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Embryo Transfer: Economic Implications for the Dairy Industry

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EMBRYO TRANSFER: ECONOMIC IMPLICATIONS FOR THE DAIRY INDUSTRY

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SUMMARY

Developments in nonsurgical embryo transfer have made commercial application for beef and dairy cows feasible. DHIA records were used to determine milk production variability within dairy herds. The top 10 percent of cows within herds produced 43 percent more milk than the herd average compared with 49 percent below herd average for the bottom 10 percent. The top 10 percent of cows within DHIA herds were assumed to be embryo donors for the remainder of the cows in DHIA herds. Economic implications were assessed for the U.S. dairy industry by region. Feed required to support the higher milk production level increased 296 kg while net income increased $161 per cow per year (assuming no affect on milk price). Aggregate milk production would increase by 6 percent if cow numbers remained the same. Approximately 6 percent fewer cows would be required to produce the present level of milk production if less efficient producers were forced to stop producing (11 percent of non-DHIA herds). Dairymen could pay $533 for each 1000 kg increase in milk production potential for an embryo transplant heifer calf at current milk and feed prices.

INTRODUCTION

Consumers in the United States have enjoyed a plentiful supply of wholesome milk at relatively low prices for many years. Regulated pricing has resulted in surplus milk production while producers have struggled to recover costs of production. Dairymen are constantly searching for ways to increase efficiency and lower production costs to remain competitive within the industry and with producers of other agricultural commodities.

Several technological developments have emerged in recent years that can have substantial impact upon efficiency of milk production and processing. Some of the more recent applicable biotechnology developments include embryo transfer, embryo splitting and administration of bovine Growth Hormone (bGH), (Fallert, 1985). Embryo transfer and splitting technologies permit increasing the genetic potential of herds to produce, whereas administration of bGH affects the production ability of an animal of given genetic potential. The combined effects of using both technologies simultaneously could compound the impact on the industry. The rate and extent of adoption of these technologies can have major impacts on the size, structure and location of the dairy industry within the U.S., as well as supporting agribusiness firms such as dairy processing plants, feed processors and distributors and feed grain producers.

Kalter (1983, 1984) and others have estimated impacts of bGH on the U.S. dairy industry. The purpose of this study was to explore some of the implications associated with using commercially available embryo transfer technology to improve genetic potential for milk production within herds of the more progressive dairymen. The scope of the study was limited to estimating genetic improvements of embryo transfer without inclusion of compound effects of improved production potential resulting from using bGH.

PROCEDURES

Dairy Herd Improvement Association (DHIA) 1983 individual herd records for Louisiana dairy herds were used to estimate milk production variability among cattle within herds. Analysis was confined to Holstein females to av confounding breed differences and to more closely represent the large majori of all U. S. dairy herds (cows). Records for 188 herds with 10 or mo Holstein cows showing 305 day milk production (7801 cows) were used for th analysis. Each herd was divided into 10 percentile groups to determine wit herd variation. The highest producing 10 percent of cows within herds we assumed to be donors of embryo transplants for the remainder of cows with each DHIA herd.

Donor cows were assumed to be superovulated for two nonsurgical emb collections per year before being mated to gestate their own calves. It w assumed that an average of four live calves per collection across donors cou be expected with professionals performing the services with currently availa commercial technology (Looney, 1980; Seidel, 1984; Donaldson, 1984). With t donor's natural born calf this would provide 9 live calves (4.5 heifers) p year per donor.

State and regional DHIA reports for the 1983 production year were used t estimate number of herds, number of cows and milk production by state a region for DHIA and all herds. The percent difference in 305 day mi production per cow between the top 10 percent and the herd average f Louisiana DHIA herds was used to estimate the change in production for DH herds by state and region. Averages for states within regions or the U. average were used when individual state and/or regional milk production f DHIA cows was not available. Additional feed required to support the high milk production levels was assumed to be 1.0 kg concentrate ration for ea additional 2.5 kg of milk produced. Prices for feed and milk used to estim increased income over feed cost per cow were 1983 prices by state and region reported in the state and regional DHIA 1983 reports.

Total increase in milk production by region was estimated based o production per cow, number of herds and number of cows for DHIA herds in ea region. The reduction in number of cows and number of herds required to reta the aggregate milk production in each region at the 1983 level was estimat assuming DHIA herds adopted the technology, thereby forcing less efficient no DHIA producers to cease operation.

The amount a dairyman could afford to pay for live birth transplant heif calves was estimated in terms of each 1000 kg increased annual milk producti potential above the production potential of the female the producer wou otherwise have used as a replacement. This was estimated by discounting t increased net income stream at 8 percent per annum assuming the heifer wou begin the first lactation at 30 months of age and have a production life of 3 years (State and Regional DHI Averages for the 1982-83 Testing Year, 1984).

THE MODEL

Descriptive statistics for all dairy herds and DHIA herds by region a for the U.S. are presented in Table 1 for the 1983 production year. Mi production per cow for DHIA herds averaged 6440 kg for the U.S. and rang among regions from 5703 to 7807 kg. Production per cow for all herds averag 5714 kg and ranged among regions from 4426 to 6830 kg. The percent of all co in DHIA herds was 41 for the U.S. and ranged among regions from 28 to 56.

The 7801 Holstein cows in the 188 Louisiana DHIA herds used to estim milk production variability among cows within herds had a mean 305 day mi production of 5653 kg (S.D.=1744 kg). Two subgroups consisting of the high producing 10 percent and the lowest producing 10 percent of animals in ea herd were selected for further analysis. The top producing 10 percent (7 cows) had a mean 305 day production of 8068 kg. The S.D. for this group w 1146 kg with a range of 4620 to 11959 kg. The lowest producing 10 perce

Table 1. Number of Dairy Cows, Herds, and Milk Production by Region, U.S. 1983.

Region	Total milk production	All Herds: Total number cows	Total number herds	Milk per cow	Percent of cows on DHIA	DHIA Herds: Total number cows	Number of herds	Milk per cow
	(Mkg)	(000)		(kg)		(000)		(kg)
Delta	1231	279	11500	4426	30	84	926	5703
Southeast	2112	421	9100	5064	50	183	1015	6149
Southern Plains	2344	439	16000	5132	28	132	1109	6478
Mountain	3341	538	18400	5339	49	259	1550	6440
Pacific	8900	1268	13900	6830	56	749	2687	7807
Northeast	12843	2226	51180	5833	49	1051	16481	6440
Lake States	18269	3148	78000	5860	44	1395	27224	7079
Corn States	7840	1473	49400	5331	35	524	9106	6656
Northern Plains	2585	513	20300	5033	31	155	2372	6246
Appalachian	4007	799	35800	5049	41	305	3384	6661
U. S. Total	63545	11120	303580	5714	41	4837	65854	6440

Source: "Milk Production"; "Dairy Herd Improvement Letter"; and Regional Dairy Herd Improvement Association Annual Summaries and Progress Reports.

had a mean 305 day production of 2858 kg (S.D.=891 kg). The mean production level of the top 10 percent was 43 percent above the overall average. The mean production level for the lowest producing 10 percent was 49 percent below the overall average.

Generally, dairymen enrolled in DHIA tend to be the more progressive producers. This analysis assumed DHIA producers would adopt the nonsurgical embryo transplant technology. All projections are based on the number of cows and production per cow by region for herds enrolled in DHIA. It was further assumed for this analysis that the top producing 10 percent of cows within each DHIA herd would be superovulated and used as donors to supply embryos for the remainder of the cow herd. If embryos were collected from donors twice per year (four live calves per collection) before the donors were mated to gestate their own calves, this would provide 9 live calves (4.5 heifers) per year per donor. Then 2 years would be required to provide heifer calves with germ plasm from the top 10 percent of the dams to replace all cows within the herd that have lower genetic potential. Assuming that 25 percent heritability is realized, this procedure would effectively increase the herd average by 11 percent. The analysis was based on first generation herd performance after restructuring without evaluating performance during the period before all higher producing replacements reached their initial lactation. Artificial insemination, with appropriate bull selection, should retain the higher genetic potential.

The projected impact of the preceding embryo transplant scenario is summarized in Table 2. Milk production per cow for DHIA herds was estimated to increase by 741 kg for the U.S., ranging from 656 to 898 kg among regions. Increased concentrate feeds required to support the higher production level averaged 296 kg per cow for the U.S. and ranged from 262 to 359 kg among regions. Based on 1983 milk and feed prices by region, the increased net income over added feed costs was estimated at \$160.54 per cow for the U.S. and ranged from \$151.08 to \$194.71 among regions. This represents the maximum amount dairymen could afford to pay for embryo transplantion, assuming that

Table 2. Projected Impact on Dairy Production by Region Assuming the Top Ten Percent of Cows Are Used as Donors for Embryo Transplants within DHIA Herds.

Region	Within DHIA herds					Projected total production assuming no change in number cows	All herds assuming total production remains at 1983 level and non-DHIA herds are forced to exit			
	Projected production per cow	Increased production per cow	Increased feed per cow	Increased net income per cow	Total increased production		Total number cows	Total number herds	Average production per cow	Percent non-DHIA remaining
	(kg)	(kg)	(kg)	($)	(Mkg)	(Mkg)	(000)		(kg)	
Delta	6359	656	262	153.84	55	1286	264	10707	4656	93
Southeast	6857	707	283	179.97	129	2242	390	8049	5415	87
Southern Plains	7223	745	298	171.33	98	2442	419	15032	5594	94
Mountain	7181	741	296	157.04	192	3533	506	16462	6604	89
Pacific	8705	898	359	194.71	672	9572	1154	11433	7714	78
Northeast	7181	741	296	171.58	779	13621	2076	46756	6186	87
Lake States	7893	814	326	170.27	1136	19405	2911	71145	6275	87
Corn States	7422	765	306	160.23	401	8241	1385	45673	5660	91
Northern Plains	6964	718	287	151.08	111	2696	488	19045	5298	93
Appalachian	7427	766	306	170.15	233	4240	741	31991	5408	88
U. S. Total	7181	741	296	160.54	3583	67128	10429	277430	6093	89

This table is computed using the top ten percent of the herd as donors, collecting twice per year with four live calves per collection.

there would be no change in milk prices resulting from the increased production. The total increase in milk production for the U.S. was estimated at 3583 Mkg assuming no change in the number of cows.

It could be expected that, as producers adopt the embryo transfer technology, the increased production would exert a downward pressure on milk prices, thereby forcing higher cost producers to leave the industry or stimulating regulations to impose maximum limits on production. The last four columns in Table 2 reflect projected characteristics of the U.S. dairy production industry assuming aggregate milk production remained at the 1983 level and increased production efficiency of DHIA producers forced higher cost less progressive producers to cease dairy production. Given these assumptions, 89 percent of the cows not enrolled in DHIA would remain nationwide. The percent of non-DHIA cows remaining by region was estimated to range from 78 to 94 percent. The proportion of herds (cows) remaining would be dependent upon the production level per cow and proportion of cows enrolled in DHIA.

Nonsurgical embryo transplant technology has commercial application potential for the dairy industry beyond within herd transfer. This technique offers potential to upgrade the herd using embryos of greater genetic potential than exists within the herd. The dairyman could purchase embryos of known superior genetic quality from other dairymen or commercial embryo suppliers and use the cows within the herd as recipients to gestate the potential replacement calves. Table 3 illustrates the amount a dairyman could afford to pay for each 1000 kg increased annual milk production potential for a live transplant heifer calf at selected milk and feed prices. At current milk and feed prices, the dairyman could pay as much as $533.50 per 1000 kg production potential above the on-farm recipient animal for a live heifer calf. These estimates assume the dairyman would use his own females as embryo recipients and bear the costs of maintaining the recipient during gestation and raising the heifer calf to age of lactation age.

Table 3. Price Per Thousand Kilograms Increased Milk Production Potential Producers Can Afford to Pay for a Live Embryo Transplant Heifer Calf at Selected Milk and Feed Prices.

Feed Price ($/kg)	Milk Price ($/kg) .22	.26	.31	.35	.40	.44
	$$$					
.13	405.46	512.16	618.86	725.56	832.26	938.96
.18	362.78	469.48	576.18	682.88	789.58	896.28
.22	320.10	426.80	533.50	640.20	746.90	853.60
.26	277.42	384.12	490.82	597.52	704.22	810.92
.31	234.74	341.44	448.14	554.84	661.54	768.24

Table values based on the increased net income stream discounted at 8 percent per year.

CONCLUSIONS

Sufficient variation in genetic potential exists among cows within dairy herds to permit increasing the herd annual milk production average as much as 11 percent the first generation by using commercially available embryo transfer technology and germ plasm existing within the herd. The increased profitability at current milk and feed prices offers some incentive for progressive dairymen to adopt the technology. Potential exists to increase production and net returns per cow even further by acquiring embryos of superior genetic potential from sources external to the herd.

The economic incentive for adopting embryo transfer technology by the dairy industry may result in increased levels of milk production that will exert downward pressure on milk prices. These conditions would aggravate the problems associated with existing surplus milk production and result in even more dramatic restructuring of the dairy industry by size and location of producing firms. Further, the shift to a larger proportion of the ration required to be supplied from concentrate feeds, along with relocation of producers, could result in substantial impact on feed processors and suppliers.

In the future embryos can be priced based on their economic value to producers. The prices producers can afford to pay are sufficient that viable markets could be established, thereby creating an environment conducive to development of commercial embryo banks and firms specializing in embryo transfer technology.

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