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Eel Farming in Israel

Abstract

The European eel *Anguilla anguilla* L, reaches the Israeli coastline, (the most eastern part of the Mediterranean sea) through its annual migration, but in relatively small numbers, to enter the very few river systems of Israel. It is occasionally found in fishponds connected to the river and canal system. However, because of its lack of visible scales, eel is considered not kosher and therefore inedible for religious and traditional Jewish people. It is for this reason that there is only a short history of eel farming in Israel compared to the longer fish farming history of the country.

To date, the only producer of eel in Israel is the Kibbutz Dan Fish Farm located in the most northern part of the country. This farm receives good quality water from one of Israel's major water resources, the River Dan.

Several hundred kg of glass eel are imported from England every spring. On arrival, they are stocked at densities of 25,000 (ca 7-8 kg)/m^3. They undergo acclimation to reach the nursing water temperature of 23°C, and are bathed for 6 hours in oxytetracycline daily for the first 3 days. Feeding on cod roe starts the day after arrival and continues for 5 days, after which a mix of cod roe and dry eel feed is given for another week. By the end of the third week from arrival, the eel already feed only on dry feed crumbs.

In the first year of nursing, the eel grow from an average of 0.20 g to an average of 19 g with an average FCR of 1.36. However, only ca 15% of the stock reaches the size of over 150 g, ready to be exported, by the middle of the second year of culture. The remainder reaches an export size after 2 years of culture.

At the size of 7-40 g, the eel are transferred from the nursery to a set of outside ponds, sized 40 m^3 or 250m^3 for ongrowing. In these ponds, the eel are fed a paste feed, once or twice a day, depending on the season.

The main export market for the eel (export size of 150 g to 280 g) is The Netherlands. The current yield is ~30 tons a year. If market prices improve, it is hoped to achieve a yield of 200 tons by the year 2002.

Key words: Eel, *Anguilla anguilla*, Farming, Intensive

The European eel *Anguilla anguilla* L, reaches the Israeli coastline, (the most eastern part of the Mediterranean sea) through its annual migration, but in relatively small numbers, to enter the very few river systems of Israel. It is occasionally found in fishponds connected to the river and canal system.

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However, because of their lack of visible scales, eel are considered not kosher and therefore inedible for religious and traditional Jewish people. It is for this reason that there is only a short history of eel farming in Israel compared to the longer fish farming history of the country.

Nevertheless, the fact that eel need warm water for optimal growth, and obtain high prices on the European market, drew the attention of fish farmers and economists in Israel.

The first attempts of fish farmers to grow eel in Israel, aiming at export to the European market, began in the 70's when small quantities of glass eel were sporadically imported from Europe to be stocked into existing open earthen carp ponds. These few trials were not well planned and failed because eel escaped through the unprotected pond edges and there was a lack of knowledge and experience on eel culture among the Israeli fish experts.

In the 80's, supported by the Fish Breeding Association and the Ministry of Commerce and assisted by the Fish Health Laboratory of the Fish Breeding Association, more serious and better prepared trials were undertaken in several fish farms located in the northern part of the country. The attempts to culture eel both indoors and in outdoor ponds/tanks in mono and polyculture under controlled conditions, stimulated academic research towards nursing and culture technologies under controlled conditions, suitable to meet Israeli conditions.

As a result, much experience and information has been accumulated which has facilitated the establishment of a temperature-controlled water recirculation system for nursing glass eel and for the fattening of juveniles to marketable size at high stocking densities.

These partially successful investigations continued for almost ten years with useful results including the production of a locally made eel feed (composition: fishmeal 50%, chicken-meal 20%, starch 5%, wheat-meal 11%, oil 5%, vitamins 4%). Eel samples, fresh and smoked, were sent to Europe for culinary evaluation and were very well received.

Nevertheless, though encouraging progress was achieved, and solid and sound knowhow and experience gained, for a complexity of reasons this did not result in the establishment of significant eel production and, finally, the trials ceased.

In spite of the dwindling attempts to grow eel in Israel, interest in it as a possible commercial commodity remains. Geographical proximity to the European market, associate membership of the EEC, and favourable climatic conditions, provide Israel with significant advantages for eel farming (ability to supply Europe with fresh eels of different sizes by air at short notice).

It was not until the largest trout producer in Israel (Kibbutz Dan) decided to diversify and include eel in its production and, in early 1997, to import glass eel from England to run a commercial operation, that serious eel culture in Israel began. To date, the only producer of eel in Israel is the Dan Fish Farm of Kibbutz Dan, located in the most northern part of the country. This farm receives good quality water from one of Israel's major water resources, the River Dan.

Materials and methods

Nursery

(a) **System:** The shaded, indoor nursery system is made of 24 round rearing tanks (4 m^3 and 6 m^3) combined with a purification unit creating a recirculation system. Water from all nursery tanks is collected to be mechanically filtered by a biodrum (Wintec) with a mesh of 70 μm. Thereafter the water is pumped up a 6-m high tower from where it runs down over plastic strips to which the nitrifying bacteria are attached. The water is then collected in a pool from where it is pumped into a reactor for enrichment with pure oxygen before re-entering the eel nursery tanks. The entire water volume of the nursery is 160m^3 which can accommodate a total

standing crop of ~ 14 tons of small eels.

(b) **Eel and stocking:** Several hundred kg of glass eel are imported from England (on one occasion from France), every spring. On arrival, they are stocked into the nursery tanks at densities of 25,000 (ca 7-8 kg)/m^3. The eel undergo 2 days acclimation to reach the nursing water temperature of 23°C and from the day after arrival, are bathed for 6 hours in oxytetracycline (30 ppm) with a higher level of oxygen, daily for 3 days. When the eel reach an individual weight of 10-40 g, their stocking density in the nursery tanks can rise to 150-160 kg/m^3 (average of 100 kg/m^3)). However, the number of fish in the 4m^3 tanks is kept at under 100,000 in order to reduce the risk of oxygen depletion.

(c) **Feeding:** For five days from the day after arrival, the glass eel are fed on cod roe, imported from England at a price of $4.5 /kg. Thereafter, for two weeks, the cod roe is mixed with a paste made of a dry eel feed (Coppens, Hendrix, protein 50-53%; fat 18-22%) mixed with water (1 : 1) and 10% fish oil. To this diet is added a gradually increasing amount of crumbs of dry eel feed. When the eel reached an average weight of 0.5 g, the paste feed is changed exclusively to crumbs of an adequate size. The crumbs are provided via automatic feeder and remain the sole eel feed until the end of the first nursery period. The dry feed is administered every second hour for one to two minutes, totalling an average of 3-4% of the total fish biomass daily. When the eel reach a minimum size of about 7-40 g they are moved to the fattening ponds.

Fattening

(a) **System:** Eel are transferred from the nursery for fattening to an outdoor set of 15 ponds of 250 m^3 each and 12 ponds of 40 m^3 each, making a total of 4230 m^3, (depth 1 m) (occasionally two of these 40 m^3 ponds are used to purge the eel before marketing). The fattening ponds have concrete walls and bottoms which are lined with PVC sheeting. Each of the 250 m^3 ponds has 2 floating oxygen supply devices which is made of an engine to lift pond water into a covered umbrella under which the lifted water is mixed with pure oxygen (at a cost of $0.25 /kg), injected from a nearby liquid oxygen tank into the covered device. In addition to these two devices, a 1.5-hp paddle wheel to create water movement and enhance water oxygenation is also positioned in each pond. Each pond has an oxygen metre (Oxygard) which is connected to a computer and controls the operation of the oxygen devices. Each of the smaller 40m^3 ponds has 1 oxygen supply device. The fattening ponds receive water from two sources, one is water from a 2-hectare carp and tilapia pond. The other is the River Dan (constantly around 16°C) that Hows either directly or through raised pout ponds in to the eel fattening ponds. The mixing of both water supplies determines the water temperature in the eel fattening ponds which is maintained during the warm summer season (9 months) at around 25°C and from 14°C to 17°C in the short (3 months) winter. The daily water exchange for the 40 m^3 ponds is 5-10 m^3/h, directly from the Dan River, and 5-10m^3 from the carp/tilapia pond. The 250m^3 ponds receive 10-12 m^3/h daily from the carp/tilapia pond and 20-30 m^3/h from nearby, raised trout ponds receiving water from the river Dan.

(b) **Stocking:** Eel of between 7-40 g are stocked into the fattening ponds of 40m^3 at a density of 7-35 kg/m^3. Eel of between 10-150 g are stocked into the 250 m^3 fattening ponds at a density of 4-16 kg/m^3. During growth, the density of eel can reach 30-40 kg/m^3.

(c) **Feeding:** Eels are fed twice a day in the summer and once in the winter with a paste feed which is made up of dry feed in powder form (Hendrix, Italy), mixed with fish oil and water at a ratio of 1 : 1 : 0.05 to create a proper, dough-like consistency. The feed is placed on a shaded, framed mesh positioned at the pond edge next to the water surface.

(d) **Grading:** Grading according to size takes place every 6 to 8 weeks in the small ponds and every 3 months in the large ones using graders (Italian made)

that divide the eel into 4 sizes under running water. Selection between male and female eel of 100-160 g is done by hand.

Water quality

Water quality in the fattening ponds is maintained at:

total ammonia - NH_4^+- N 0.1-1.0 ppm;
Nitrite NO_2 - N 0.6-1.0 ppm;
pH 7.5 ± 0.4
Temperature: 12°C minimum, 25°C maximum
Oxygen (controlled on-line), at 6-10 ppm.

Diseases and parasites

Eel are checked routinely for diseases and parasites, particularly when less feed is consumed and there is loss of appetite. Treatment with formalin, 200 ppm for 3 hours, is carried out in cases of *Ichthyophthyrius* and *Chilodonella*. For Dactylogyrus and Pseudodactylogyrus, 4 ppm Mebendazol or Fluvenol is used for 20 hours for the entire nursery as well as for each of the fattening ponds: the procedure is repeated after 8 days. *Trichodina* infection treated with formalin (37%) at a concentration of 50 ppm for 4 hours. Occasionally *Anguillicola crassus* has been found in the swim bladder of a few eel but the rate of infection has been low and does not appear to have been a cause of mortality.

Treatment against the bacterium *Aeromonas hydrophila* (symptoms: red stains on the head, pectoral fins and on the ventral side, as well as destruction of the gill tissues) is carried out by using the antibiotic Quinabic (active drug: Norfloxacin) at 30 mg for 1 kg of live fish per day. This drug is mixed with the dry food, then fish oil is added for better adhesion of the drug to the feed, which is administered manually for 18 days.

Harvesting and shipment

Eel are harvested from the fattening ponds by raising the 10" pipe that blocks the drain at the the edge of the pond the water, with the eel then flows from the pool in to a pipe to a central pit of 1 m^2 where eel are collected to 400 kg loads in a metal perforated colander. The eel are then lifted in the colander and transferred by vehicle into an eel grader to be sorted to 4 sizes (samples are counted and weighed to determine the average weight), and placed into the pond corresponding to their size either for shipment or for further growing. Eel reaching the market size of 150-180 g are kept in a 40 m^3 pond without food under clean running water at a temperature of 16°C. where they remain for 3 days before marketing. Eel for export are prepared for shipment overseas by being cooled with ice to 4°C to 5°C. The cooled, live eels are then packed in portions of 10 kg in cardboard boxes with ice for export by air, arriving at their destination live.

Results

The growth and mortality parameters of the eel in the nursery and fattening ponds can be seen in Figs. 1, 2, 3 and 4 and Tables 1, 2 and 3. The average FCR of the eel in the nursery is 1 : 1.4 and the daily SGR ranges between 0.8-1.0%. Table 4 gives data on seasonal comparison of growth performance in the fattening ponds. In March 2000 a final grading, weighing and counting of the eels in all fattening ponds, reflecting the winter season, showed a daily SGR of 0.2% and FCR of 1:2.7. In October 2000, the final grading, weighing and counting of the eels in all the 4230 m^3 fattening ponds, reflecting the growth season of summer 2000, gave the following results: the total number of fish was 1,150,000 weighing 68.6 tons, out of which 20 tons were ready for the market at an average weight of 150 g. The average daily growth rate was 0.44% with a feed conversion rate of 1:3.2 . This growth period was characterized by a significant improvement in feeding and growth.

Marketing

In the year 2000, approximately 35 tons of marketable eel (average weight 150 g), were sold: 5-6 tons on the local market; 5 - 6 tons in France at a retail price of $ 9/kg; most eel, however, were exported to the Netherlands at a price of 11 Gilden/kg.

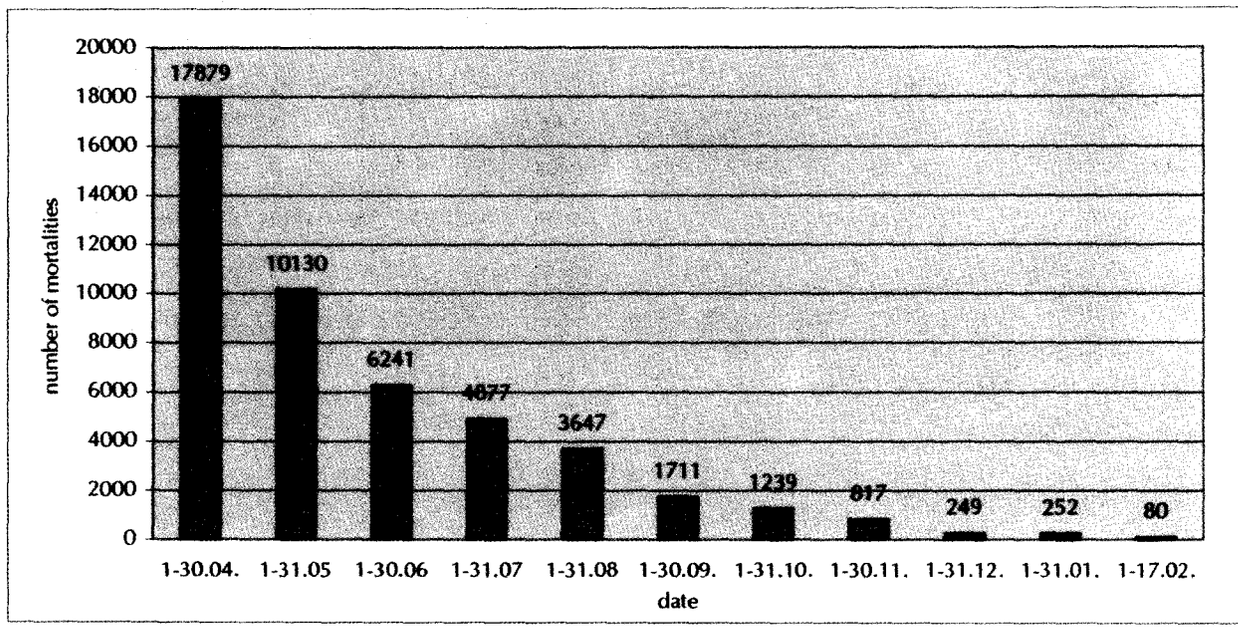

Fig. 1. Monthly eel mortality.

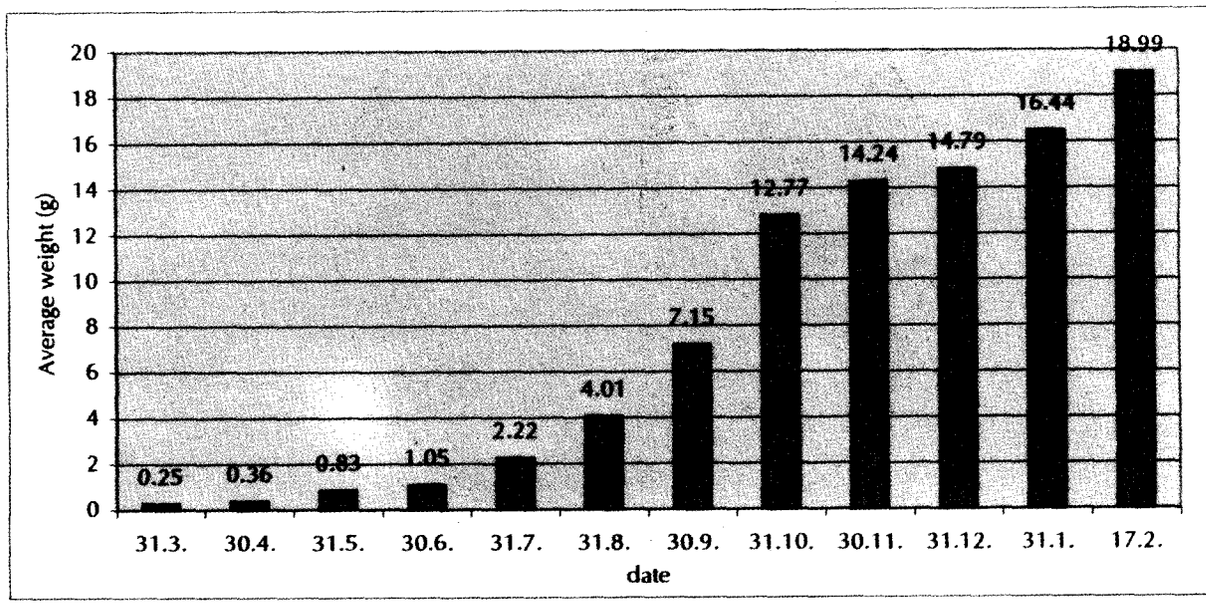

Fig. 2. Average weight of the eel during the first year of culture .

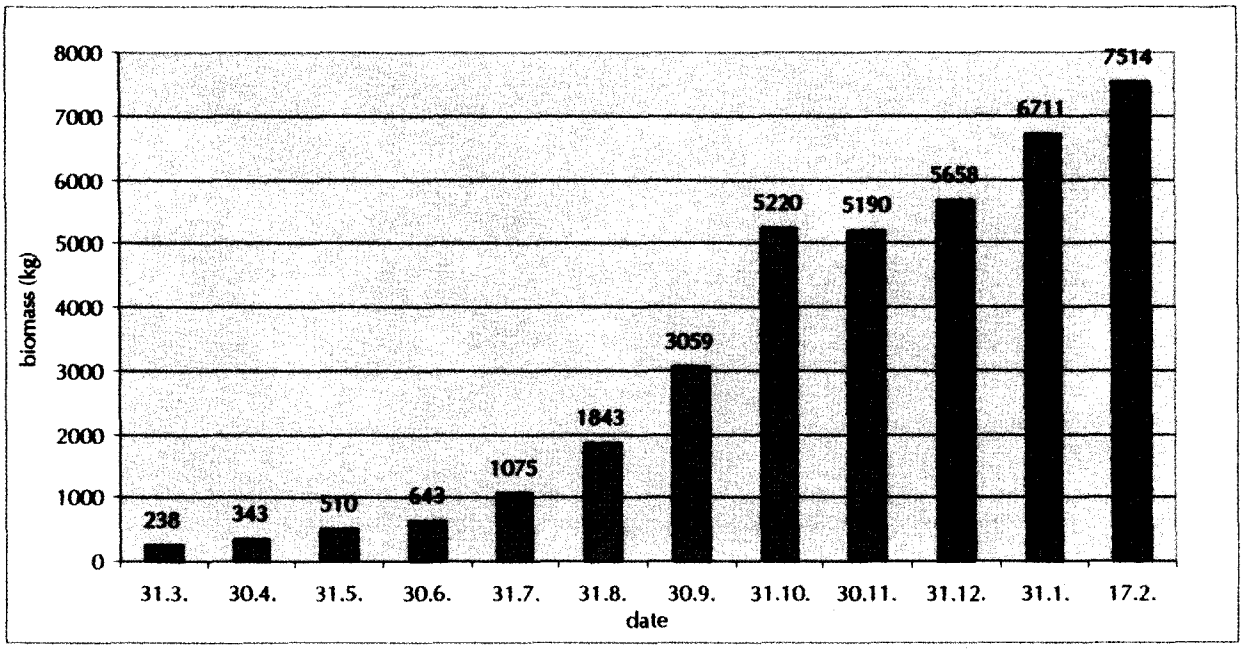

Fig. 3. Changes in biomass of the eel during the first year of culture.

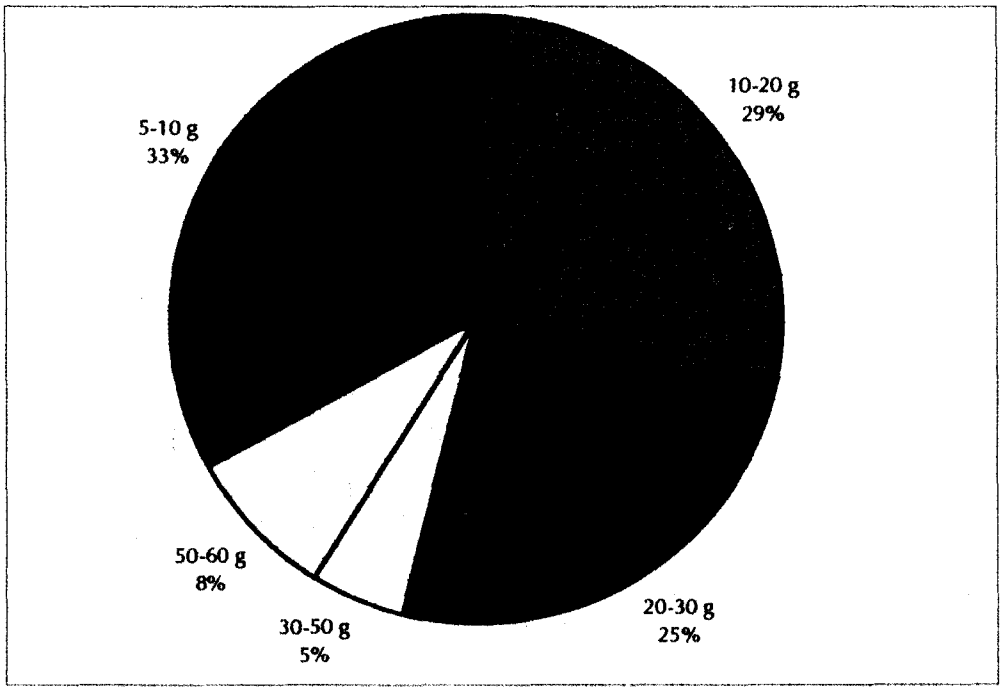

Fig. 4. Weight distribution of eel at the end of the first year of culture.

Table 1. Weight of eel (week 8 - nursery).

Tank	*Biomass (g)*	*Average (g) weight*	*Number fish*
3	61.230	1.20	51.116
4	67.600	2.98	22,685
5	61.870	1.03	60,067
6	63.520	2.69	23,615
7	60.868	0.62	98,174
8	63.220	1.29	49,007
9	62.880	0.64	98,250
10	65.720	1.72	38,209
11	53.418	0.47	11,365
12	55.272	2.03	27,227
Total	615.708	1.28	479,715

Table 2. Weight of eel (week 30 - fattening ponds).

Pond	*Biomass (g)*	*Number fish*	*Average (g) weight*
401	544	20,571	26.22
402	571	10,748	53.11
404	470	17,882	26.20
405	334	6,512	51.30
Total	1,919	55,893	34.30

Table 3. Performances of different stocks of eels.

Year	*1997*	*1998*	*1999*
Glass eels	865,000	1,900,000	2,250,000
Number of eel at the end of the first year of culture	440,000	998,700	1,575,000
Biomass of eel at the end of the first year of culture (kg)	5,406	7,572	16,177
Eel at the end of nursing (kg)	3,414	5,072	8,854
Survival in the nursery	51%	52.6%	70%
Weight gain in the nursery (kg)	5,156	7,072	15,427
Food conversion ratio	1.3	1.22	1.36

Table 4. Data comparing seasonal eel growth performance in the fattening ponds.

Season	*Growth period (Days)*	*SGR*	*FCR*	*Mortality (%)*
Autumn 1998	54	0.24	7.2	9
Winter 1998/1999	88	0.19	3.86	4
Autumn 1999	120	0.2	2.69	5
Winter 1999/2000		0.2	3.9	1.9
Spring 2000	90	0.38	3.83	2
Summer 2000	130	0.44	2.88	1
Winter 2000/ 2001	180	0.4	2.08	1

Discussion

Looking back at the growth parameters for the recent two years (the farm has been operating since 1997), there is encouraging evidence that growth is improving annually while mortality is reducing annually. This is certainly a result of a continuous improvement in busbandry techniques with better provision of oxygen, greater control of the water temperature, improved preparation of feed and grading of eel.

For the year 2001, 100 tons of marketable eel are expected to be exported (to the same markets as before). It is planned to produce 200 tons in the same system operation by the year 2002.

The future of eel farming in Israel depends on European market prices for eels. It is hoped that the price will rise, thereby improving profitability.

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