22	4,642	22	4,698	20	4,477	19	5,561
Total	167	39,993	163	42,764	155	41,252	156	41,697	165	45,375	166	40,210	164	43,958	156	42,719	153	44,186	146	44,571	146	47,763
Shoestrings	-	557	-	547	-	587	-	520	-	439	-	383	-	581	-	352	-	302	-	461	-	691
Total for chips and shoestrings	-	40,650	-	43,331	-	42,339	-	42,217	-	45,814	-	40,593	-	44,539	-	43,071	-	44,489	-	45,031	-	48,454

<sup>1</sup>New England - CT, ME, MA, NH, RI, VT; Eastern - DE, DC, MD, NJ, NY, PA, VA; North Central - MI, OH, WV; Mid-Central - KS, MO, NE; Midwest - IL, IN, IA, MN, ND, SD, WI; Southeast - AR, OK, TX; Rocky Mts. - CO, ID, MT, NM, UT, WY; West Coast - AZ, CA, NV, OR, WA, HI.

Source: Economic Research Service, USDA, *Potato Facts*, Various Issues.

## **Per Capita Consumption**

Since 1960, potato production and consumption of potato products have increased due to research and development in convenience and instant processed products from potato tubers. These products include potato chips, French-fried potatoes, potato flakes, hashed brown potatoes, potato granules, diced potatoes, potato flour, potato starch, canned potatoes, prepeeled potatoes, dehydrated mashed potatoes, restructured potato chips, potato soup, shoestring potatoes, potato pancake mixes, potato nuts, potato puffs, potato salad, and chemicals, such as solanine, chaconine, lactic acid, and many more products (Salunkhe and Kadam 1991). Since 1960, per capita consumption on a farm weight basis has increased from 106.3 pounds to 131.4 pounds in 1991. At the same time, per capita fresh use has declined from 81.0 pounds to 47.1 pounds, per capita potato chip consumption increased from 11.4 pounds to 17.3 pounds, and the per capita use of dehydrated potatoes increased from 4.9 pounds to 12.5 pounds. The largest increase has been in the consumption of frozen potatoes. In 1960, per capita consumption was 7.6 pounds of frozen potatoes, but that had increased to 51 pounds in 1991 (Table 3; Erickson 1993a; Lucier et al. 1991).

## **Foreign Trade**

In 1992, the United States exported 5.6 percent of U.S. potato production, twice the export volume of 1980. Japan and Canada are the leading destinations for U.S. potato products. Japan imports U.S. frozen potato products, Canada imports U.S. fresh potatoes and chips, and Mexico imports U.S. potatoes and potato products. Exports of frozen potato products have increased steadily from 1977 through 1992, led by frozen French fries (Table 4). Exports of flakes and granules have declined in this same period, while potato chip exports have increased in the last five years.

U.S. imports of potato products rose through the 1980s, but have declined since peaking in 1990 (Table 5). The United States is a major importer of Canadian fresh potatoes at 99 percent of fresh imports. On a fresh weight basis, potato starch is the predominant potato import, and the Netherlands is the single largest supplier of potato starch (ERS USDA 1991 1992) (Tables 6 and 7). Imports of frozen potato products have increased steadily.

Table 3. Potatoes: U.S. Per Capita Use, 1970-1993

Year	Total		Processed				Canned
	Fresh and Processed	Fresh	Total	Frozen	Chips and Shoestrings	Dehydrated	
	----- Pounds fresh weight equivalent -----						
1970	121.8	62.3	59.5	28.1	17.4	12.0	2.0
1971	117.8	56.1	61.7	30.1	17.2	12.3	2.1
1972	119.4	57.9	61.5	30.3	16.7	12.4	2.1
1973	118.2	52.4	65.8	34.2	16.3	13.1	2.2
1974	117.2	49.4	67.8	35.3	15.7	14.5	2.3
1975	121.9	52.6	69.3	37.1	15.5	14.7	2.0
1976	125.2	49.4	75.8	41.8	15.8	16.3	1.9
1977	122.1	50.1	72.0	42.2	16.2	11.4	2.2
1978	119.6	46.0	73.6	42.6	16.6	12.1	2.3
1979	117.8	49.3	68.5	38.5	16.7	11.2	2.1
1980	114.7	51.1	63.6	35.4	16.5	9.8	1.9
1981	116.5	45.8	70.7	41.5	16.6	10.8	1.8
1982	115.1	47.1	68.0	38.6	17.1	10.4	1.9
1983	118.7	49.8	68.9	39.2	17.8	10.0	1.9
1984	122.1	48.3	73.6	43.7	18.0	10.3	1.8
1985	122.4	46.3	76.1	45.4	17.6	11.2	1.9
1986	126.0	48.8	77.2	46.3	18.2	10.9	1.8
1987	126.0	47.9	78.1	47.9	17.6	10.8	1.8
1988	122.4	49.6	72.8	43.3	17.2	10.4	1.9
1989	127.1	50.0	77.1	46.8	17.5	10.8	2.0
1990	127.8	45.9	81.9	50.2	17.0	12.8	1.9
1991	130.6	46.7	84.0	51.3	17.3	13.7	1.7
1992	132.6	49.1	83.5	51.0	17.5	13.2	1.8
1993	132.7	49.3	83.4	50.8	17.4	13.3	1.9

Source: Economic Research Service, *Potato Facts*, Fall Winter 1992-93.

Table 4. Potatoes: Selected U.S. Exports by Type, 1977-93<sup>1</sup>

Year	Fresh <sup>2</sup>	Frozen			Flakes & Granules	Chips <sup>3</sup>	Dried <sup>4</sup>	Total
		Total	Fries	Other				
----- 1,000 pounds fresh weight equivalent -----								
1977	693,379	---	---	---	790,433	50,658	305,228	1,839,698
1978	406,629	106,198	84,050	22,148	479,024	46,383	202,538	1,240,772
1979	414,667	133,308	110,562	22,746	566,895	41,928	184,079	1,340,877
1980	274,631	169,088	146,656	22,412	716,359	39,696	71,225	1,270,979
1981	398,578	204,870	173,422	31,446	396,312	34,422	55,468	1,089,648
1982	305,156	219,438	190,604	28,834	459,438	40,026	61,985	1,086,043
1983	283,237	242,704	212,102	30,604	365,533	27,414	59,031	977,921
1984	360,325	280,870	246,268	34,600	296,604	25,797	55,888	1,019,482
1985	329,885	291,656	255,394	36,262	215,173	23,508	64,449	924,671
1986	340,607	390,132	343,512	46,620	298,368	26,406	62,846	1,118,359
1987	363,214	492,008	425,964	66,044	341,446	37,224	77,476	1,311,368
1988	421,985	618,218	531,272	86,946	411,803	49,746	87,633	1,589,385
1989	467,836	726,636	639,540	87,096	322,469	61,974	40,866	1,619,781
1990	327,333	843,194	771,768	71,424	288,344	132,666	44,723	1,636,258
1991	341,682	819,558	755,616	63,942	446,600	163,704	75,159	1,846,703
1992	537,939	927,650	858,332	69,318	504,966	253,107	94,535	2,318,197
1993	539,345	1,055,498	965,086	90,412	405,615	330,756	101,374	2,432,588

<sup>1</sup>Exports of processed potatoes are in product weight as reported by census.

<sup>2</sup>Includes fresh seed. Data for 1978 to 1988 incorporate data on Canadian imports of U.S. potatoes.

<sup>3</sup>Includes corn chips before 1978.

<sup>4</sup>Excludes flour and starch.

Source: Developed from Economic Research Service, *Potato Facts*, March 1994, USDA.

Table 5. Potatoes: Selected U.S. Imports by Type, 1978-1993<sup>1</sup>

Year	Fresh	Seed	Frozen	Flakes & Granules	Dried	Flour	Starch	Total
----- 1,000 pounds fresh weight equivalent -----								
1977	80,800	25,600	0	0	525	1,503	127,719	236,147
1978	85,376	64,674	12,626	11,774	5,663	6,939	193,851	380,903
1979	98,058	61,376	32,848	2,051	11,487	1,935	134,505	342,260
1980	140,675	77,691	21,830	1,253	1,057	5,607	143,253	391,366
1981	246,984	145,369	29,978	952	16,618	5,418	372,690	818,009
1982	348,374	130,026	44,328	308	10,605	6,300	241,101	781,042
1983	279,557	69,529	53,114	945	2,919	6,975	196,155	609,194
1984	253,579	71,570	99,464	2,548	22,204	9,063	270,756	729,184
1985	300,469	105,403	138,162	19,782	17,997	10,278	549,729	1,141,820
1986	280,813	63,645	147,054	8,358	29,582	11,745	426,798	967,995
1987	402,791	96,995	187,802	3,164	25,914	13,905	546,678	1,277,249
1988	388,394	95,029	203,814	1,407	35,154	5,139	698,742	1,427,679
1989	509,347	160,932	208,412	11,368	19,306	6,237	876,654	1,792,256
1990	482,903	201,044	276,392	6,160	7,574	7,272	1,137,186	2,118,531
1991	437,349	178,907	341,084	14,406	2,989	7,497	836,541	1,818,773
1992	273,515	128,071	391,314	8,127	1,939	5,076	860,382	1,668,424
1993	541,383	171,200	581,006	11,763	1,519	6,849	1,131,885	2,445,595

<sup>1</sup>Imports of potato chips and canned potatoes are not included in total imports.

Source: Economic Research Service, *Potato Facts*, March 1994, USDA.



Table 6. Potatoes: U.S. Exports to Selected Destinations, 1993

Destination	Fresh <sup>1</sup>	Frozen			Dehydrated		Canned	Starch	Total
		Fries	Other	Total	Chips	and Dried <sup>2</sup>			
----- 1,000 pound fresh weight equivalent <sup>3</sup> -----									
Bahamas	1,489	394	1,220	1,614	3,309	15,589	402	—	22,403
Canada	481,184	30,520	5,240	35,760	63,114	49,000	19,027	9,648	657,733
Hong Kong	3,483	51,244	7,730	58,974	14,496	3,101	2,210	—	82,264
Japan	—	563,350	31,256	594,606	11,358	347,109	573	2,088	955,734
Malaysia	—	25,976	92	26,068	4,749	1,218	46	—	32,081
Mexico	44,481	37,654	28,134	65,788	23,937	3,955	544	1,638	140,343
Philippines	—	27,662	1,992	29,654	13,722	2,982	1,120	—	47,478
Singapore	1,469	30,672	1,502	32,174	8,136	13,825	523	—	56,127
South Korea	—	69,056	1,294	70,350	11,781	3,682	82	—	85,895
Sweden	—	—	—	5,058	15,512	—	—	—	20,570
Taiwan	—	38,122	796	38,918	35,427	17,514	318	—	92,177
All others	7,239	90,436	11,156	101,592	135,669	77,042	7,712	11,007	340,261
<b>Total</b>	<b>539,345</b>	<b>965,086</b>	<b>90,412</b>	<b>1,055,498</b>	<b>330,756</b>	<b>550,529</b>	<b>32,557</b>	<b>24,381</b>	<b>2,533,066</b>

<sup>1</sup>Includes seed and tablestock.

<sup>2</sup>Includes flakes, granules, flour, and dried.

<sup>3</sup>Converted to farm weight equivalents using 1 pound for fresh, 2 pounds for frozen, 3 pounds for chips, 7 pounds for dehydrated and dried, 1.6 pounds for canned, and 9 pounds for starch.

Source: Economic Research Service, *Potato Facts*, March 1994, USDA.

Table 7. Potatoes: U.S. Imports by Country of Origin, 1993

Destination	Fresh <sup>1</sup>	Frozen			Dehydrated		Canned	Starch	Total
		Fries	Other	Total	Chips	and Dried <sup>2</sup>			
----- 1,000 pound fresh weight equivalent <sup>3</sup> -----									
Canada	712,140	555,576	23,134	578,710	1,347	14,882	346	35,874	1,343,299
Belgium/Lux.	—	—	74	74	—	—	149	5,103	5,326
Netherlands	—	1,196	—	1,196	—	2,079	506	535,509	539,290
Mexico	40	—	146	146	6,138	—	—	—	6,324
All others	403	—	880	880	48	1,631	520	555,399	558,881
<b>Total</b>	<b>712,583</b>	<b>556,772</b>	<b>24,234</b>	<b>581,006</b>	<b>7,533</b>	<b>18,592</b>	<b>1,520</b>	<b>1,131,885</b>	<b>2,453,119</b>

<sup>1</sup>Includes seed and tablestock.

<sup>2</sup>Includes flakes, granules, flour, and dried.

<sup>3</sup>Converted to farm weight equivalents using 1 pound for fresh, 2 pounds for frozen, 3 pounds for chips, 7 pounds for dehydrated and dried, 1.6 pounds for canned, and 9 pounds for starch.

Source: Economic Research Service, *Potato Facts*, March 1994.

## Potato Markets

### Fresh Potatoes

Fresh or table potato consumption remains the second largest market for U.S. potato production at 30 percent in 1992. Fresh potato exports also increased in 1992, partly because of a large 1991 potato crop which led to lower prices for fresh potatoes. Imports of fresh potatoes dropped nearly 37 percent in 1992. Canada remains the primary trading partner for fresh potatoes (ERS 1992/1993). The U.S. use of table stock and fresh potato exports from 1978 to 1992 is shown in Figures 1 and 2.

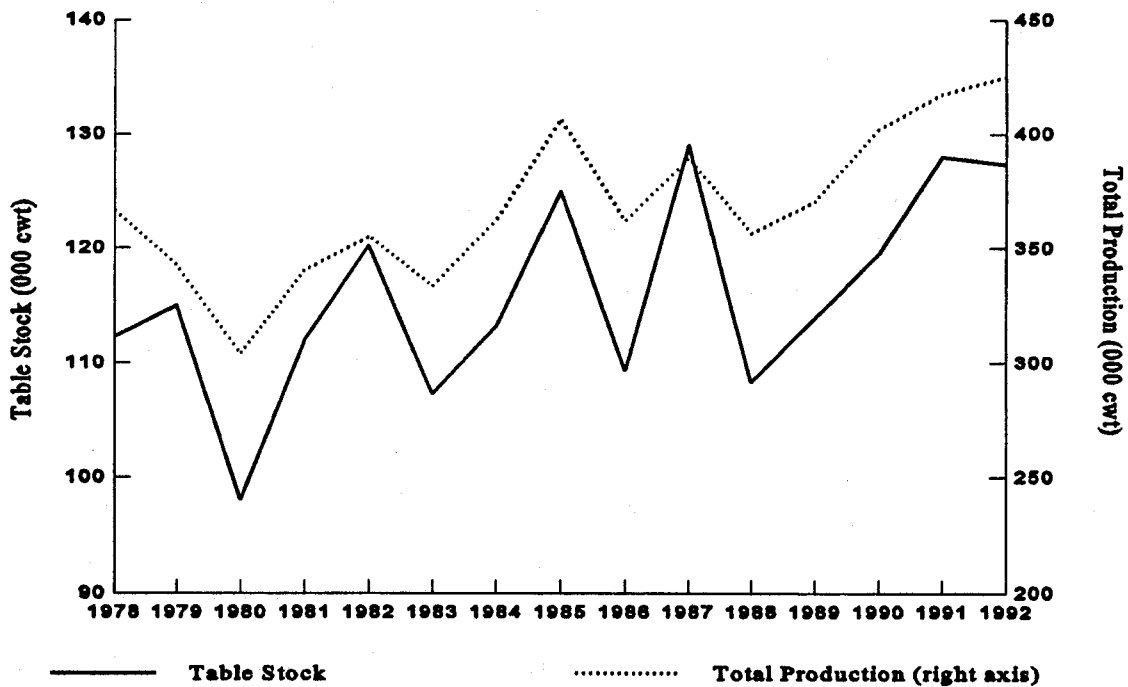


Figure 1. Potato: Table Stock Use, United States, 1978-1992.

Source: Appendix Table 1.

To recapture more of the potato market, fresh potato producers are raising different varieties and colors of potatoes for small niche markets. Some supermarkets are selling the golden-yellow, buttery-looking Yukon Golds and Yellow Finns. Gourmet markets are stocking 10 to 15 varieties of potatoes. Some of the more exotic include Purple Peruvians (purple inside and out); elongated, finger-like potatoes called fingerlings; Rattes (white creamers); and Russian Bananas (*The Forum* April 13, 1994). Organically raised potatoes are another small niche market for potato producers.

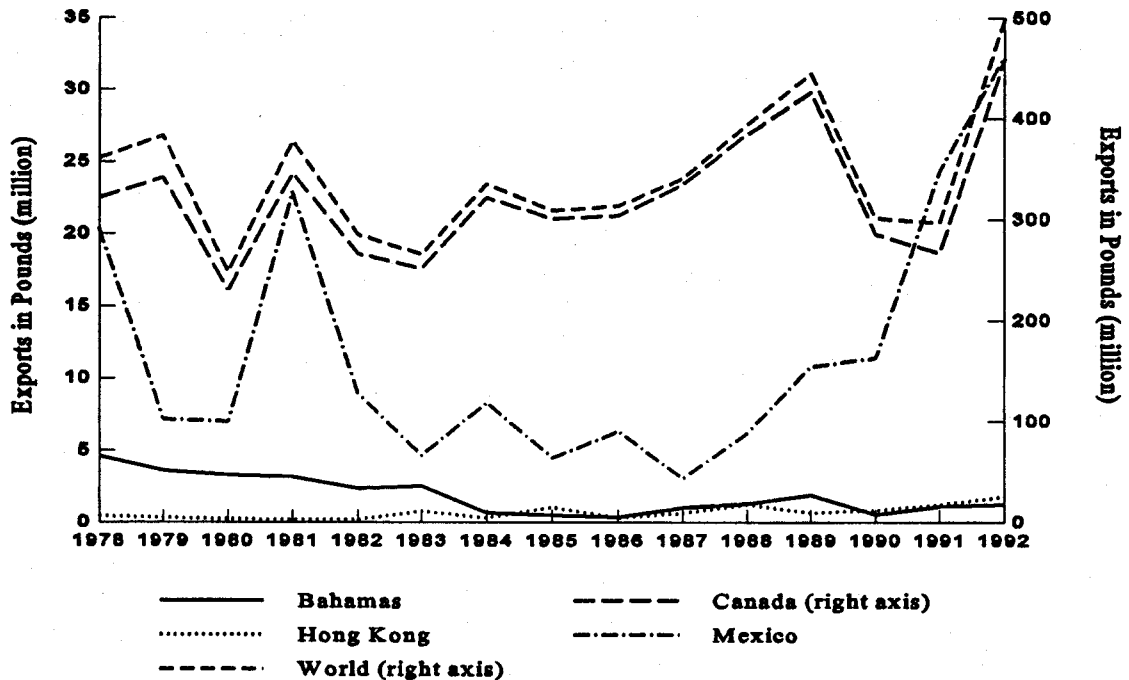


Figure 2. U.S. Fresh Potato Exports, Selected Countries. 1978-1992.  
 Source: Appendix Table 2.

### Potato Chips

Potato chips are still the most popular snack in the United States, but processors are being challenged by consumers in search of spicier flavors. Many new potato chip products have been offered to the public (McMath 1990). In 1991, supermarket-only figures showed steady increases in the popularity of barbecue flavor (+4.7%) and sour cream and onion chips (+7.1%). Sales of onion-flavor and cheese-flavor chips declined 21.8% and 6.7%, respectively. Sales of salt and vinegar (+24.6%) and hot and spicy chips (+20.7%) rose, while cajun-seasoned chips dropped 47.9%. The volume of low-oil potato chips increased 7.3%, and the volume of low-salt chips rose 23.7%; but this were only 0.6% of potato chip pound volume (Valley Potato Grower 1993).

The chipping industry has become more concentrated with fewer plants processing more volume. Approximately 400 plants in 1960 used an estimated 20.6 million cwt. of potatoes (Table 2). In 1991, the number of plants declined to 146, using 44.5 million cwt. of potatoes (Erickson, 1993a). Five major companies control nearly 60% of the potato chip market: Frito-Lay, Borden, Anheuser-Busch's Eagle Snacks, Keebler, and Procter and Gamble. The trend is toward further consolidation of smaller companies (Davis 1992).

Regional preferences show that kettle-style chips are more popular in New England than elsewhere (Table 8). Fabricated potato chips such as Procter & Gamble's Pringles, Keebler's O'Boises and Tato Skins, and Frito-Lay's Munchos are popular in the Southeast, Southwest, and West Central regions. Regular potato chips were still the most popular in all regions. Ridged potato chips were popular in the East Central, West Central, and Pacific regions (Valley Potato Grower 1993).

Table 8. Potato Chip Utilization by Types, by U.S. Region, 1991

Region	% of Potato Chip Market	Regular	Ridged	Kettle-style	Fabricated
Total U.S.	100.0	45.1	34.4	6.9	13.6
New England	5.7	46.1	29.7	12.5	11.7
Mid-Atlantic	14.6	49.6	30.5	8.0	11.9
East Central	17.4	46.0	36.2	6.0	11.8
Southeast	18.1	42.5	33.7	5.6	18.2
Southwest	10.9	44.5	33.9	6.1	15.5
West Central	18.4	42.8	37.5	6.3	13.4
Pacific	14.9	46.1	35.4	7.4	11.1

Source: Valley Potato Grower, February 1993.

U.S. potato chip exports to Canada and Asian Pacific countries have been increasing steadily since 1988. In 1992, the United States exported 2.5 million cwt of potatoes (fresh weight) as potato chips. Meeting this demand would have required approximately 10,000 acres of potatoes. Figure 3 shows the export activity for potato chips to selected countries from 1978 through 1992.

U.S. chip production and consumption have steadily increased. Fluctuations in chip consumption are shown in Figure 4. Increased utilization can be attributed to population growth as per capita consumption has remained constant since 1970 (Table 3).

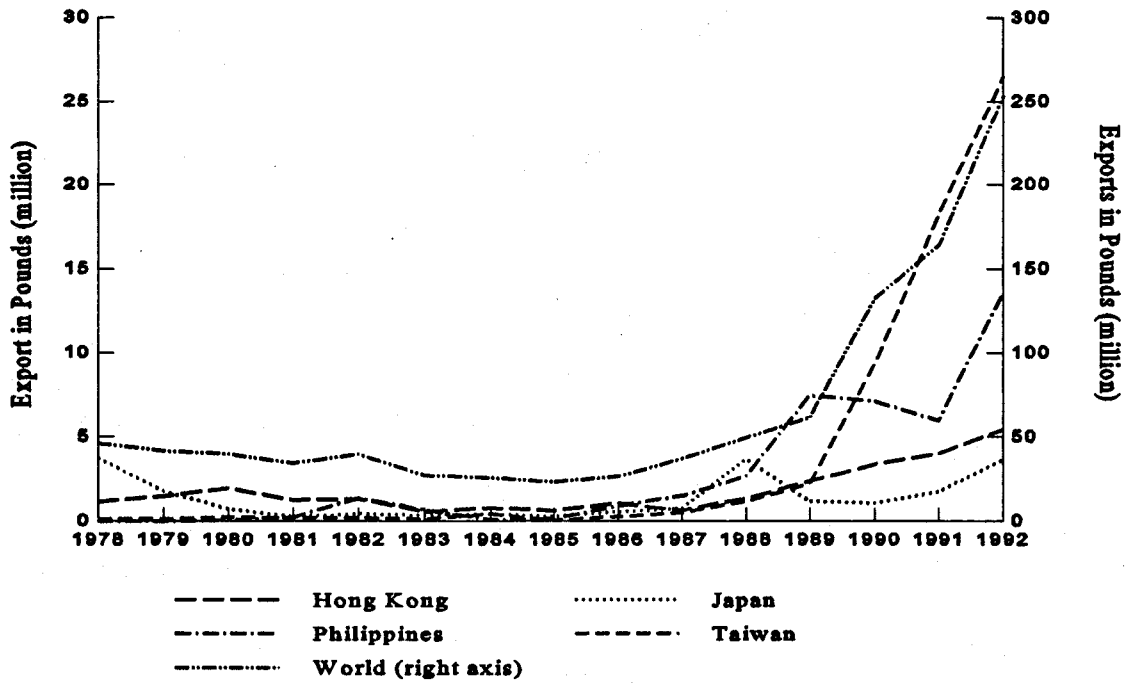


Figure 3. Potato Chip Exports, United States, 1978-1992, Fresh Weight.  
 Source: Appendix Table 3.

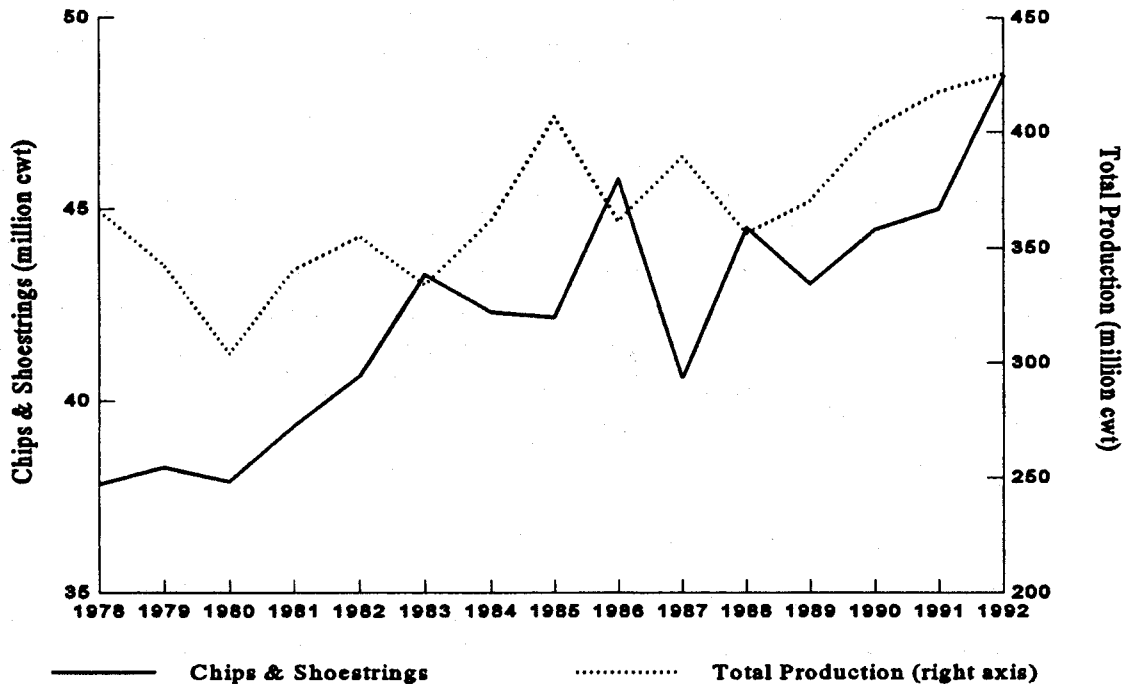


Figure 4. Potato Chips and Shoestring Use, United States, 1978-1992.  
 Source: Appendix Table 1.

### French Fries

The largest increase in potato consumption has occurred in frozen potatoes. Per capita consumption in 1960 was 7.6 pounds of frozen potatoes, farm weight, increasing to 52.6 pounds by 1991, a 600 percent increase (Erickson 1993b).

Since the customer prefers long fries, industry has demanded larger potato varieties that can produce longer fries. The Russet Burbank variety is a popular choice for French fry production. Production of new products from small potatoes and nubbins has resulted in chopped molded products such as Tater Tots™, southern style hashbrowns, and fabricated products such as toaster hash browns. Other specialty products have expanded the markets for frozen potato products. Some of these include frozen baked potatoes, twice baked potatoes, breaded French fries, and mashed potato products (Willard 1993). However, Gabriella Stern in the *Wall Street Journal* (January 14, 1993) reported that the overall market for frozen potatoes declined 3.5% in 1992, based on supermarket sales.

During the 1980s, the popularity of frozen French fries increased in East Asian nations not previously known for potato consumption. In Japan, Taiwan, and South Korea, American-style fast food outlets expanded rapidly. A positive result of this expansion has been strong gains in exports of frozen French fries (Frozen Food Digest 1992) (Figure 5). To increase market share, Ore-Ida, a subsidiary of H.J. Heinz, introduced a vending machine that dispensed French fries. This machine cooks a 3.5-ounce serving of French fries with hot air (Miller 1991; Figure 6).

U.S. exports of frozen French fries have increased rapidly since 1985. Exports to Canada rose in 1990 when a Canadian French fry processing plant was destroyed by fire (Economic Research Service 1992). Canadian imports of fries dropped in 1991 as the plant came back on line, but imports remained higher than pre-1990 levels. Part of this can be attributed to changes in procedures for collecting trade statistics and part to increased imports of frozen French fries. On January 1, 1989, the United States began collecting trade data according to the harmonized system tariff schedule. Since January 1, 1990, estimates have been based on Canadian statistics of imports from the United States (ERS 1990).

### Other Frozen Potato Products

The U.S. exports of other frozen potato products have decreased slightly since 1989 (Figure 7). Domestic consumption has increased slightly since 1988 (Figure 8).

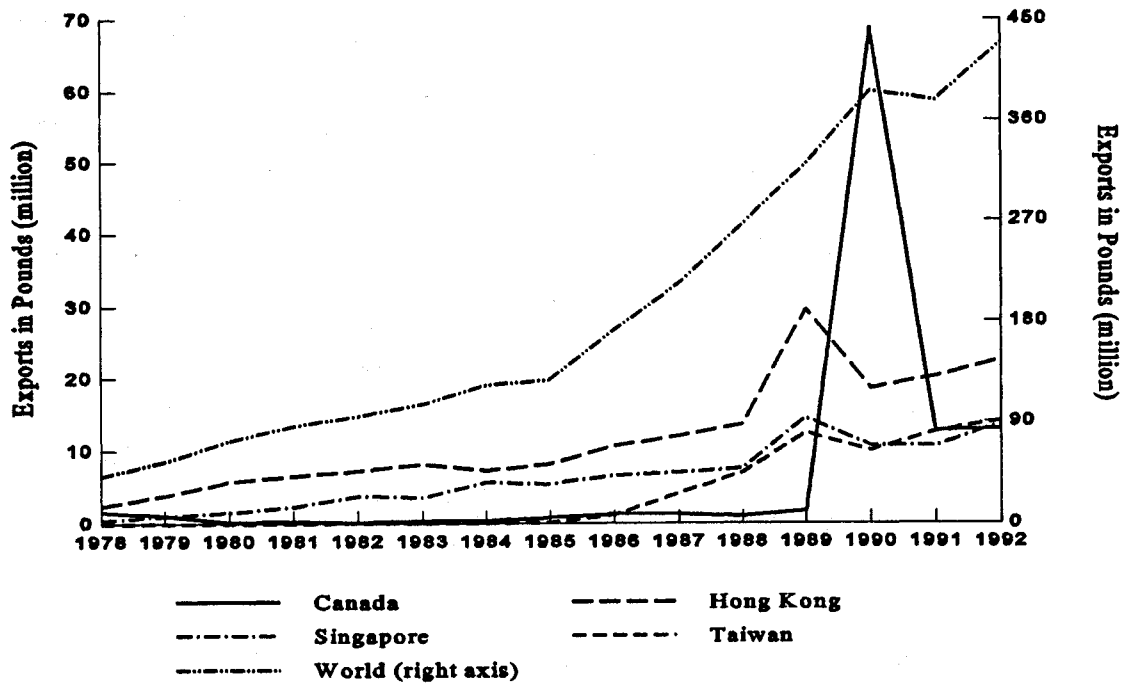


Figure 5. U.S. Potato Exports, French Fries, Selected Countries, 1978-1992.  
Source: Appendix Table 4.



Figure 6. Frozen French Fry Production, United States, 1978-1992.  
Source: Appendix Table 1.

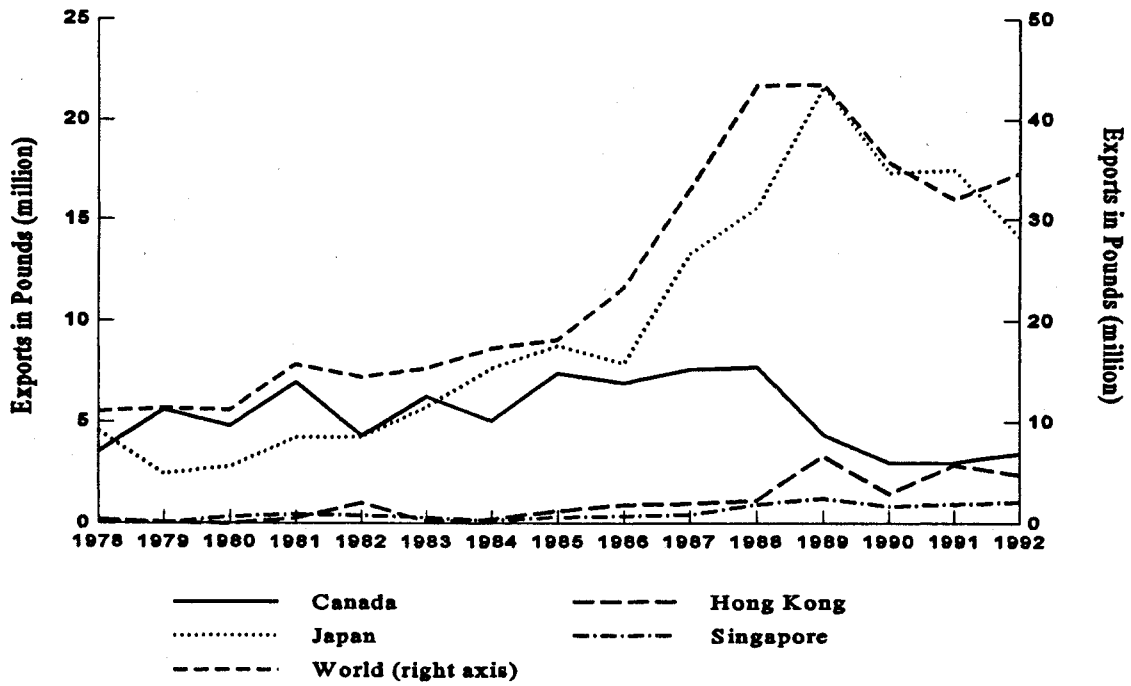


Figure 7. U.S. Exports, Other Frozen Products, Selected Countries, 1978-1992.  
Source: Appendix Table 5.

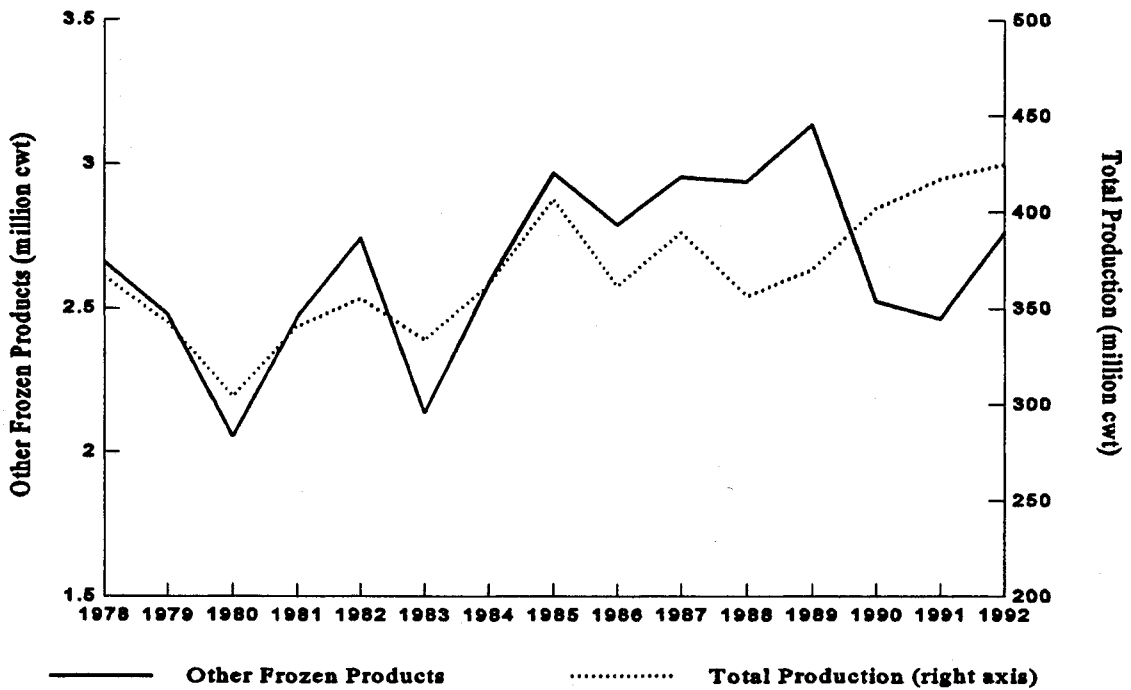


Figure 8. Other Frozen Potato Products, United States, 1978-1992.  
Source: Appendix Table 1.



### Potato Flour and Starch

U.S. production of potato flour is decreasing. The potato flour manufacturers face several economic problems. In this process, where over half of the production costs are in the cost of the raw material, changes in the supply and or cost of raw materials have serious consequences. Potato flour manufacturing faces increased competition for lower grade potatoes from dehydrated products, such as granules, flakes, and diced potatoes. Potato flour, still used largely in baking, competes with cheaper specialty flours and chemical emulsifiers (Willard and Hix 1987).

The world uses about two million tons of potato starch annually (Wiesenborn 1992). Food grade potato starch is imported from Europe, particularly the Netherlands and Germany, where government subsidies have made possible a world wide monopoly (Willard 1993). The thrust toward improved water quality in streams has presented a serious problem for the starch processor. The starch maker is faced with the need for expensive waste treatment plants (Treadway 1987). Because of the problem with disposal of waste effluent, only one commercial potato starch plant exists in the United States (Agweek June 28, 1993). Starch modification plants in the United States convert by-product starch from processing for use in the paper industry. Potato processors recover starch generated by cutting raw potatoes to reduce cost of effluent treatment (Willard 1993).

Domestic use of potato flour has declined steadily since 1985, but starch imports have increased. A steady decline in the domestic use of potato flour, starch, and other uses is shown in Figure 9.

### Potato Flakes, Granules, and Dried Products

Potato flakes and granules products are made from dehydrated mashed potatoes. Production of these products has declined because of decreased purchases by the military, but these products have substantial domestic institutional and food service markets. Statistics for domestic use of these potato products are not available (Talbert and Kueneman 1987b). However, exports of potato flakes decreased through the 1980s from a high in 1979. Since 1990, however, imports have increased. Approximately 16,500 acres of potatoes, at 300 cwt. acre, would be required to meet the 1992 U.S. export needs for potato flakes, while only 340 acres of potatoes, at 300 cwt. acre, would be required to meet export needs for potato granules in 1992 (Figures 10, 11, and 12).

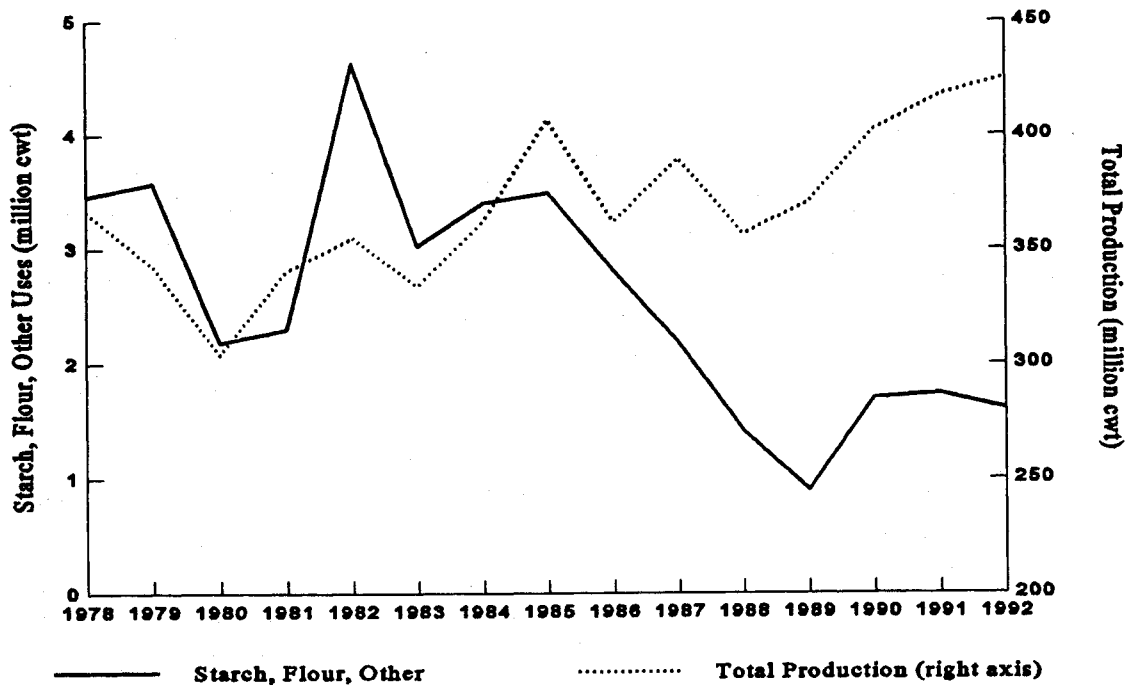


Figure 9. Potato Starch, Flour, and Other Uses, United States, 1978-1992.  
Source: Appendix Table 1.

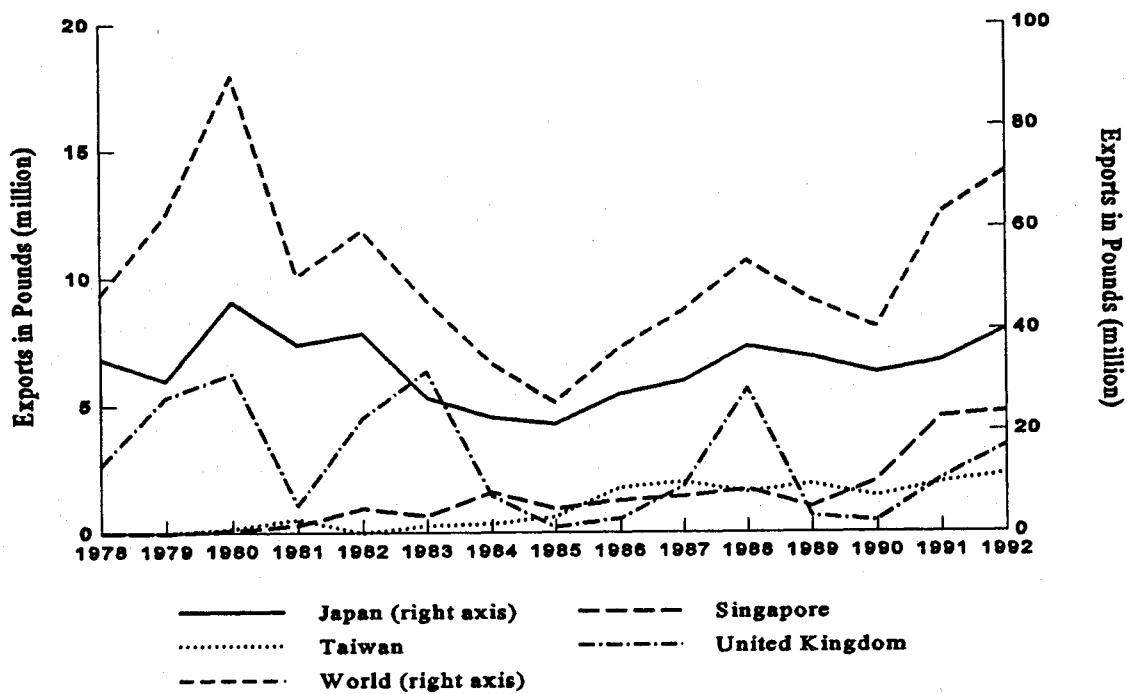


Figure 10. U.S. Potato Flakes Exports, Selected Countries, 1978-1992.  
Source: Appendix Table 6.

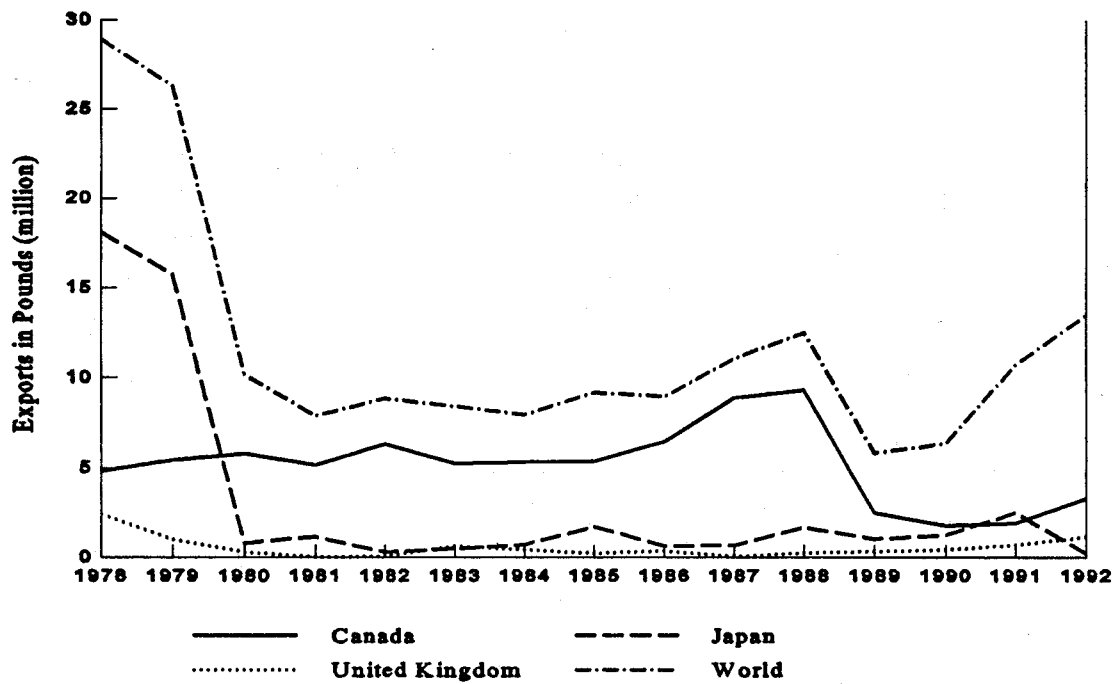


Figure 11. U.S. Dried Potato Products Exports, Selected Countries, 1978-1992.  
Source: Appendix Table 7.

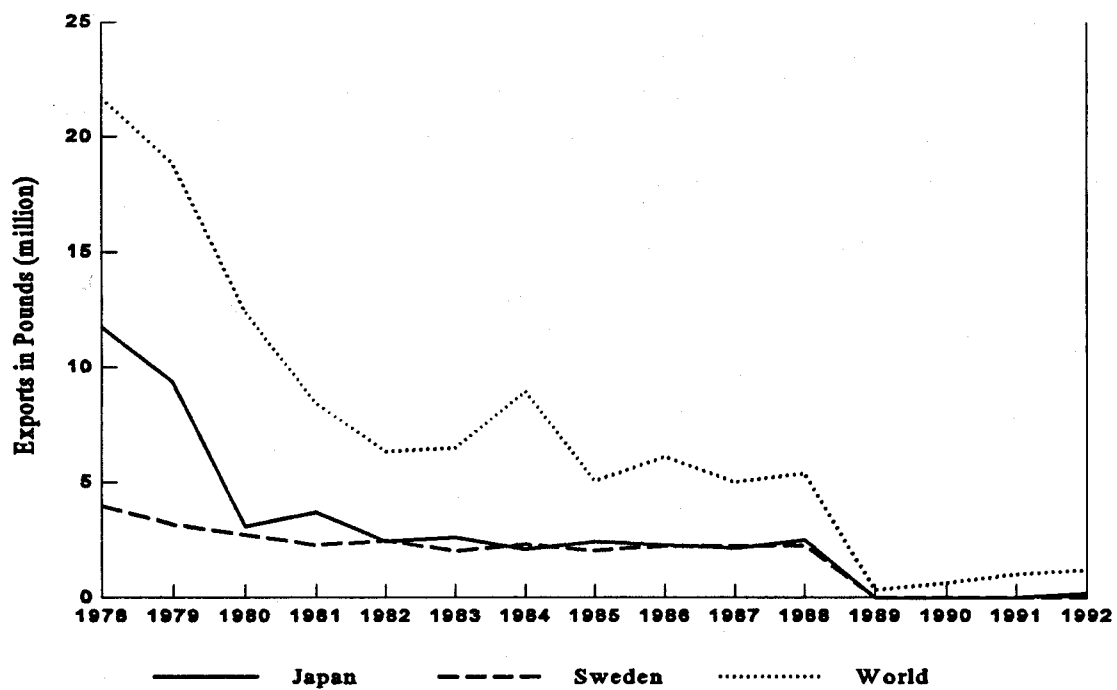


Figure 12. U.S. Potato Granules Exports, Selected Countries, 1978-1992.  
Source: Appendix Table 8.

## Seed Potatoes

Seed potato production has not significantly changed since 1980 (Table 9). Total acres of certified seed potatoes range from 163,395 acres in 1980 to 196,089 acres in 1985. Only three years, 1981, 1984, and 1985, have exceeded 175,000 acres. Production in most states remained steady from year to year. Potato seed exports are almost nonexistent, while imports increased in 1989 and have remained steady during the last several years (Table 5).

Table 9. U.S. Certified Seed Potato Acreage, 1980-93

Crop year	North					All other 1/	Total
	Idaho	Maine	Minnesota	Dakota	Wisconsin		
	----- acres -----						
1980	44,233	34,580	22,300	22,559	10,760	28,963	163,395
1981	51,081	36,380	23,545	25,393	10,512	33,021	179,932
1982	43,857	33,843	22,869	27,266	10,742	33,529	172,106
1983	43,365	32,899	21,846	29,184	10,937	34,273	172,504
1984	46,782	32,031	23,735	30,346	11,343	40,031	184,268
1985	55,069	30,763	24,025	32,982	11,115	42,135	196,089
1986	46,342	24,864	21,740	29,050	10,061	38,858	170,915
1987	40,423	25,539	22,577	30,769	9,706	38,517	167,531
1988 2/	43,587	24,329	23,163	29,265	9,774	36,931	167,049
1989	46,141	23,285	20,839	31,203	9,803	36,121	167,392
1990	47,738	24,618	21,871	33,713	10,128	36,633	174,701
1991	43,315	26,212	21,146	33,421	10,831	33,401	168,326
1992	40,314	29,035	20,690	28,747	10,825	38,401	168,012
1993 3/	45,000	25,988	22,569	28,899	10,100	37,596	170,152

1/ All other includes California, Colorado, Michigan, Montana, Nebraska, New York, Oregon, Pennsylvania, South Dakota, Utah, Washington, and Wyoming.

2/ Does not include Utah in all other.

3/ For 1993, represents seed entered for certification but not yet certified.

Source: National Agricultural Statistics Service, USDA.

## **Impact of NAFTA and GATT**

Expanding international markets are an important outlet for potential increases of potato production. The impacts of NAFTA on trading potatoes and potato products among Canada, Mexico, and the United States will be minor. Tariffs among these trading partners are already low and, under NAFTA, will be phased out over the next five years. However, the effects of GATT on potato exports to Pacific Rim countries will be significant. Japan, Korea, Taiwan, and most other Asian Pacific countries have high tariffs on frozen potato products to protect local potato producers (Foreign Agricultural Service 1991).

## **North Dakota and Minnesota Production**

Potato production has changed in North Dakota and Minnesota. Total acreage in the two states has become stable, but there has been a shift in the mix, with fewer reds and more whites and russets. Reds are used primarily for boiling or baking, whites for chipping, and russets for French fry production. There has also been a geographic change in potato production in Minnesota and North Dakota. In the 1970s, nearly 75% of Minnesota's production was in the Red River Valley. Today, 44% of Minnesota's production is grown in the Red River Valley and 56% outside of the valley, and 56% of the production is in russet varieties. In North Dakota, irrigated acreage has increased by 15,000 acres in the past five years. Potatoes respond well to irrigation, and quality is generally more uniform than dryland production. Potatoes require a three- to four-year rotation to prevent buildup of soil-borne diseases, which reduces the pool of available land. About 315,000 acres in a 10-county area of central North Dakota are irrigable (*Agweek* June 28, 1993; *The Forum* June 1, 1994).

During the late 1970s and 1980s, the number of acres of chipping potatoes in the Red River Valley increased. The Red River Valley chipping industry has been affected by the consolidation and closing of plants, fewer buyers, and fewer outlets using more volume (Erickson 1993b; Tables 10 and 11). Potato processing and wash plants in eastern North Dakota and northwestern Minnesota are shown in Figure 13.

Recent developments in potato processing have affected potato production in North Dakota and northwestern Minnesota. Introduction of the 'Snowden', a chipping variety of potato which performs well under irrigation, has influenced potato chip processors' production decisions. The Snowden potato has characteristics that chip makers favor: light color, uniform size and little oil (*The Forum* March 16, 1994).

**Table 10. North Dakota Potato Acreage and Value of Production, 1950-1993**

Year	Reds		Whites		Russets		Total		Value of Production
	Har-vested	Pro-duction	Har-vested	Pro-duction	Har-vested	Pro-duction	Har-vested	Pro-duction	
	(000 acres)	(000 cwt.)	(000 acres)	(000 cwt.)	(000 acres)	(000 cwt.)	(000 acres)	(000 cwt.)	(000 Dols)
1950	--	--	--	--	--	--	112.0	12,768	17,393
1960	--	--	--	--	--	--	112.0	14,560	19,330
1970	--	--	--	--	--	--	117.0	17,550	29,309
1980	30.2	3,940	70.6	9,960	11.2	1,780	112.0	15,680	107,408
1989	20.9	2,190	90.7	9,070	25.4	3,810	137.0	15,070	96,448
1990	17.8	2,050	99.6	8,957	27.6	5,650	145.0	16,675	95,048
1991	19.4	3,210	103.7	18,000	30.9	8,820	154.0	30,030	118,609
1992	20.5	3,383	95.0	16,225	26.5	8,082	142.0	27,690	125,990
1993	20.0	3,000	69.0	11,700	22.0	5,280	111.0	19,980	--

Source: North Dakota Agricultural Statistics, various issues.

**Table 11. Potato Acres Harvested, North Dakota and Minnesota, by Type**

	1974 Crop	1991 Crop	1992 Crop
	-----acres-----		
Reds	72,250	34,900	33,500
Whites	118,750	132,000	121,000
Russets	29,000	58,400	54,500
<b>Total</b>	<b>220,000</b>	<b>225,500</b>	<b>208,500</b>

Source: *Valley Potato Grower* April 1993.

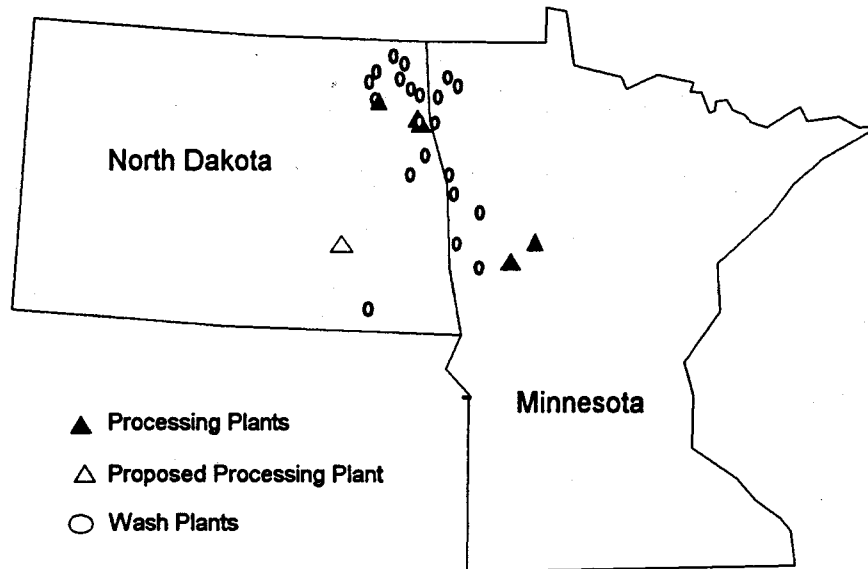


Figure 13. Potato Processing and Wash Plants, E. North Dakota and NW Minnesota, 1994.  
 Source: Red River Valley Potato Growers Association.

Frito-Lay Co., Grand Forks, ND, announced that it would cut in half the number of contract growers in the region and buy more irrigated potatoes from growers in central Wisconsin and fewer dryland potatoes from growers in the Red River Valley of Minnesota and North Dakota (*Agweek* April 4, 1994). This would remove the market for 5,500 acres of dryland potatoes. At the same time, J.R. Simplot Co., Grand Forks, ND, announced an expansion of its potato processing plant that would increase the plant's capacity to make frozen French fries by 80 percent. Simplot said the expansion, which would require 8,000 acres of irrigated potatoes, is feasible because of the expansion of irrigated farming and the new potato varieties. The plant's primary markets are in the eastern United States (*Farm and Ranch Guide* June 3, 1994).

Central Dakota Growers, Jamestown, ND, is proposing a new potato storage cooperative which will grow and store potatoes on contract for American Prairie Foods (APF). American Prairie Foods is structured as a limited liability corporation owned by Columbia Valley Foods, Inc., Syracuse, NY. It is building a \$45 million potato processing plant in the Jamestown area and should be on line in September 1995 (*Farm and Ranch Guide* June 3, 1994). Central Dakota Growers and APF are planning to capitalize on the increased potato production in the area due to expansion of irrigated farmland.

The RDO frozen potato plant, Park Rapids, MN, is planning a \$28.5 million expansion at its processing plant. Owned by R.D. Offut Companies, Fargo, ND, RDO provides the plant and potatoes in a partnership with Lamb-Weston, a Kennewick, WA, firm. Lamb-Weston, a subsidiary of ConAgra, contributes the management and sales staff (*The Forum* June 1, 1994). Potato acreage changes are summarized in Table 12.

**Table 12. Potato Acreage Changes due to Changes in Plant Capacity, North Dakota and Minnesota, 1994**

Potato Processor	Acres	Operational Date	Comments
American Prairie Foods, Jamestown, ND	8,500	September 1995	Potential for 25,000 acres of irrigated potatoes
J.R. Simplot, Grand Forks, ND	8,000	January 1995	Three years to full production
Frito Lay, Inc., (Buyer) Grand Forks, ND	(5,500)		Reduced purchase of ND potatoes
RDO, Park Rapids, MN	n.a.	April 1995	Plant expansion
Expanded Irrigation in Western and Central ND	n.a.	After 2000	Purely speculative

Source: *The Forum*, various issues.

Givers et al. (1994) investigated the impact of changing from dryland to irrigated crop production in northwestern North Dakota. They investigated the potential of value-added processing and concluded that production of irrigated potatoes has the most economic potential for expansion. They also concluded that a processing plant would be necessary to warrant increased irrigation of any high-value vegetable crop.

Potential markets for North Dakota grown potatoes include increasing export markets for fresh potatoes, frozen French fries, and chips with potential for increased domestic markets for potato starch. Fresh potato exports to Mexico and Canada have been steadily increasing; this trend should continue with adoption of NAFTA and North Dakota's proximity to Canadian markets. U.S. potato chip exports to Pacific Rim countries have expanded steadily since 1989. The largest increase has been to Taiwan and the Philippines. Chip exports to Japan and Hong Kong are also increasing, but at a slower rate. Exports to the latter countries could improve at a faster rate with adoption of GATT.

U.S. exports of frozen French fries and other frozen potato products have increased steadily since 1985. This product would seem to hold the most export potential for North Dakota potato processors. Lower production costs in North Dakota (Wulff and Helgeson 1988) compensate for higher transportation costs from the area and allow shipment of a product with less loss or breakage found in shipping fresh potatoes and chips.

North Dakota producers and processors may also benefit from improved technology in potato starch production and adoption of GATT. These two factors would allow North Dakota



other U.S. processors to compete with highly subsidized European Community produced potato starch.

## **Potato Uses**

This section discusses the uses of potatoes and potato products. It also discusses past use and future trends for the various products.

### Fresh or Table Potatoes

#### **Prepeeled Potatoes**

Today's high labor costs make hand peeling a costly and time-consuming job, and paring losses from hand peeling amount to as much as 50% in some restaurants. Mechanical and chemical peeling methods, though more efficient than hand peeling, require space and capital investment that many restaurant operators prefer to use for other operations. Many restaurant operators purchase prepeeled potatoes with "built-in labor service" rather than invest in machinery to do their own peeling. These potatoes are preserved from discoloration, cold stored, extremely perishable, and have a relatively short shelf life. They are usually preserved from discoloration by some chemical treatment and stored at a temperature of 7° C. Prepeeled potatoes are supplied to the hotel, restaurant, and institutional trade. They may be cut into julienne strips for French frying, whole potatoes for general use, pre-cooked and shredded for hashed brown potatoes, and par-fried in deep fat for French frying (Kadam, et al. 1991; Feinberg, Olson, and Mullins 1987).

Commercially prepeeled potatoes are available in most U.S. cities. Raw peeled potatoes and other shapes were traditionally preserved by treatment with sulfite solution. Regulations concerning the use of sulfite in refrigerated food products have reduced the use of sulfite as an antioxidant (Willard 1993).

Because larger potatoes have less peel per pound of potato flesh, they are more desirable. However, smaller potatoes, even with more peel per pound of potato, are more feasible in some cases where small potatoes have lower raw material costs. Prepeeling operations must be located in or adjacent to the trade area that they supply to be within easy reach of their customers (Feinberg et al. 1987).

## Processed Potatoes

### Potato Chips

The potato chip industry is interested in 1) the yield of chips produced from any given quantity of potatoes, 2) color of chips, 3) oil content of chips, and 4) the flavor of chips. When selecting potatoes for processing into chips, tubers of high specific gravity or dry matter content must be chosen, because this is the single most important factor determining yield of chips. Fully mature potatoes are highly desirable for chipping. As potatoes become more mature, they usually increase in specific gravity. Maturity can be obtained by early planting, late harvesting, and killing potato vines slowly (Smith 1987).

Probably the most important problem in the potato chip industry is the maintenance of desirable color throughout the year. This is difficult because color is determined by chemical composition of the tubers from which they are made. Chemical composition depends on many uncontrollable environmental factors in the field and also on conditions during transit and storage. Fluctuations in the composition of tubers due to cultivar, maturity, storage temperature, and other factors result in chip color variations. Some chip color can be controlled in the processing plant during cooking. Such factors as temperature of fat or oil used, thickness of slice, and length of frying period affect color of chips. Chip color is the result of the browning reaction between sugars and other constituents, such as amino acid or ascorbic acid. Potatoes with high reducing sugars produce darker chips when fried in oil. The color of potato chips can be improved by using microwave processing and vacuum frying developed in the Netherlands.

The oil content of potatoes is important to chip processors. Oil content affects taste and handling quality and influences the shelf life of chips. Antioxidants can be added to the oil or salt to delay rancidity and extend shelf life. Other factors, such as exposure to air, light, and high temperature, contamination of oils with metals, and poor packaging, affect the keeping quality of chips.

### French Fries

French fries are one of the most important processed potato products. A large percentage of frozen French fries is served in restaurants and institutions. They are prepared for serving by finish frying in deep fat. Like potato chips, the reducing sugars should be low to avoid dark pieces. Proper selection of raw material is of primary concern in production of a quality product. They must be suitable for processing, but because of the seasonal nature of the crop, they must be held in virtually year-round storage so that production schedules can meet demand (Talbert et al. 1987c; Kadam et al. 1991).

In general, high-solid content tubers of mealy, culinary texture are preferred for manufacturing frozen French fries. One reason for this preference is that high-solid content potatoes contain less water; however, high solids alone do not ensure an optimum high quality

finished product. Potatoes of high specific gravity produce fries that are more crisp, more mealy, and less oily than potatoes of low specific gravity. Palatability increases with specific gravity. Tenderness, however, shows a slight, but significant, decrease as specific gravity increases; this is the only quality factor negatively correlated with specific gravity (Kadam et al. 1991).

### Other Frozen Potato Products

**Potato patties:** These products are made from slivers and nubbins from the French fry line and from chopped or sliced partially cooked small potatoes. The final product is shredded after cooking and mixed with potato or rice flour, salt, monosodium glutamate, or other seasoning. The mixture is placed into a patty-forming machine, which forms either round or rectangular three-ounce patties that are subsequently frozen.

**Diced potatoes:** This product is used for frying as hashed-brown potatoes, in potato salads, or for general purposes. Small pieces or nubbins are diced and blanched in steam for three minutes. The product is cooled, and flavoring such as onion is added if desired. It is then loose frozen in a contact or blast freezer and packaged.

**Mashed or whipped potatoes:** By-product material from French fry processing is diced and blanched. Rolls mash the material, which is mixed with skimmed-milk solids and salt. After passing through a finisher, it is beaten vigorously and placed in film-lined packages and frozen in an air blast tunnel.

**Hashed brown potatoes:** Small whole potatoes are cooked, cooled, shredded, and packed loose in cartons before freezing. Byproduct material from French fry production lines is also shredded or diced, blanched, and cooked.

**Potato puffs:** Slivers and small pieces of potatoes are cooked with steam, mashed, and mixed with wheat flour, eggs, vegetable shortening, and seasoning. The mixture is usually extruded into the shape of croquettes, allowed to cool, and fried in deep fat.

**Au-gratin potatoes:** A sauce of milk, cheddar cheese, salt, monosodium glutamate, and pepper is mixed with cooked diced potatoes in a 2:1 ratio of potatoes to sauce. A topping of cheddar cheese, toasted bread crumbs, and margarine may be added before freezing.

**Potato cakes:** A mixture of beaten eggs, salt, cold mashed, or grated raw potatoes is combined with small blanched potato pieces from the French fry line, chopped parsley, celery, celery seed, and grated onion. This mixture is cooked in a continuous blancher and riced in a pulper. The mixture is formed into cakes that are dipped either in fine bread crumbs, cracker crumbs, or flour and fried to a brown color on both sides and packed before freezing or served as part of a frozen, pre-cooked dinner.

**Potato rounds:** A relatively new product, potato rounds, are made from slivers and short pieces from the French fry line and potatoes too small to produce French fries. The pieces are blanched, shredded, and mixed with potato flour, salt, and spices. The mixture is extruded, fried in deep fat, frozen, and packaged. The term "potato round" was developed by the Frozen Potato Products Institute to include many similar products under various trade names that are not interchangeable among packers and could not be used to designate the product for pack statistics.

**Rissole potatoes:** Small, whole potatoes are blanched, fried in deep fat, and frozen.

**Dehydrofrozen products:** Dehydrofrozen or frozen "concentrated" mashed potato is being supplied to institutional markets. This product is prepared by peeling potatoes, cutting into one-half inch slabs, and cooking. Nonfat, dry milk solids are mixed with the cooked potato and made into a mash, extruded into a thin layer on a continuous belt dryer, dehydrated to about 15% moisture, milled slightly, and frozen.

**Precooked frozen dinners:** A great variety of frozen potato dinners and dishes are available, including French fried, whipped, mashed, hashed-brown, au-gratin, roasted, baked, boiled, scalloped, cottage-fried, and stuffed-baked potatoes, potato cakes, and rissole potatoes.

**French fried potato skins:** This product is prepared by slicing the potato in half, scooping out all of the flesh, and passing the residual skin through fryers. The shells are frozen and used, at the final point of sale, by finish frying in deep fat. These skins may be filled with cheese mixed with other ingredients and various seasonings. The market for this product is small but could expand in the future (Kadam et al. 1991; Talburt et al. 1987c).

## Canned Products

Potatoes are canned in nearly all major growing areas, although the industry is heavily concentrated in the early crop states. Potatoes are canned in several forms, including whole, sliced, diced, strips, and julienne. The principal product, however, is smaller whole potatoes, about 1½ inches in diameter and of low specific gravity. Raw chopped or diced potatoes or reconstituted dehydrated diced potatoes are also used in canned corn beef hash or beef stew (Kadam et al. 1991; Talburt 1987c).

## Fabricated French Fries and Chips

"Pre-formed French fries" are a relatively new product in the United States and the Netherlands. These consist of a mixture of dehydrated potatoes and other ingredients that can be reconstituted rapidly in cold water to form a dough-like material. The dough is extruded in square cross sections and cut at the desired length while being extruded. The simulated French fry strip is deep-fat fried, resulting in a product very uniform in color, shape, form, and texture.

Fabricated chips are also available in markets. This product contains dried potatoes, gelatinized maize, gluten, and oil. The dough is shaped into disks, dried to 12% moisture, and deep-fat fried. Such products exhibit homogeneity or uniformity. However, the flavor of the fried product does not resemble that prepared from raw potatoes (Kadam et al. 1991).

## Dehydrated Products

Military procurement of dehydrated potato products, including dehydrated slices and dices, dropped substantially after 1972, presumably because of increased use of fresh or frozen products. Overall production of dehydrated slices and dices during the 1970s and 1980s has dropped substantially because of reduced military procurement (Talbur and Kueneman 1987b). But, civilian uses of dehydrated potato products, namely granules, flakes, diced potatoes, and potato flour, have held their own, and, in fact, increased through the 1980s (Appendix Table 1).

**Potato granules:** Granules are one of the important products prepared from mashed potatoes that are dried to about 6 to 7% moisture. The granules are made into mashed potatoes by adding hot or boiling water. Essential to manufacturing potato granules are minimizing rupture of potato cells and satisfactory granulation. Rupturing cells releases free starch; the product becomes sticky or pasty if this is excessive. Satisfactory granulation is necessary to avoid graininess or lumpiness in the product.

**Potato flakes:** Flakes are dehydrated mashed potatoes prepared by applying cooked mashed potatoes to the surface of a drum drier fitted with applicator rolls, drying the deposited layer of potato solids to the desired final moisture content and breaking the sheet of dehydrated potato solids into a suitable size for packaging. In the process, a considerable number of cells are ruptured, but the texture of the reconstituted product is acceptably mealy because of a precooking and cooling treatment to which the potatoes are subjected during processing and adding a monoglyceride emulsifier (Willard, et al. 1987).

Potato flakes are the leading use of dried mashed potatoes used for retail consumption and as a food ingredient. Potato flakes have a problem of reconstitution with boiling water, so these cannot be served as a hot product. They cannot be mixed with milk. They can be used to form French fries for restaurant consumption using a dry mix combined with other dry binding agents. Potato flakes can be ground to produce flour, which is used as an ingredient in soups, baby foods, and baked goods.

The largest portion of raw materials for flake manufacturing is a processing grade potato. Flakes can also be made from short pieces, removed by size grading during manufacture of French fries, when combined with sliced or small whole potatoes ( Willard et al. 1987).

**Diced potatoes:** Diced potatoes are prepared by slicing whole potatoes, followed by blanching and dehydrating. Dehydrated diced potato are used in a number of processed foods. One of the principal outlets is in canned meats, with canned corned beef using a large portion of the dehydrated diced potatoes (Talbur and Kueneman 1987b).

**Potato flour:** Potato flour is the oldest commercial processed potato product. It is used widely by the baking industry to bake bread. Small amounts of added potato solids help to retain freshness, impart a distinctive, pleasing flavor, and improve toasting qualities. The flour is prepared by dehydrating peeled, cooked potatoes on a single drum dryer equipped with applicator rolls. The thin dried sheet of potato solids is ground to the desired fineness.

Potato flour is also used in the baking industry for baking snack-type crackers (soda and graham), as a breading meal (frozen fried chicken and seafood products), and in manufacturing frankfurters and fabricated potato chips. Manufacturing potato flour has not changed since the drum drier equipped with applicator rolls was developed. The new techniques, which have made possible the rapid expansion of the potato-processing industry, are being applied to this process to develop new and more desirable products (Willard and Hix 1987).

#### Miscellaneous Products

Potatoes serve as raw material for several food and industrial products. Industrial wastes from potato processing may be used as cattle feed or for isolation of various chemicals (Kadam et al. 1991).

**Canned potato salad:** German-style potato salad is prepared from potatoes, bacon, onions, and sauce. It is served as a hot dish. American-style potato salad, as prepared in the home, cannot be canned because of problems stabilizing the salad dressing. Heat sterilization causes the salad dressing to separate and curdle. The processing industry has been able to overcome this problem by using a "boiled" salad dressing emulsion of lower oil content and higher acidity. It is also necessary to use a waxy type of starch as a base for the dressing to prevent gelation of the canned product (Feustel 1987).

**Canned beef hash and beef stew:** Dehydrated diced potatoes are commonly used for canned meat products. Canned beef hash is prepared from meat, potatoes, onions, fat, sugar, salt, pepper, and sodium nitrate. Canned beef stew, in addition, contains carrots, tomato puree, and cereal flour (Kadam et al. 1991).

**Potato soup:** Diced potatoes are commonly used in canned soups. These are prepared with chopped onions, milk, salt, pepper, butter, vegetable oil, and flour.

**Canned French fries and shoestring potatoes:** These are prepared for canning by frying in oil until the moisture is reduced to 5 to 8%. After frying, the potatoes are passed over a mesh conveyer to drain excess fat. A salt sprinkler is used to salt the product. An antioxidant may be added with the salt if the product is not gas- or vacuum-packed.

**Potato pancakes and potato mixes:** This Bavarian dish is prepared from grated raw potatoes mixed with eggs, flour, onion, baking powder, salt, and bacon fat. The batter is placed in hot fat and fried until golden brown. Dehydrated pancake mixes are manufactured commercially.

**Potato chip bars:** This product was developed for military use by crushing potato chips and compressing them at 500 to 3000 p.s.i. to about 1/20th of the original volume. These bars have excellent performance characteristics in terms of the Quartermaster requirements for acceptability, nutritive qualities, storage life, and convenience of use.

**Potato chip confections:** These products are prepared by dusting or glazing the chips with the desired coating. Chocolate-coated chips are prepared by dipping the chips in semisweet baker's chocolate.

**Potato nuts:** Small fresh potato pieces are dehydrated to about 12% moisture and fried in deep fat to give an end product containing about 20% fat. Potato nuts were developed shortly after World War II. Because some pieces contained hard compact areas that were difficult to chew, production was discouraged.

**Potato puffs:** Potatoes are peeled, trimmed, and cut into strips 1/8th inch thick. These are blanched in boiling water, placed in a special drier, and subjected to a high-velocity, vertical, hot-air stream. This accomplishes rapid drying of the surface and, at the same time, heats the potato sufficiently high so that steam forms internally and expands each piece. As the moisture level decreases, the puffed pieces become rigid and take on a light brown color. Consumer acceptance of the puffs may be enhanced by adding flavors such as cheese, garlic, onion, sugar, monosodium glutamate, and salt.

**Sponge-dehydrated potatoes:** Potatoes with high solid content are washed, peeled, half-diced, and cooked in a steam blancher. The pieces are cooled and frozen to -23° C. The thawed product is dried to about 8% moisture. The dehydrated product can be converted to mashed potatoes in a few minutes by adding hot water. This product can be used in potato cakes, soups, casserole dishes, or hash chowder.

**Potato snack item:** This potato snack item was prepared on a laboratory scale from freshly cooked potatoes, potato starch, potato flour, vegetable gum, salt, and shortening. The finished product is hollow, crisp, and light golden brown (Feustel 1987).

## Potato Starch

Starch is an abundant and well-known source of renewable raw material. It is used as a feed or food, and about one to one and one-half percent is processed further for other applications. Nearly 10% of the potato crop is normally made up of substandard potatoes unsuitable for the table stock market, because they are either too small, too large, misshapen, or damaged. Nearly all of the cull and surplus potatoes not fed to livestock are used in starch manufacture (Treadway 1987).

Cornstarch, which is less expensive than starch from other sources, has captured most of the industrial demand for starch (ERS 1993). But, potato starch, because of its unique properties, has maintained a position in certain applications even in the face of lower-priced maize starch (Phadnis and Jadhav 1991). If potato starch becomes available at corn starch prices, it would be preferred in most applications. Its most important characteristics are 1) high consistency on pasting followed by a decrease in viscosity on further heating and agitation; 2) excellent flexible film formation; 3) good binding power; and 4) low gelatinization temperature. In specialty applications where these characteristics are needed, potato starch justifies its premium price over cornstarch.

### Uses for Potato Starch

For certain end uses, no starch is suitable in its natural form. Potato starch is amenable to modification by physical, chemical, or enzymatic means to suit the particular use (Phadnis and Jadhav 1991).

Paper: Starch has four purposes in paper manufacturing: 1) beater sizing, in which the cellulose fibers are cemented together before sheet formation; 2) tub sizing, in which the preformed sheet is passed through a dilute size solution; 3) calendar sizing, in which a smooth finish is imparted; and 4) surface coating, which is an optional step in finishing high grade papers. Starches and dextrins are also used to combine and seal paperboard for the fabrication of folding corrugated and laminated solid-fiber boxes (Treadway 1987; Phadnis and Jadhav 1991).

Textiles: Most of the potato starch used in the textile industry is used for sizing cotton, worsted, and spun rayon warps. The function of warp sizing is to bind the loose fibers tightly to the surface of the thread, strengthening and protecting the warp from abrasion during weaving. Potato starch films have a higher degree of toughness and flexibility compared with other starches. This allows potato starch-sized warps to be woven at lower humidity than those sized with cornstarch.

Food: Much of the potato starch used in the food industry is used in bakers' specialty items. It has been used as a thickener in soups, gravies, and matzoth. Potato starch has been pelleted to make puddings, especially instant puddings where the starch dissolves quickly and sets to a gelled pudding. It is used in the confectionery industry as a medium for molding cast candies



(jelly beans), a bodying agent to add smoothness to caramels and marshmallows, a thickening agent in synthetic jellies, and a dusting agent mixed with powdered sugar for chewing gums and candy gums (Treadway 1987).

Perfectamyl Gel MB, a potato starch derivative, can replace over 20% of the casein in some imitation cheese formulations, reducing finished product costs 10 to 15% or more. Potato starch's unique properties, higher viscosity than other starch types, excellent clarity, clean taste, and low gelatinization temperature, make these ingredients useful in nearly any process (*Dairy Foods* 1991).

**Adhesives:** Dextrins are produced by roasting starch in the presence of an acid catalyst. These films, made of tuber starches, have greater flexibility and resistance to checking than dextrins of cereal starches. Potato dextrins are used as a binder in sandpaper, abrasive cloth, bookbinding, and rug sizing requiring high paste tackiness and flexible residual film. The same properties make them desirable for use in gumming stamps, labels, envelopes, and paper tape.

About five million tons of adhesives were used in the United States in 1990. Natural adhesives accounted for more than 40% of the total (Morris and Ahmed 1992).

**Biodegradable polymers:** Producers have targeted four areas for biodegradable polymers: food packaging, nonfood packaging, personal and health care items, and other disposables. Although these polymers are fully degradable, they generally cost 2 to 10 times more than petroleum-based plastics (ERS 1993). Use of biodegradable polymers slows the emission of fossil-fuel-derived carbon dioxide into the air.

Warner-Lambert's Novon Products Division is marketing a line of starch-based polymers derived from corn and potatoes. The NOVON polymers are used to make packing peanuts, candle cups for churches, and golf tees. Potential uses include fast food packaging such as cups, drink lids, straws, and cutlery. These products decompose in sewage treatment plants or in soil composts (Brownback and Glaser 1992).

**Miscellaneous uses:** Potato starch is also used as a hygroscopic additive in baking powder, fermentation raw material, binder for tablets, binder and extender for sausages, builder for soap, separator in dry cell batteries, raw material for nitro-starch manufacture, oil-well drilling muds, attractant in insecticidal mixtures, boiler feed water treating agent, and clarifier for waters used in mining purposes.

### Outlook for Potato Starch

The potato starch industry has improved its techniques for producing high quality starch. Consistent demand exists because of its unique properties. The decline in potato starch production from highs in the 1950s is due to two factors: food processors found it economical to use potatoes that are sound, but below the standards for the fresh table stock market; and the

thrust toward improved water quality in streams has presented a problem to starch producers. The problems were obtaining raw materials at a price that permits processors to produce a competitive product and the need for expensive waste water treatment facilities. Faced with these problems, many potato starch factories have closed (Treadway 1987).

### Alcohol

Utilization of potatoes by fermentation has not achieved any degree of commercial importance in the United States except for brief periods during and immediately following World War II. Idaho owned and operated a small experimental alcohol plant when there was an effort to solve the problem of disposing of cull and surplus potatoes. Following WWII, efforts were made to popularize blended whiskey containing potato alcohol. The law required that the source of the alcohol be shown on the label. This had an adverse effect on the use of potato alcohol because of consumer prejudice and the idea that this was an inferior product (Feustel 1987). Europeans have long used potato alcohol in potato vodka and other liquors, especially in northern Europe where the climate is too cold for wine grapes and production of grains is limited (Willard 1993). The J.R. Simplot Company now produces alcohol from plant effluent and solid waste from two large French fry plants in Idaho. The major outlet is for gasohol, but this is not attractive because of storage problems, seasonality, and high cost (Natu et al. 1991).

### Waste Products

There are two types of potato processing waste: liquid waste due to soluble solids and solid waste from potato tissue. The use of a large quantity of water in French fry, chip, and starch manufacturing plants increases the volume of the liquid waste. Green, immature, and cull potatoes can also be considered potato processing waste (Natu et al. 1991).

### Protein Recovery

Potato protein is rich in lysine and contains methionine and cystine as the limiting amino acids. However, the nutritive quality of potato protein is comparable to that of whole egg. Because of the quality of potato protein and the need for reducing waste effluent, waste from potato processing plants should be used for feed, food, and useful products. European starch processing plants are recovering potato protein concentrates as animal feed (Natu et al. 1991).

Single-celled protein: Single-celled protein are unicelled organisms grown on an industrial scale specifically for their protein content under controlled fermentation conditions.

Yeast: Starchy wastes, preinoculated with an amylolytic preparation, are suitable as a carbon source for the biosynthesis of feed proteins.

**Fungi:** Cultivation of mycelial fungi on potato processing industry waste is useful as they contain a complex of hydrolytic enzymes that eliminate the necessity of hydrolyzing potato substrates before culturing. *Penicillium gigitatum* 24 P grown on potato processing wastes increased the biological value of the protein preparations because of their high contents of unsaturated fatty acids and vitamin F.

The potato distillery byproducts obtained from French fry industry waste after alcoholic fermentation had fair amounts of crude protein (17.6 to 25.3%), but a large portion was nonprotein nitrogen. Although the products were good sources of lysine and methionine, high ash and glycoalkaloids contents would limit their potential feeding value (Natu et al. 1991).

### Animal Feed

Potato peel, cull potatoes, and products derived from processing wastes have been utilized for animal feed. Fermented potato waste is an excellent nitrogen source for ruminant animals. An estimated 1.3 million tons of potato processing waste could be available annually in the United States for such products (Natu et al. 1991). Using potato protein as part of a composite livestock feed has been an age-old practice.

Potato residue can replace barley as an energy source for beef cattle, and potato waste meal can be considered a practical diet for broiler chickens and other livestock (Natu et al. 1991).

### Other Uses

An organic cleaner from potato processing plant wastes is biodegradable. It contains low phosphorus and nitrogen, has good washing and cleaning properties, and can be prepared in granular or bar form to meet various use requirements. Potato waste, when mixed with wheat starch milk, can give an adhesive with improved properties. Pectin can be obtained after the removal of residual starch from waste by heating in water and subsequent treatment with glucoamylase. The starch product, obtained by drying the debris recovered from peeling potatoes, is recommended for use in drilling muds (Natu et al. 1991). Medical and biological sciences are researching uses of solanine, chaconine, and leptine extracted from potato wastes (Dhumal et al. 1991).

Chlorogenic acid (CGA), a naturally occurring phenolic compound found in fruits and vegetables, is readily extractable from potato peels. The CGA, the major phenolic in potato peels, can be extracted from potato wastes with boiling water and is as good an antioxidant as the commonly used antioxidant butylated hydroxyanisole (BHA) (Rodriguez de Sotillo et al. 1993). Research is under way to develop economically feasible techniques for extracting CGA or a phenolic mixture from potato peels.

Byproducts of potato processing were considered as a source of extraction of L-ascorbic acid that can be used in an agar gel. Potato starch, derived from processing, has also been converted to glucose and then to lactic and citric acids and used to construct biodegradable plastic (Coleman 1990; ERS 1993). Research sponsored by the Department of Energy's Office of Industrial Technologies has found a more cost-effective way to make the environmentally friendly plastic. Scientists have demonstrated the process of converting potato wastes to polylactic acid (PLA) plastic in a process costing \$1 to \$2 per pound compared to \$30 per pound to synthesize PLA-based plastic from petrochemicals (Valley Potato Processor 1994).

### Summary

Since 1960, potato production and consumption of potato products have significantly increased due to research and development of convenience and instant processed products from potato tubers. Per capita consumption, on a farm weight basis, has increased from 106.3 pounds in 1960 to 132.7 pounds in 1993. At the same time, per capita fresh use has declined from 81.0 pounds to 49.3 pounds, potato chip consumption has increased from 11.4 pounds to 17.4 pounds, and the use of dehydrated potatoes has increased from 4.9 pounds to 13.3 pounds. The largest increase has been in the consumption of frozen potatoes. In 1960, the per capita consumption was 7.6 pounds of frozen potatoes and by 1993 had increased to 51 pounds.

Industrial changes include declining numbers of raw potato processors and spatial redistribution of production for both raw and processed forms. Increased demand for away-from-home food consumption has led to increased demand for processed potato products. Growth in demand has been especially rapid at fast food establishments. Fast food growth has led to increased consumption of frozen potatoes, especially French fries.

In 1992, the United States exported 5.6% of U.S. potato production, doubling the volume of exports from 1980. Japan, Canada, and Mexico are the leading destinations for U.S. potato products. Japan imports U.S. frozen potato products, Canada imports U.S. fresh potatoes and chips, and Mexico imports U.S. potatoes and potato products. While exports of frozen potato products have increased steadily from 1977 through 1992, exports of flakes and granules have declined. Potato chip exports have increased in the last five years.

U.S. imports of potato products rose through the 1980s but have declined since peaking in 1990. Ninety-nine percent of U.S. fresh potato imports come from Canada. On a fresh weight basis, potato starch is the predominant potato import, and the Netherlands is the single largest supplier of potato starch. Imports of frozen potato products have increased steadily.

Fresh or table potato consumption remains the second largest market for U.S. potato production at 30% in 1992. Imports of fresh potatoes dropped nearly 37% in 1992. Canada remains the primary trading partner for fresh potatoes. To develop niche markets, fresh potato producers are raising different varieties and colors of potatoes and certified organically raised potatoes.

U.S. potato chip exports to Canada and Asian Pacific countries have been increasing steadily since 1988. In 1992, the United States exported 2.5 million cwt of potatoes (fresh weight) as potato chips. During the 1980s, the popularity of frozen French fries increased in Japan, Taiwan, and South Korea as American-style fast food outlets expanded rapidly. A positive result of this expansion has been strong gains in exports of frozen French fries since 1985. Domestic consumption of frozen potato products has doubled since 1970 from 25 to over 50 pounds per person in 1993.

U.S. production of potato flour is decreasing. The potato flour manufacturers face several economic problems. In this process, where over half of the production costs are in the cost of the raw material, changes in the supply and or cost of raw materials have serious consequences.

The world uses about two million tons of potato starch annually (Wiesenborn 1992). Food grade potato starch is imported from the Netherlands and Germany, where government subsidies have made possible a world wide monopoly. The U.S. potato starch factories have been forced to close because of high raw materials and water treatment costs.

Production of potato flakes and granules products, made from dehydrated mashed potatoes, has declined because of decreased purchases by the military, but still has substantial domestic institutional and food service markets.

Potato production in North Dakota and northwestern Minnesota has been affected by recent developments in potato processing. Introduction of the 'Snowden', a chipping variety of potato which performs well under irrigation, has influenced potato processors' production decisions. In the 1970s, close to 75% of Minnesota's production was in the Red River Valley. Today 44% of Minnesota's production is grown in the Red River Valley, 56% outside of the valley. In North Dakota, in the past five years, irrigated acreage has increased by 15,000 acres. During the late 1970s and 1980s, the number of acres of chipping potatoes in the Red River Valley increased. The Red River Valley and North Dakota chipping industry has been affected by the consolidation and closing of plants, fewer buyers, and fewer outlets using more volume.

As chipping varieties that respond well to irrigation are developed, North Dakota potato production has expanded toward the central portion of the state (Jamestown, Carrington, and Oakes areas), where soil types are suited to irrigated potato production. Minnesota production has moved away from the Red River Valley toward the Perham and Park Rapids areas, where chipping plants are expanding production.

## Conclusions

Potatoes are an important high-value crop to North Dakota producers, generating \$126 million in sales in 1992, with a steady increase in the past ten years. The new American Prairie Foods processing plant at Jamestown and expansion of J.R. Simplot processing plants in Grand

Forks and RDO Foods, Park Rapids will utilize much of the proposed increased production from irrigated acres and will have a positive economic impact on the communities where the plants are located and on the state. Research indicated that frozen potato products have more growth potential than other potato products and the market will be able to absorb the expansion.

A dilemma facing Red River Valley (RRV) dryland potato producers is how to utilize the 5,500 acres of potatoes that have been utilized in the chipping industry, but will not be needed because of reduced contracts. North Dakota dryland (RRV) potato producers have excellent name recognition in the fresh potato market. Former chipping potato producers may have to shift production to high quality fresh or table stock varieties to compensate for loss of processing potato contracts. Both domestic and Canadian export markets for fresh potatoes should be considered. Producers interested in raising quality potatoes may develop niche markets by producing new colored varieties, certified organic potatoes, or baking potatoes for the food service and fast food market.

Potential export markets for North Dakota grown potatoes include fresh potatoes, frozen French fries, and chips. Fresh potato exports to Mexico and Canada have been steadily increasing; and this trend should continue with adoption of NAFTA and North Dakota's proximity to Canadian markets. U.S. potato chip exports to Pacific Rim countries have expanded steadily since 1989. The largest increase has been to Taiwan and the Philippines. Chip exports to Japan and Hong Kong are also increasing, but at a slower rate. Exports to the latter countries could improve at a faster rate with adoption of GATT. U.S. exports of frozen French fries and other frozen potato products have increased steadily since 1985. Frozen products seem to hold the most export potential for North Dakota potato processors. Lower production costs in North Dakota compensate for higher transportation costs from the area and allow shipment of a product with less loss or breakage found in shipping fresh potatoes and chips.

Potato starch, which has many specialized uses in industry, is more costly than cornstarch. It is possible, if future improvements in processing technology become available, that North Dakota processors may increase production of potato starch. Currently, researchers at NDSU are developing a technique to make noodles from potato starch.

Potatoes will continue to be an important source of cash receipts for producers in North Dakota and increased processing capacity will have a positive economic impact on the state. Potato production will likely increase in Central and Western North Dakota as irrigated acreage increases because producers have a limited number of crops which respond well to irrigation.

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## **Appendix Tables**



Appendix Table 1. Utilization of U.S. Potatoes, 1960-1992

Year	Table stock	Used for processing								Other sales			Non-sales				Total non-sales	Total production
		Total	Chips and shoe-strings	De-hydra-tion	Frozen french fries	Other frozen products	Canned potatoes	Other canned products	Starch, flour, other	Total 1/	Livestock feed	Seed	Total sales	Seed used on farms where grown	Household and feed use 2/	Shrinkage and loss		
1,000 cwt																		
1960	149,002	59,150	21,018	10,104	13,373	1,669	1,572	1,237	10,177	20,171	5,348	14,823	228,323	7,560	8,250	12,971	28,781	257,104
1961	153,594	72,566	22,642	8,518	15,911	2,227	1,458	1,317	20,493	34,163	20,340	13,823	260,323	7,191	8,965	16,687	32,843	293,166
1962	149,710	65,977	24,086	9,280	15,962	2,438	1,664	1,262	11,285	22,246	7,913	14,333	237,933	5,955	7,295	13,627	26,877	264,810
1963	146,981	74,004	26,693	9,909	19,782	2,643	1,836	1,404	11,737	24,262	10,103	14,159	245,247	5,911	6,487	13,513	25,911	271,158
1964	129,490	69,429	28,783	10,801	20,494	3,160	1,727	1,474	2,990	19,927	5,587	14,340	218,846	7,249	4,647	10,334	22,230	241,076
1965	139,548	100,189	31,292	20,166	32,263	5,039	1,728	1,620	8,081	22,854	5,797	17,057	262,591	6,398	4,691	17,429	28,518	291,109
1966	134,571	106,558	32,729	19,811	34,029	5,602	1,961	1,425	11,001	24,831	8,440	16,391	265,960	7,952	5,142	28,188	41,282	307,242
1967	131,742	106,506	32,406	19,084	34,601	5,008	1,821	1,537	12,049	32,897	16,800	16,097	271,145	7,301	4,786	22,534	34,621	305,766
1968	126,087	113,151	34,035	22,761	37,794	6,768	2,192	1,849	7,752	26,505	8,877	17,628	265,743	6,851	3,842	18,965	29,658	295,401
1969	127,586	125,112	35,459	25,483	44,654	6,899	2,066	1,750	8,801	27,264	9,620	17,644	279,962	6,848	3,111	22,657	32,616	312,578
1970	129,480	136,574	35,861	26,053	54,478	7,381	2,367	1,870	8,564	25,855	8,301	17,554	291,909	7,001	2,956	23,850	33,807	325,716
1971	120,251	138,310	35,376	27,021	54,667	8,884	2,556	2,014	7,792	23,932	7,184	16,748	282,493	5,542	3,385	27,909	36,836	319,329
1972	111,717	133,719	34,578	27,450	56,126	7,901	2,118	2,183	3,363	23,014	5,025	17,989	268,450	5,567	2,346	19,996	27,909	296,359
1973	107,550	143,744	34,485	31,407	60,349	9,564	2,664	2,544	2,731	23,827	3,707	20,120	275,121	5,137	1,379	18,376	24,892	300,013
1974	125,726	154,157	32,777	34,660	69,206	9,218	2,561	2,052	3,683	23,544	4,154	19,390	303,427	4,405	2,067	32,496	38,968	342,395
1975	114,160	154,106	34,107	33,821	70,641	9,334	1,946	2,075	2,182	24,975	4,301	20,674	293,241	4,941	1,619	22,177	28,737	321,978
1976	123,091	174,747	34,583	40,354	79,654	12,872	1,914	2,557	2,813	26,822	6,325	20,497	324,660	5,069	1,691	26,246	33,006	357,666
1977	117,171	171,902	36,947	32,783	79,949	14,597	2,797	2,474	2,355	28,424	7,396	21,028	317,497	4,961	1,757	31,119	37,837	355,334
1978	112,336	174,274	37,839	33,243	79,539	15,406	2,660	2,127	3,460	46,248	7,173	19,750	332,858	4,581	1,721	34,439	47,251	366,314
1979	115,109	166,104	38,276	30,784	74,320	14,420	2,479	2,251	3,574	32,107	6,636	18,075	313,320	4,241	1,663	30,128	42,135	342,447
1980	98,066	153,230	37,894	28,222	67,208	13,673	2,054	1,993	2,186	28,262	3,903	19,089	279,558	4,974	1,406	23,237	35,759	303,905
1981	111,976	172,328	38,344	29,875	73,829	16,812	2,469	1,700	2,299	27,719	3,583	20,393	312,023	4,538	1,466	26,339	38,535	340,623
1982	120,232	170,891	40,650	27,720	76,013	17,290	2,743	1,839	4,636	30,667	6,308	19,413	321,790	4,707	2,535	31,045	44,910	355,131
1983	107,295	338,453	41,311	26,754	74,350	19,655	2,137	1,991	3,028	29,625	3,734	20,870	475,373	4,605	1,332	24,664	37,191	333,726
1984	113,187	360,919	42,339	27,845	87,350	20,322	2,589	1,834	3,401	31,612	4,662	22,752	505,718	4,407	1,294	30,057	41,577	362,039
1985	125,006	378,658	42,217	29,958	94,741	17,856	2,971	1,610	3,489	34,373	8,098	19,895	538,037	5,060	3,001	52,707	67,649	406,609
1986	109,331	382,948	45,814	28,445	96,244	15,708	2,790	1,308	2,808	30,737	3,992	20,700	523,016	5,070	1,178	28,355	41,758	361,743
1987	129,097	390,818	40,593	30,823	101,377	18,305	2,958	1,597	2,184	28,731	3,808	21,023	548,646	4,521	1,133	31,901	43,506	389,320
1988	108,348	386,224	44,539	28,786	95,466	17,558	2,941	2,031	1,416	28,045	3,330	21,146	522,617	4,827	983	25,067	36,609	356,438
1989	113,932	396,301	43,071	32,187	100,459	19,115	3,138	1,858	898	28,155	2,800	22,290	538,388	4,735	987	24,974	36,462	370,444
1990	119,545	432,062	44,489	38,838	108,456	23,915	2,526	2,075	1,699	29,322	3,264	23,026	580,929	5,035	914	28,329	34,278	402,111
1991	128,036	447,937	45,031	40,895	111,123	22,316	2,465	2,202	1,739	28,849	3,652	21,739	604,822	5,008	987	2,429	38,424	417,622
1992	127,333	228,952	48,454	38,109	112,497	23,016	2,763	2,503	1,610	28,352	3,928	23,381	385,637	4,746	1,177	33,807	39,730	425,367

1/Includes potatoes diverted to livestock feed and seed uses under USDA potato diversion program during 1977-79.

2/Includes household use of potatoes and use as feed on farms where grown.

Source: Updated Tables, U.S. Potato Statistics, 1949-89.

Appendix Table 2. U.S. Fresh Potato Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1,000 dollars														
<b>Value:</b>															
Bahamas	405	312	374	468	301	350	118	58	155	208	185	361	111,268	179,071	237,205
Barbados	14	45	33	6	5	7	10	2	48	59	98	241	139,234	101,101	51,288
Canada 2/	22,479	18,885	23,675	43,929	31,331	29,051	35,290	26,556	27,460	38,314	31,704	62,701	58,455,183	59,137,003	59,520,525
Hong Kong	65	32	22	45	50	85	71	117	52	108	184	163	207,144	218,984	281,132
Leeward & Windward Isles	116	128	189	188	173	530	299	150	138	10	0	--	--	--	--
Mexico	1,104	371	578	2,325	897	322	478	219	567	360	738	1,872	1,006,152	3,799,385	4,270,078
Netherlands Antilles	141	209	277	387	616	167	174	21	19	23	46	46	190,513	2,768	249,563
Singapore	4	14	8	33	128	112	42	52	56	44	28	98	57,980	82,368	44,561
Trinidad & Tobago	5	33	5	2	2	8	17	9	38	39	0	0	23,458	--	89,521
Others	1,015	2,091	450	649	642	423	430	360	149	82	138	822	421,015	530,158	450,377
<b>World</b>	<b>24,943</b>	<b>21,808</b>	<b>25,237</b>	<b>47,544</b>	<b>33,844</b>	<b>30,705</b>	<b>36,811</b>	<b>27,486</b>	<b>26,527</b>	<b>39,057</b>	<b>32,927</b>	<b>65,741</b>	<b>58,613,627</b>	<b>64,080,812</b>	<b>65,214,230</b>
	Pounds														
<b>Volume:</b>															
Bahamas	4,833,773	3,634,501	3,320,081	3,208,647	2,404,575	2,550,427	683,936	503,524	384,753	1,080,815	1,344,125	1,859,825	567,894	1,148,488	1,268,829
Barbados	249,364	557,226	281,416	13,050	20,013	23,214	62,500	5,100	263,622	273,505	239,212	1,273,567	558,874	756,484	333,934
Canada 2/	321,823,814	341,572,800	230,872,216	345,089,327	265,989,808	251,397,228	321,908,794	300,827,013	304,308,108	334,870,755	364,388,725	426,560,901	265,560,054	267,376,337	458,778,387
Hong Kong	473,365	329,333	250,627	223,914	229,449	783,582	355,860	1,089,151	335,549	658,100	1,298,209	682,886	857,169	1,259,492	1,789,172
Leeward & Windward Isles	735,657	1,086,362	1,202,005	880,799	863,475	2,486,366	1,108,518	659,089	789,095	58,257	0	0	--	--	--
Mexico	20,356,878	7,181,347	7,017,867	22,892,373	8,871,019	4,840,550	8,304,502	4,536,254	6,359,948	3,072,035	6,187,210	10,823,978	11,452,588	24,387,212	32,361,851
Netherlands Antilles	1,152,711	1,704,502	1,680,124	1,948,107	2,568,116	816,831	754,000	116,624	108,012	129,245	102,743	170,733	687,888	11,250	1,247,843
Singapore	28,000	80,070	35,274	137,216	600,810	522,348	189,677	153,804	230,000	238,898	148,550	479,280	305,529	116,001	322,188
Trinidad & Tobago	50,000	228,672	5,702	7,540	9,285	36,000	43,250	107,275	85,915	124,940	0	0	202,457	--	494,012
Others	11,778,480	28,291,950	3,372,394	2,819,403	3,716,939	2,288,367	1,814,735	1,428,672	745,468	429,844	872,611	3,041,349	1,688,136	2,259,881	2,268,183
<b>World</b>	<b>361,282,182</b>	<b>362,686,783</b>	<b>248,037,686</b>	<b>377,198,376</b>	<b>285,374,289</b>	<b>285,547,626</b>	<b>335,227,772</b>	<b>308,436,708</b>	<b>313,618,488</b>	<b>340,933,594</b>	<b>394,379,385</b>	<b>444,892,549</b>	<b>301,890,545</b>	<b>297,316,943</b>	<b>499,894,489</b>

1/ Data for 1978 and 1979 include both fresh table potatoes and seed potatoes.

2/ Data are Canadian imports (as recorded by Canada) of U.S. potatoes.

Trade codes used are 1354900 for 1978-79, 1354940 for 1980-88, and 0701900000 for 1989.

Sources: Bureau of the Census, U.S. Department of Commerce except for Canadian data which is from the Foreign Agricultural Service, USDA.

Appendix Table 3. U.S. Potato Chips Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1,000 dollars														
Value:															
Bahamas	738	676	745	821	1,908	1,825	1,542	1,473	1,598	1,800	2,213	2,188	2,081,138	2,258,738	1,424,182
Canada	2,408	1,932	1,947	1,827	1,457	1,318	1,031	898	1,598	3,457	4,371	4,381	17,823,133	25,002,534	25,487,332
Hong Kong	422	491	947	567	560	277	418	349	716	362	612	891	1,425,082	1,711,128	2,180,325
Japan	1,230	710	343	178	221	223	238	211	341	354	989	421	498,134	731,122	2,009,893
Malaysia	125	98	173	180	148	578	1,080	1,408	927	477	758	758	1,258,208	772,180	1,167,522
Netherlands Antilles	271	312	409	521	537	158	265	195	271	372	218	447	582,342	235,898	332,907
Philippines	0	0	44	107	658	331	62	70	552	833	1,089	2,934	3,194,310	2,780,341	5,528,853
Saudi Arabia	1,900	1,826	1,052	2,841	2,820	1,652	2,464	2,847	1,197	2,188	831	824	711,800	1,753,433	801,804
Singapore	797	1,018	1,834	547	1,200	1,201	1,353	411	902	644	594	1,014	1,485,140	3,083,570	2,623,380
Taiwan	38	51	113	111	100	60	177	38	181	230	470	949	4,448,059	7,868,382	12,288,078
Venezuela	797	541	1,309	1,081	1,250	183	3	0	0	0	0	40	45,804	142,652	585,291
Others	5,152	5,772	6,285	5,037	4,821	2,508	2,287	2,680	2,918	2,531	2,418	5,624	12,035,589	21,784,500	40,189,282
World	13,874	13,425	15,001	13,788	15,308	10,108	10,800	10,584	11,197	13,428	14,521	20,731	45,534,537	68,170,482	94,818,357
	Pounds														
Volume:															
Bahamas	860,513	735,999	798,485	784,210	1,940,861	1,400,813	1,241,410	1,130,715	1,104,527	1,415,577	1,799,087	1,387,427	1,308,559	1,571,542	1,147,783
Canada	5,555,157	4,618,182	3,453,783	2,805,680	2,250,803	2,058,284	1,632,084	1,422,184	2,538,533	5,587,213	7,085,877	6,920,520	14,475,615	20,851,813	22,948,180
Hong Kong	374,384	488,474	657,281	410,604	435,453	191,134	259,802	216,150	353,942	212,184	455,820	803,438	1,128,849	1,340,454	1,818,922
Japan	1,249,145	589,584	240,048	105,577	144,874	128,830	145,070	112,182	180,255	251,383	1,233,085	391,139	363,623	598,129	1,220,924
Malaysia	110,885	80,718	130,678	114,891	108,929	338,528	637,909	755,088	508,061	340,742	1,073,970	480,032	198,695	458,358	677,713
Netherlands Antilles	283,321	288,575	365,538	371,088	424,861	158,059	183,424	137,132	183,034	213,184	410,275	538,182	818,617	236,820	408,582
Philippines			24,883	82,411	457,928	221,442	33,300	57,589	298,718	502,872	898,173	2,481,712	2,380,115	1,895,284	4,533,731
Saudi Arabia	1,344,712	1,151,149	668,385	1,861,808	1,708,821	1,233,391	1,528,822	1,948,184	878,228	1,888,000	788,080	737,584	871,882	1,048,939	709,180
Singapore	598,158	871,492	1,137,189	397,155	887,138	1,083,005	1,084,434	288,863	525,271	344,438	809,248	1,171,877	1,035,875	2,005,451	1,570,248
Taiwan	42,230	48,839	82,950	78,125	69,837	45,767	147,820	29,063	105,787	179,521	388,387	748,703	3,126,847	6,080,028	8,827,367
Venezuela	656,089	417,918	1,082,728	743,598	851,890	157,862	4,655	0	0	0	0	35,770	24,218	127,542	374,489
Others	4,385,717	4,876,704	4,588,754	3,811,098	3,862,868	2,110,769	1,719,528	1,728,198	2,137,128	1,772,702	1,881,601	4,958,542	18,501,210	18,453,749	40,138,183
World	15,481,318	13,975,722	13,231,670	11,474,239	13,342,131	9,138,102	8,599,138	7,836,279	8,802,463	12,407,614	16,581,581	20,657,887	44,221,805	54,587,808	84,389,302

Trade codes used are 1829420 for 1978-88 and 2005200020 for 1989.

Source: Bureau of the Census, U.S. Department of Commerce.

Appendix Table 4. U.S. Frozen French Fried Potato Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1,000 dollars														
Value:															
Canada	330	261	55	84	43	100	135	307	437	441	412	492	21,978,377	5,602,793	5,180,709
Hong Kong	661	1,046	2,045	1,826	2,212	2,551	2,195	2,613	3,322	3,648	3,762	4,739	5,575,600	6,329,346	6,372,755
Indonesia	2	44	137	97	83	297	426	197	314	108	527	794	995,650	1,258,171	1,356,054
Japan	8,426	11,143	16,230	20,585	25,369	29,375	30,928	33,795	44,946	57,042	66,265	71,962	74,294,740	83,458,949	84,578,367
South Korea	11	20	70	65	104	216	261	359	131	39	575	1,710	3,034,815	7,256,581	10,917,161
Malaysia	46	68	117	188	263	392	566	862	963	1,210	1,606	2,484	2,831,963	3,115,203	3,690,493
Singapore	134	316	560	766	1,269	1,139	2,010	1,820	2,396	2,268	2,374	3,175	3,293,829	3,483,732	4,250,794
Taiwan	0	0	0	0	26	10	12	46	380	1,327	2,155	2,576	3,231,984	4,296,980	4,418,570
United Arab Emirates	20	33	67	174	149	68	278	177	73	300	544	425	371,480	22,919	87,712
Others	1,262	2,354	2,767	3,335	3,406	2,858	3,470	1,094	1,259	2,367	3,671	5,487	6,616,615	10,666,196	16,413,960
World	10,892	15,267	22,048	27,220	32,948	37,006	40,323	41,392	54,231	66,745	82,093	93,664	124,225,243	125,512,960	137,236,205
	Pounds														
Volume:															
Canada	1,629,978	1,124,934	231,020	310,824	144,066	360,300	467,910	916,256	1,293,183	1,324,112	1,053,711	1,760,270	66,852,273	12,645,494	13,033,114
Hong Kong	2,447,606	3,667,065	5,709,850	6,506,046	7,251,727	8,240,124	7,359,276	8,211,661	10,696,012	12,023,781	13,636,052	29,601,627	18,584,731	20,330,559	22,596,757
Indonesia	4,834	43,674	549,433	331,010	292,736	867,201	1,165,257	625,272	956,351	418,363	1,918,923	2,722,913	3,183,921	3,739,372	4,430,731
Japan	32,393,135	39,215,067	55,706,060	66,615,708	71,788,177	82,121,425	94,786,011	105,718,459	144,818,870	177,605,249	216,100,509	225,827,141	230,206,689	256,576,792	266,649,680
South Korea	25,882	58,172	233,120	183,117	315,988	577,183	865,510	1,220,347	367,370	80,850	1,656,252	5,668,063	10,152,418	23,077,200	33,148,965
Malaysia	177,700	236,183	429,678	672,409	949,477	1,503,467	1,870,252	2,220,759	2,424,999	3,117,376	4,621,533	6,766,425	8,239,995	8,240,872	10,715,560
Singapore	491,922	1,024,809	1,626,790	2,420,036	3,772,649	3,561,571	5,752,137	5,512,645	6,616,659	6,973,121	7,613,453	14,525,629	10,696,171	10,714,052	13,745,906
Taiwan	0	0	0	0	114,450	35,100	44,010	160,446	1,179,653	4,136,277	6,958,656	12,467,366	10,012,117	12,696,062	14,202,628
United Arab Emirates	51,332	67,061	177,409	273,110	309,635	191,687	675,172	416,150	141,567	637,442	1,209,516	820,167	826,162	29,969	189,660
Others	4,802,296	9,640,959	8,662,223	9,367,066	10,362,724	8,512,847	10,148,663	2,694,311	3,269,446	6,665,692	10,664,907	17,508,204	25,025,679	29,555,973	50,452,964
World	42,024,767	55,280,664	73,327,583	86,711,362	95,301,651	106,050,915	123,134,366	127,896,506	171,756,110	212,982,463	265,635,514	319,770,005	365,884,156	377,806,365	426,166,077

Trade codes used are 1364100 for 1978-88 and 2004100020 for 1989-90, 2004106020 for 1991-92.

Source: Bureau of the Census, U.S. Department of Commerce.



Appendix Table 5. U.S. Potato Exports: Other Frozen Products, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1,000 dollars															
Value:															
Bahamas	21	51	107	59	48	72	93	15	3,818	5,235	4,854	6,180	5,789,949	1,829,729	161,372
Canada	784	1,171	1,061	1,432	1,069	1,490	1,313	2,083	1,810	2,134	2,234	1,179	1,357,224	1,459,916	1,573,697
Hong Kong	60	27	0	89	339	25	91	203	215	341	391	625	439,070	902,087	888,593
Japan	1,140	900	1,124	1,683	1,450	2,301	2,881	3,178	3,365	5,487	5,777	7,398	7,238,305	7,210,909	605,789
Singapore	58	19	125	249	179	156	71	117	113	163	295	269	278,516	323,945	348,448
United Kingdom	35	0	13	1	78	84	20	38	151	142	252	261	453,062	325,819	149,718
Others	644	677	842	1,237	1,806	660	2,273	302	397	336	391	1,411	1,640,322	2,078,447	9,686,217
World	2,742	2,845	3,272	4,750	4,969	4,788	6,742	5,936	9,969	13,838	14,194	17,301	17,196,448	13,930,532	13,413,834
Pounds															
Volume:															
Bahamas	77,901	259,366	549,232	335,674	212,712	344,449	451,652	101,110	5,552,484	9,774,524	16,286,508	8,377,796	8,381,367	2,116,925	229,995
Canada	3,556,457	5,626,634	4,804,241	6,974,620	4,305,253	6,255,287	5,075,730	7,422,170	6,943,054	7,809,718	7,729,002	4,355,657	3,008,655	2,999,020	3,445,742
Hong Kong	230,020	73,150	0	281,378	997,106	125,350	205,908	631,594	925,663	986,212	1,144,246	3,328,242	1,454,800	2,865,820	2,388,197
Japan	4,561,940	2,459,534	2,814,608	4,228,423	4,238,820	5,745,641	7,654,921	8,755,407	7,898,509	13,292,333	15,586,752	21,645,810	17,314,332	17,464,835	14,111,913
Singapore	167,676	48,954	346,561	465,617	399,848	323,878	139,712	297,718	361,965	422,124	949,207	1,237,976	843,515	943,435	1,085,646
United Kingdom	122,400	0	39,679	1,444	160,000	201,375	73,095	129,749	421,352	240,713	466,712	563,190	754,026	442,299	239,722
Others	2,358,445	2,905,553	2,681,803	3,436,129	4,103,152	2,305,593	3,699,305	793,417	1,187,594	896,186	1,310,729	4,039,038	3,955,674	5,138,387	13,178,261
World	11,074,839	11,373,191	11,216,124	15,723,285	14,416,891	15,301,573	17,300,323	18,131,165	23,310,321	33,021,810	43,473,156	43,547,709	35,712,369	31,970,721	34,659,476

Source: National Agricultural Statistics Service, USDA.

Appendix Table 6. U.S. Potato Flakes Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1,000 dollars															
Value:															
Australia	0	168	2	0	62	71	18	61	52	84	127	368	--	--	807,417
Canada	396	400	620	518	353	291	434	246	309	245	251	449	468,671	695,694	628,818
France	204	764	1,286	24	710	509	403	0	272	445	23	0	--	--	--
Japan	8,315	7,126	11,837	14,227	13,960	6,961	7,690	7,707	7,812	8,984	10,133	14,070	19,687,410	14,105,365	14,290,782
Netherlands	66	45	112	0	114	287	209	33	160	363	296	0	27,600	683,104	413,469
Singapore	0	2	61	191	410	339	794	395	510	525	568	525	1,513,971	1,879,096	1,632,968
Spain	248	454	1,026	219	596	436	65	0	749	147	94	0	30,780	530,227	561,304
Sweden	414	326	340	416	406	246	172	120	116	148	262	1,548	1,046,122	253,806	188,586
Taiwan	0	0	80	254	1	92	118	229	531	588	445	969	1,048,422	855,270	784,492
United Kingdom	508	1,309	1,629	508	1,495	1,542	539	103	166	467	1,532	336	298,438	786,319	1,095,892
Others	1,235	4,063	6,142	3,521	3,776	1,930	977	387	641	1,239	1,255	1,140	1,692,248	5,799,030	4,543,269
World	11,366	14,657	23,135	19,878	21,685	12,704	11,417	9,281	11,318	13,235	14,966	19,405	25,811,872	25,677,801	24,747,017
Pounds															
Volume:															
Australia	0	463,556	3,466	0	124,936	319,184	76,562	141,308	128,088	244,364	435,614	645,197	--	--	1,660,604
Canada	1,439,564	2,059,844	3,166,829	2,643,365	1,484,739	1,262,159	2,082,125	1,158,433	1,444,729	1,267,548	1,299,586	2,236,794	962,156	1,371,595	1,435,040
France	1,045,010	3,073,215	5,165,276	65,024	1,199,808	1,409,755	1,274,439	0	837,675	1,369,250	84,000	0	--	--	--
Japan	34,285,718	29,975,585	45,510,390	37,113,521	39,269,468	26,543,340	22,833,131	21,431,627	27,343,235	29,924,791	36,728,564	34,601,330	31,489,843	33,793,859	40,001,539
Netherlands	200,137	189,567	420,254	0	387,777	1,191,309	648,909	127,440	570,000	1,369,274	1,075,849	0	75,976	1,679,862	1,353,979
Singapore	0	4,995	92,893	304,378	964,773	666,246	1,589,472	927,720	1,267,485	1,419,380	1,685,959	1,004,985	2,026,132	4,557,012	4,768,551
Spain	1,026,659	1,790,422	3,948,864	567,060	1,563,292	1,578,037	160,000	0	678,749	437,996	300,496	0	32,399	1,079,936	1,397,083
Sweden	1,570,207	1,249,747	1,133,410	1,069,982	1,099,392	894,359	388,258	291,518	241,020	483,118	796,453	2,691,424	1,433,597	827,201	556,027
Taiwan	0	0	175,008	539,290	890	272,970	339,976	628,373	1,776,791	1,977,716	1,601,884	1,867,223	1,418,243	1,857,514	2,286,073
United Kingdom	2,626,532	5,337,058	6,271,130	1,059,541	4,519,493	6,370,117	1,436,271	220,025	548,935	1,821,368	5,662,611	635,618	453,890	2,104,995	3,426,202
Others	4,567,482	18,010,897	23,998,726	6,998,030	8,652,049	5,203,097	2,604,507	759,593	1,658,570	3,434,563	3,769,292	2,033,500	2,632,270	15,213,564	14,041,755
World	46,763,307	62,154,866	89,906,246	50,400,191	59,286,717	45,710,573	33,445,550	25,686,037	36,495,277	43,749,368	53,442,310	45,736,072	40,554,506	62,785,536	70,926,853

Trade codes used are 1405620 for 1978-88 and 1105100000 in 1989.

Source: Bureau of the Census, U.S. Department of Commerce.

Appendix Table 7. U.S. Dried Potato Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1,000 dollars															
Value:															
Australia	50	80	137	94	168	132	118	130	70	44	89	29	104,167	-	257,267
Canada	1,575	1,794	1,556	1,296	1,596	1,342	1,441	1,532	1,577	2,130	2,268	618	1,231,675	1,313,885	1,923,795
Hong Kong	8	10	14	10	17	17	4	143	32	21	32	0	33,792	23,710	230,238
Japan	5,019	4,591	285	703	199	328	409	592	364	335	656	478	887,248	1,318,882	1,576,224
Netherlands	12	297	155	38	28	0	48	94	106	6	3	10	-	-	-
Norway	0	37	77	62	0	1	28	0	22	67	91	41	40,691	30,034	210,257
Sweden	110	56	86	70	0	5	27	11	151	15	226	0	-	1,946,667	1,738,831
United Kingdom	741	319	180	20	54	544	315	148	186	29	172	86	375,181	696,785	849,333
Other	1,155	675	579	440	677	955	440	486	407	559	215	721	1,417,433	1,574,449	1,142,132
World	8,670	7,859	3,049	2,733	2,739	3,324	2,828	3,134	2,915	3,206	3,752	1,981	4,080,187	6,894,242	7,928,097
Pounds															
Volume:															
Australia	87,795	160,119	246,564	144,980	239,697	197,245	153,448	135,059	96,640	75,712	89,815	42,726	-	-	346,208
Canada	4,853,917	5,433,625	5,811,783	5,147,034	6,355,691	5,258,760	5,338,321	5,393,141	6,471,134	8,900,221	9,313,820	2,539,120	1,829,218	1,944,704	3,296,472
Hong Kong	19,930	21,711	14,111	19,607	15,732	39,073	8,176	50,006	30,610	31,330	37,121	0	93,978	36,001	360,200
Japan	18,138,957	15,748,012	815,697	1,167,374	323,155	527,607	752,400	1,748,075	665,417	710,906	1,689,539	1,073,002	1,262,898	2,531,058	234,412
Netherlands	51,086	1,263,184	691,966	160,982	86,200	0	179,634	376,000	211,578	24,565	10,578	59,117	-	-	-
Norway	0	80,200	160,000	124,040	0	1,100	28,280	0	40,000	109,370	136,750	92,389	52,675	35,000	275,547
Sweden	410,133	166,978	257,670	171,198	0	18,810	129,600	40,000	265,556	42,525	406,335	0	-	2,682,078	2,204,905
United Kingdom	2,458,284	1,034,937	310,230	36,437	85,745	659,980	450,441	248,101	383,410	57,103	269,509	352,660	448,583	758,506	1,161,788
Other	2,918,098	2,387,755	1,866,511	952,102	1,749,144	1,732,879	944,016	1,218,381	813,308	1,116,695	563,526	1,678,873	2,703,309	2,749,378	5,623,215
World	28,934,210	26,296,521	10,174,532	7,923,754	8,855,364	8,433,454	7,964,326	9,206,763	8,977,851	11,068,427	12,518,995	5,837,867	6,388,661	10,736,723	13,504,747

1/ Due to the change to the harmonized tariff system in 1989, items included in this category may differ from previous years.  
 Trade codes used are 1405660 for 1978-88 and 0712100000 for 1989.  
 Source: National Agricultural Statistics Service, USDA.

Appendix Table 8. U.S. Potato Granules Exports, Selected Countries, 1978-1992.

Trade partner	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1,000 dollars														
Value:															
Canada	28	108	69	83	58	30	0	2	151	50	3	40	--	--	--
Japan	3,771	3,382	1,209	1,526	1,028	1,046	804	976	896	975	919	0	--	216,002	69,212
Sweden	1,654	1,441	1,451	1,217	1,407	1,183	1,410	1,184	1,342	1,507	1,422	0	--	--	--
United Kingdom	1,165	1,424	1,245	879	407	505	1,294	296	206	269	184	0	--	18,157	--
Others	965	825	1,029	622	520	436	619	132	297	71	156	229	503,803	302,853	637,161
World	7,603	7,178	5,003	4,337	3,420	3,210	4,127	2,590	2,892	2,872	2,684	269	503,803	537,012	706,373
	Pounds														
Volume:															
Canada	73,400	293,980	181,514	184,125	82,336	65,550	0	4,100	495,348	138,216	1,450	55,907	--	--	--
Japan	11,752,334	9,320,073	3,109,635	3,709,948	2,467,702	2,629,545	2,069,580	2,433,778	2,282,741	2,154,045	2,510,331	0	--	--	166,945
Sweden	4,009,632	3,176,789	2,731,136	2,288,172	2,482,535	2,044,899	2,331,891	2,039,583	2,224,333	2,274,907	2,264,141	0	--	--	--
United Kingdom	2,930,830	3,559,880	3,716,899	1,396,807	609,520	906,807	3,203,363	436,925	289,165	343,095	262,966	0	--	--	--
Others	2,902,396	2,479,461	2,691,762	836,381	705,666	861,883	1,302,066	138,238	837,496	118,130	328,040	274,660	637,943	1,014,438	1,043,969
World	21,668,592	18,830,183	12,430,946	8,415,433	6,347,759	6,506,684	8,926,900	5,052,622	6,129,085	5,028,393	5,366,948	330,567	637,943	1,014,438	1,210,914

1/ Due to the change to the harmonized tariff system in 1989, items included in this category may differ from previous years.

Trade codes used are 1405640 for 1978-88 and 2005200040 for 1989.

Source: Bureau of the Census, U.S. Department of Commerce.