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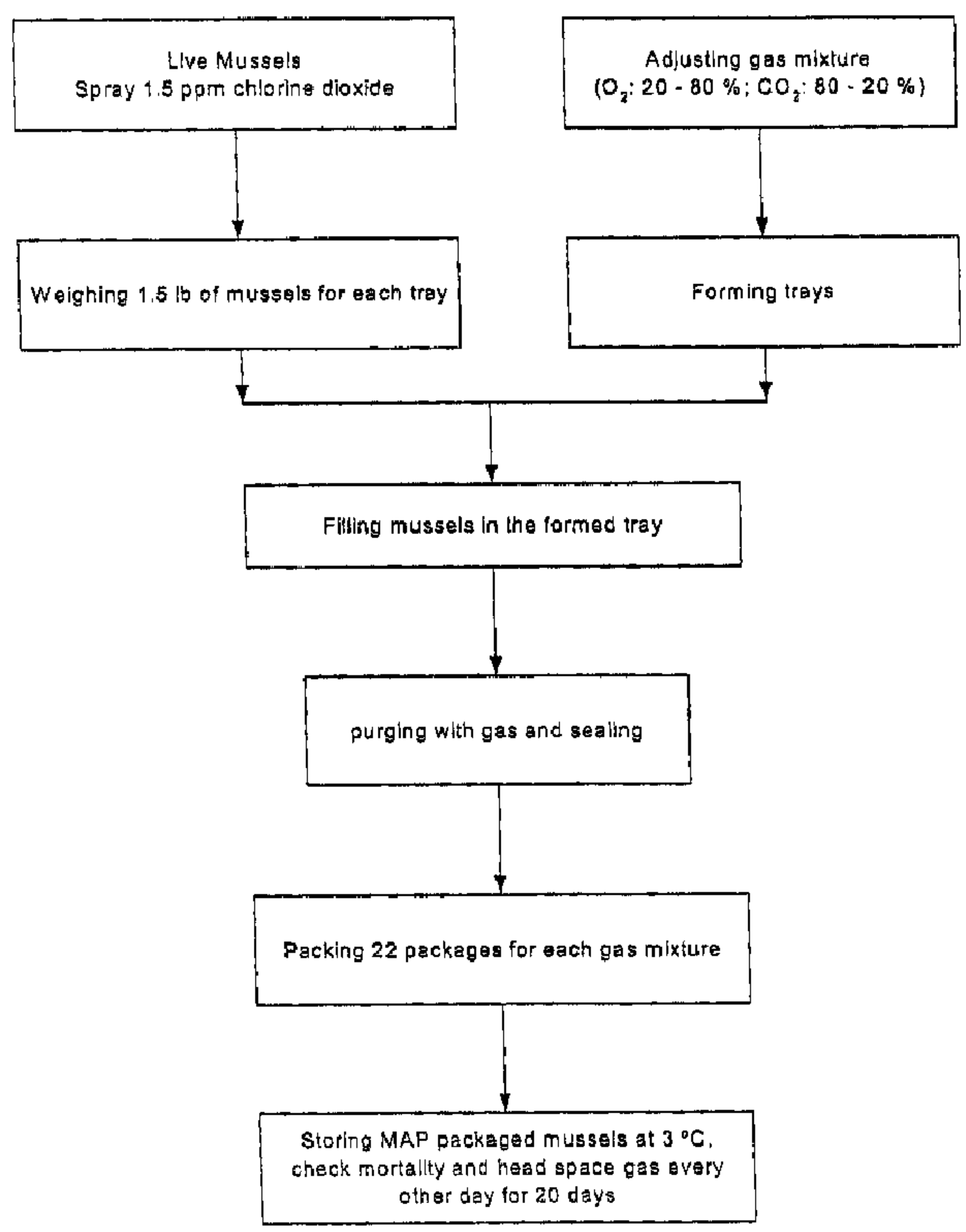
(54) Title: MODIFIED ATMOSPHERE PACKAGING FOR SEAFOOD

Flow diagram for MAP packaging mussel



(57) Abrégé/Abstract:
A method of packaging live seafood comprises the steps providing a sealable container, placing the live seafood in the container, and replacing the atmospheric gas in the container with a gas mixture comprising CO_2 and O_2, with an O_2 content of at least 50%, and a CO_2 content of at least 20%.

ABSTRACT

A method of packaging live seafood comprises the steps providing a sealable container, placing the live seafood in the container, and replacing the atmospheric gas in the container with a gas mixture comprising CO_2 and O_2, with an O_2 content of at least 50%, and a CO_2 content of at least 20%.

The present invention relates to the field of live seafood packaging. In particular, the present invention provides an improved live seafood packaging method, and package, that improves mortality rate of packaged live seafood, as compared with known live seafood packaging.

In the marketing of seafood, in particular shellfish, crustaceans and mollusks, it is very desirable to deliver a live product, to permit a restaurant or seafood market to offer the best possible seafood to the consuming public. Bringing live seafood to inland markets can be problematic, and expensive. The most obvious, and expensive, way to do so is to expedite transport of the live animals by air, preferably in an aqueous environment simulating their natural environment. This is effective, but expensive, because of the weight involved.

There have been several packaging methods proposed to keep live seafood alive during transit. In JP58129930, the product is packaged in a mixture of O_2 and CO_2, after it has been injected with alkaline solution of pH 7-12. This method, then, requires additional handling of each item, and the use of an additive thereto, and is therefore not economically feasible.

In US6238716, a packaging method using 50%-90% of a CO_2 and O_2 mix including 25%-50% O_2 is proposed. It has been found to be effective on some shellfish, but as will be discussed below, is ineffective in relatively long time frame shipping and storage.

The present invention provides a method of packaging, and resulting package, that is particularly effective for long time frame shipping and storage of seafood. The method of the present invention results in very low mortality rates over twenty or more days of storage, making the present invention effective for large scale packaging of live seafood species for shipment to inland locations, utilizing low cost transit options.

In a broad aspect, the present invention relates to a method of packaging live seafood comprising the steps providing a sealable container, placing said live seafood in said container, and replacing the atmospheric gas in said container with a gas mixture comprising CO_2 and O_2, with an O_2 content of at least 50%, and a CO_2 content of at least 20%.

The sealable container will preferably include at least one layer made from flexible film.

The container may be made from two sheets of flexible film sealed around their edges to provide an interior space between the two sheets.

Moreover, the container may comprise a plastic tray having an interior volume and an upper peripheral edge, with a sheet of flexible sealable film sealed to the upper peripheral edge of the tray.

In either event, the flexible film is preferably a multi-layer high barrier film.

The gas mixture used in the present invention may comprise at least 75% O_2, and preferably comprises about 80% O_2.

In a preferred form of the present invention, the balance of gas in the gas mixture, apart from O_2, is CO_2.

The packaging method of the present invention, in a practical embodiment, includes the further step of rinsing the live seafood with ClO_2 before placing same in the packaging.

The live seafood may be a bivalve mollusk selected from the group consisting of clams, mussels and oysters.

Typically, the live seafood is mussels.

The method of the present invention, whether using a sealed plastic tray, or a sealed bag type of package, is suitable for use on any existing packaging equipment in which the final atmosphere may be controlled.

In drawings that illustrate the present invention by way of example:

Figure 1 is a flow diagram for modified atmosphere packaging of mussels;

Figure 2 is a graph of mortality % vs. time, in days, for mussels stored at varying ratios of CO_2 and O_2;

Figure 3 is a graph of mussel meat pH vs. time, in days, for mussels stored at varying rates of CO_2 and O_2;

Figure 4 is a graph of mussel drip pH vs. time, in days, for mussels stored at varying ratios of CO_2 and O_2;

Figure 5 is a graph of mortality vs. the weight ratio of drip/mussel; and

Figure 6 is a graph of pH of drip vs. weight ratio of drip/mussel..

In the method of the present invention, seafood, for instance blue mussels (Mytilus edulis) are packaged in modified atmosphere packaging (MAP) having a CO_2/O_2 ratio of less than 1:1, preferably less than 1:2, and preferably in the range of 1:4. The packaging method of the present invention is effectively illustrated by the following example.

Materials:

1. Eleven bags of 25 lb live mussels were harvested on August 13, 2003 from PE3M area and delivered to the testing facility. The temperature reading of the incoming samples was 7.3°C by using a Fluke Thermometer (52II with type K thermocouples, Fluke Corporation, USA).
2. Two types of multilayer high barrier film (OF-900M for forming the trays and OF-475M for sealing, both made of Nylon/EVOH/mpE) sourced from the Packaging Group (Concord, ON) were used.
3. One cylinder of food grade oxygen and one cylinder of carbon dioxide.
4. 500 mL of 1.5 ppm chlorine dioxide solution.

Methods: Seven gas mixtures of different ratios of CO_2/O_2 were used. The gas mixture levels are listed in table 1. A Multivac gas mixer (Model KM-100-3M) was used to produce the desired proportions of CO_2 and O_2 in the package.

Table1. Gas Mixture levels for mortality rate study of MAP mussels.

Gas	Level, v/v%						
O2	20	30	40	50	60	70	80
CO2	80	70	60	50	40	30	20

Fig. 1 shows the flow diagram for the Modified Atmosphere Packaging (MAP) process. The Dixie Reiser package system (Reiser DV 2000E, Dixie Union, Germany) was used for thermoforming of the trays and the sealing of the package using the multilayer high barrier films (OF-900M and OF-475M) with the desired gas mixture. About 1.5 lb (681 g) of live mussels were used for each package. Twenty-two packages were prepared for each gas mixture level. A total of 154 packages for the 7 gas mixture levels were packed.

All MAP packed mussels were stored at 3°C. On every second day, two packages of each gas mixture were used for mortality evaluation by FTC staff and client. The pH values of mussel meat and drip in the packages were checked by using a Corning pH/ion meter (Model 155, Corning Inc, Corning, NY). The head space gas composition of the package was also measured by using a Gas Analyser (MAPtest 4050, Hitech Instruments, Luton England).

Results:

Table 2 is the summary of data for mortality of the MAP mussels.

TABLE 2

Day		0	2	4	6	8	10	12	14	16	18	20
$CO_2/O_2 = 80/20$												
Head space gases	O_2,%	22.9	29.6	29.4	32.4	28.4	27.8	27.4	26.3	23.8	22.0	21.3
	CO_2,%	72.4	65.7	65.7	62.5	65.8	65.8	65.7	67.5	70.0	71.6	84.9
	N_2,%	4.7	4.7	4.9	5.1	5.8	6.4	6.9	6.2	6.2	6.4	8.8
Drip/mussels (g/g)		3.18	12.63	10.23	12.13	13.72	12.17	23.50	17.12	22.36	18.09	23.00
Mortality, %		0.0	51.3	57.9	55.2	50.7	72.1	55.9	45.8	78.0	82.0	77.7
PH of mussel meat		6.3	6.2	6.7	6.4	6.6	6.5	6.8	6.8	6.5	6.6	6.5
PH of drip		6.2	6.1	6.2	6.3	6.3	6.1	6.5	6.6	6.4	6.4	6.4
$CO_2/O_2 = 70/30$												
Head space gases	O_2,%	32.7	40.2	38.7	39.0	41.3	38.9	37.4	35.0	33.1	29.8	28.1
	CO_2,%	63.8	56.5	56.8	54.6	52.8	55.6	56.7	58.9	60.4	59.6	61.7
	N_2,%	3.5	3.3	4.5	6.4	5.9	5.5	5.9	6.1	6.5	10.6	10.2
Drip/mussels (g/g)		5.54	10.68	8.44	9.43	11.39	11.00	18.74	19.03	17.53	20.19	19.90
Mortality, %		2.0	52.8	43.8	38.5	23.4	45.2	34.9	23.7	62.2	61.0	60.8
PH of mussel meat		6.3	6.4	6.4	6.5	6.5	6.4	7.2	6.6	6.6	6.5	6.8
PH of drip		6.1	6.4	6.3	6.4	6.4	6.2	6.7	6.6	6.5	6.6	6.5

TABLE 2 (Continued)

Day		0	2	4	6	8	10	12	14	16	18	20
CO_2/O_2 = 60/40												
Head space gases	O_2,%	36.7	42.5	53.0	58.1	54.4	54.0	47.9	49.2	45.2	46.6	41.5
	CO_2,%	35.0	25.1	31.5	31.2	27.7	32.1	36.3	34.5	44.5	38.8	37.6
	N_2,%	28.3	32.4	15.5	10.7	17.9	13.9	15.8	16.3	10.3	14.6	20.9
Drip/mussels (g/g)		6.83	12.45	6.16	4.40	4.82	3.02	18.05	16.09	16.95	12.56	12.40
Mortality, %		0.0	24.6	32.1	4.0	2.1	14.1	8.4	6.3	29.2	32.8	40.0
PH of mussel meat		6.5	6.5	6.6	6.4	6.6	6.6	7.0	6.8	6.7	6.6	6.4
PH of drip		6.5	6.4	6.6	6.7	6.7	6.9	6.7	6.8	6.5	6.5	6.5
CO_2/O_2 = 50/50												
Head space gases	O_2,%	50.6	56.9	59.0	58.0	38.3	56.5	53.4	52.1	52.1	47.5	44.2
	CO_2,%	45.4	39.3	35.9	36.1	23.7	37.2	41.2	40.6	41.2	45.7	45.7
	N_2,%	4.0	3.8	5.1	5.9	38	6.3	5.4	7.3	6.7	6.8	10.1
Drip/mussels (g/g)		4.00	12.14	7.82	6.78	12.25	11.82	18.46	14.40	18.17	19.67	20.35
Mortality, %		0.0	44.0	37.5	10.9	12.3	32.7	12.4	7.9	26.9	44.8	35.7
PH of mussel meat		6.5	6.4	6.6	6.5	6.9	6.6	7.1	7.1	6.7	6.7	7.1
PH of drip		6.3	6.1	6.4	6.5	6.7	6.4	6.8	6.9	6.7	6.7	6.5
CO_2/O_2 = 40/60												
Head space gases	O_2,%	60.5	66.7	68.9	65.5	64.3	63.1	62.3	59.8	57.6	57.9	51.9
	CO_2,%	36.3	28.7	26.7	29.3	30.3	29.9	31.5	33.8	35.9	37.9	36.8
	N_2,%	3.2	4.6	4.4	5.2	5.4	7.0	6.2	6.4	6.5	6.7	11.3
Drip/mussels (g/g)		2.96	14.28	6.7	6.61	10.76	9.01	16.00	13.80	16.20	14.81	18.54
Mortality, %		0.0	26.0	28.0	15.0	19.7	13.5	0.0	1.9	16.2	17.0	12.0
PH of mussel meat		6.4	6.4	6.7	6.5	6.6	6.7	6.9	7.0	7.0	6.9	7.0
PH of drip		6.4	6.3	6.6	7.0	6.6	6.5	7.0	7.0	6.9	6.9	6.8

TABLE 2 (Continued)

Day		0	2	4	6	8	10	12	14	16	18	20
$CO_2/O_2 = 30/70$												
Head space gases	O_2,%	68.8	74.4	74.6	74.4	72.7	70.6	69.4	68.2	62.9	62.9	59.9
	CO_2,%	57.5	21.2	20.5	20.5	21.4	22.9	24.9	25.6	30.9	30.8	29.5
	N_2,%	3.7	4.4	4.9	5.1	5.9	6.5	5.7	6.2	6.2	6.3	10.6
Drip/mussels (g/g)		2.35	12.03	6.75	12.41	9.82	9.51	16.72	18.56	16.88	19.15	19.32
Mortality, %		1.9	7.7	17.3	6.0	18.7	11.3	2.0	0.0	5.7	13.9	0.0
PH of mussel meat		6.6	6.5	6.6	6.7	6.6	6.8	7.2	7.3	7.0	7.1	7.1
PH of drip		6.8	6.4	6.7	6.6	6.7	6.6	7.2	7.0	6.9	7.0	7.0
$CO_2/O_2 = 20/80$												
Head space gases	O_2,%	78.7	81.2	81.8	79.9	78.5	74.8	74.0	70.1	66.6	66.2	61.1
	CO_2,%	18.6	13.5	13.4	15.5	16.5	18.9	19.1	23.0	25.9	27.3	26.3
	N_2,%	2.7	5.3	4.8	4.6	5.0	6.3	6.9	6.9	7.5	6.5	12.6
Drip/mussels (g/g)		2.41	9.66	9.41	12.59	13.30	9.97	19.02	15.59	13.94	16.82	14.85
Mortality, %		1.9	3.9	7.5	0.0	22.0	9.5	0.0	0.0	4.0	5.9	0.0
PH of mussel meat		6.5	6.5	6.9	6.8	6.8	6.8	7.2	7.4	7.1	7.4	7.1
PH of drip		6.9	6.5	6.7	6.7	6.7	6.6	7.3	7.1	7.1	7.1	7.1

The lowest mortality rate was with the 20% CO_2 and 80% O_2 initial gas mixture. Fig. 2 shows the mortality rate of MAP mussels with different gas mixture levels. Generally, there is a higher mortality rate during the storage time with higher CO_2 concentration in the packages. The fluctuation in mortality rate during the course of evaluation was partially due to the slow response of some mussels to tapping, which was used to determine the status of the mussels.

Generally, the oxygen levels were slightly decreased during the course of storage while the carbon dioxide content in all MAP packages decreased in the first few days and then increased slightly. The nitrogen contents in the packages increased with the storage time in all the gas mixture levels. The decrease of O_2

is apparently due to the activity of mussels as a result of respiration. The increase in N_2 is possibly a result of permeation of the packages from atmospheric gas. This would suggest that the change in O_2 might also be due to permeation through the package in addition to consumption by the mussels. This indicates tight film may be desirable.

The pH values of mussel meat and drip with different gas mixture levels are showed in Fig. 3. It is clear that the higher carbon dioxide content in the package had the lower pH in the meat and drip. The pH on the meat and in the drip had a trend toward increasing with the storage time with most of the gas mixtures. It may extend the shelf life of mussels by effectively adding a acid solution in the MAP package.

Fig. 4 shows the plots for mortality and pH of the drip vs. the weight ratio of drip to mussels with different gas mixture levels. The patterns seem to indicate that the relations were random, as the ratio of pH of drip to pH of mussel, as shown in Figure 5.

Conclusion: Overall, the 20% O_2 - 80% CO_2 and 30% O_2 - 70% CO_2 initial gas mixtures gave the very low mortality rate (close to 0%) of the mussels during the 20-day storage using the described packages and at 3°C storage condition.

In view of these results, it will be appreciated that enriching the O_2 content of the packaging atmosphere has demonstrable results in terms of enhances viability of the seafood product being shipped.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of packaging live seafood comprising the steps providing a sealable container, placing said live seafood in said container, and replacing the atmospheric gas in said container with a gas mixture comprising CO_2 and O_2, with an O_2 content of at least 50%, and a CO_2 content of at least 20%.

2. A method as claimed in claim 2, wherein said sealable container includes at least one layer made from flexible film.

3. A method as claimed in claim 2, wherein said container is made from two sheets of flexible film sealable around their edges to provide an interior space between said two sheets.

4. A method as claimed in claim 2, wherein said container comprises a plastic tray having an interior volume and an upper peripheral edge, and a sheet of flexible sealable film sealed to the upper edge of said tray.

5. A method as claimed in claim 2, 3 or 4, wherein said flexible film is a multi-layer high barrier film.

6. A method as claimed in any one of claims 1 to 5, wherein said gas mixture comprises at least 75% O_2.

7. A method as claimed in any one of claims 1 to 5, wherein said gas mixture comprises about 80% O_2.

8. A method as claimed in claim 6 or 7, wherein the balance of gas in said gas mixture, apart from O_2, is CO_2.

9. A method as claimed in any one of claims 1 to 8, including the further steps of rinsing said live seafood with ClO_2 before placing same in said packaging.

10. A method as claimed in any one of claims 1 to 9, wherein said live seafood is a bivalve mollusk selected from the group consisting of clams, mussels and oysters.

11. A method as claimed in any one of claims 1 to 10, wherein said live seafood is mussels.

12. A package produced by the method of any one of claims 1 to 9.

13. A packaged seafood product comprising a package produced by the method of any one of claims 1 to 12, enclosing a live seafood product selected from the group consistin of clams, oysters and mussels.

Fig.1 Flow diagram for MAP packaging mussel

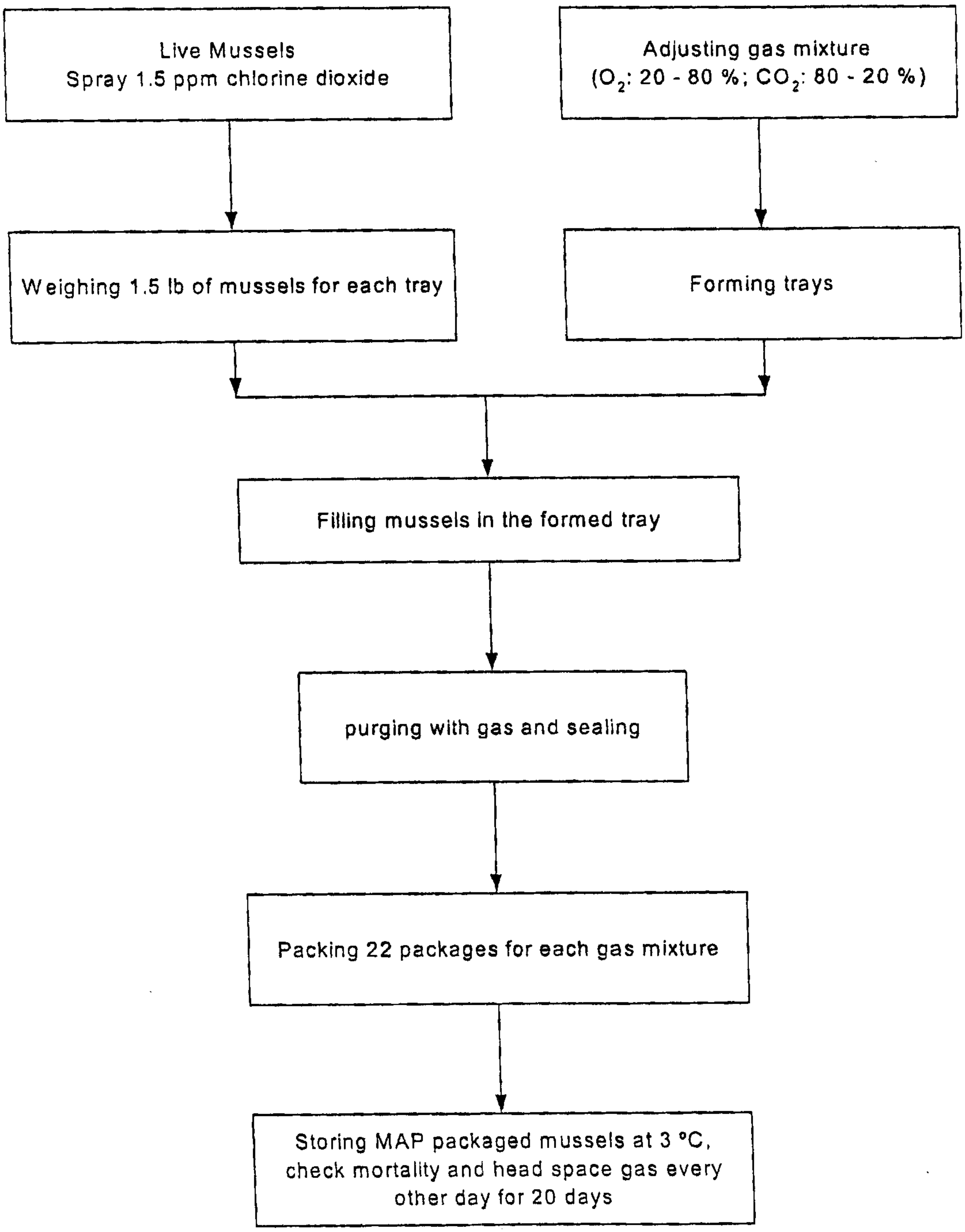


Fig. 2 Mortality rates of MAP mussels
Stored at 3 °C

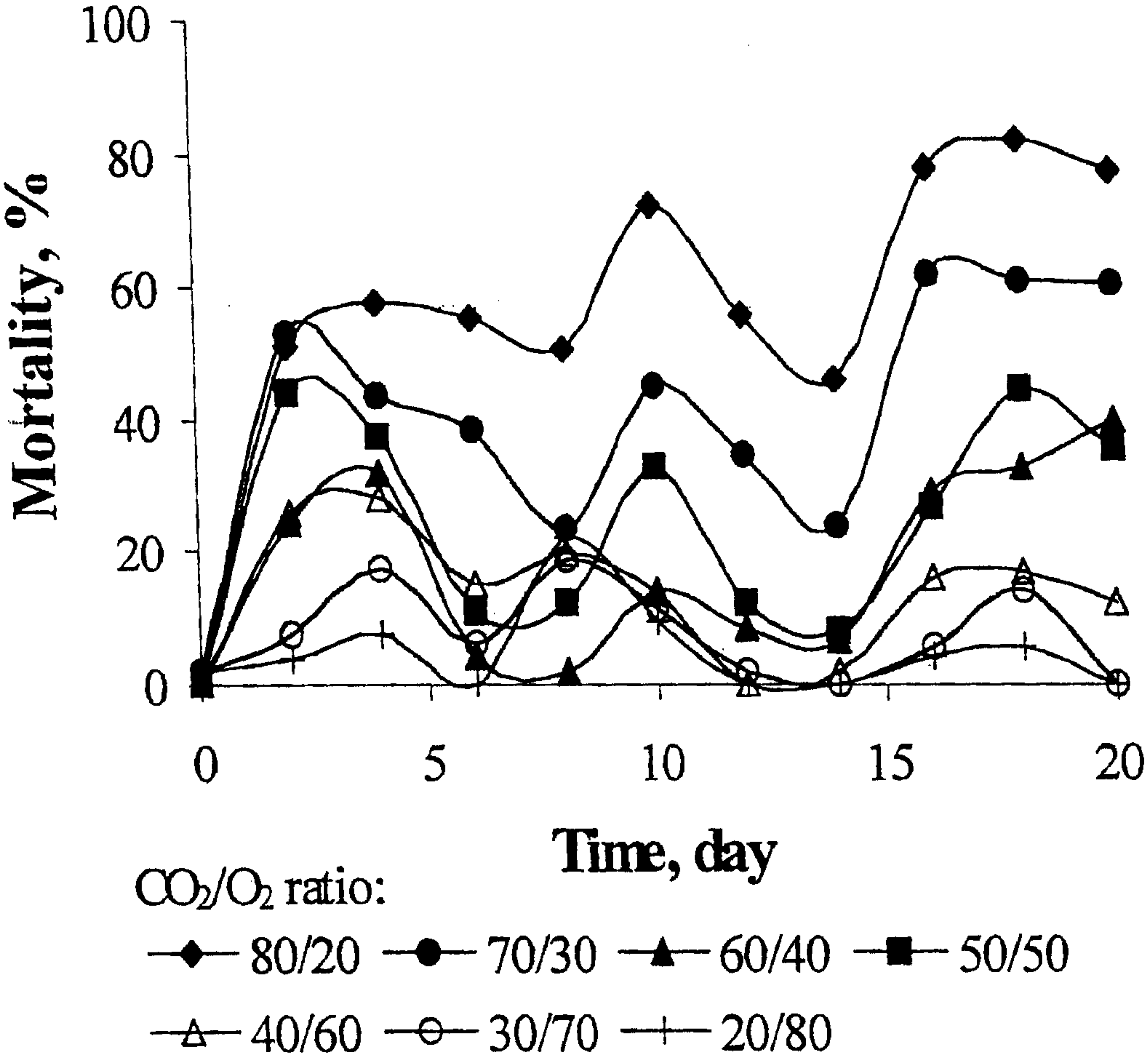


Fig. 3 Mussel meat pH v. time in days

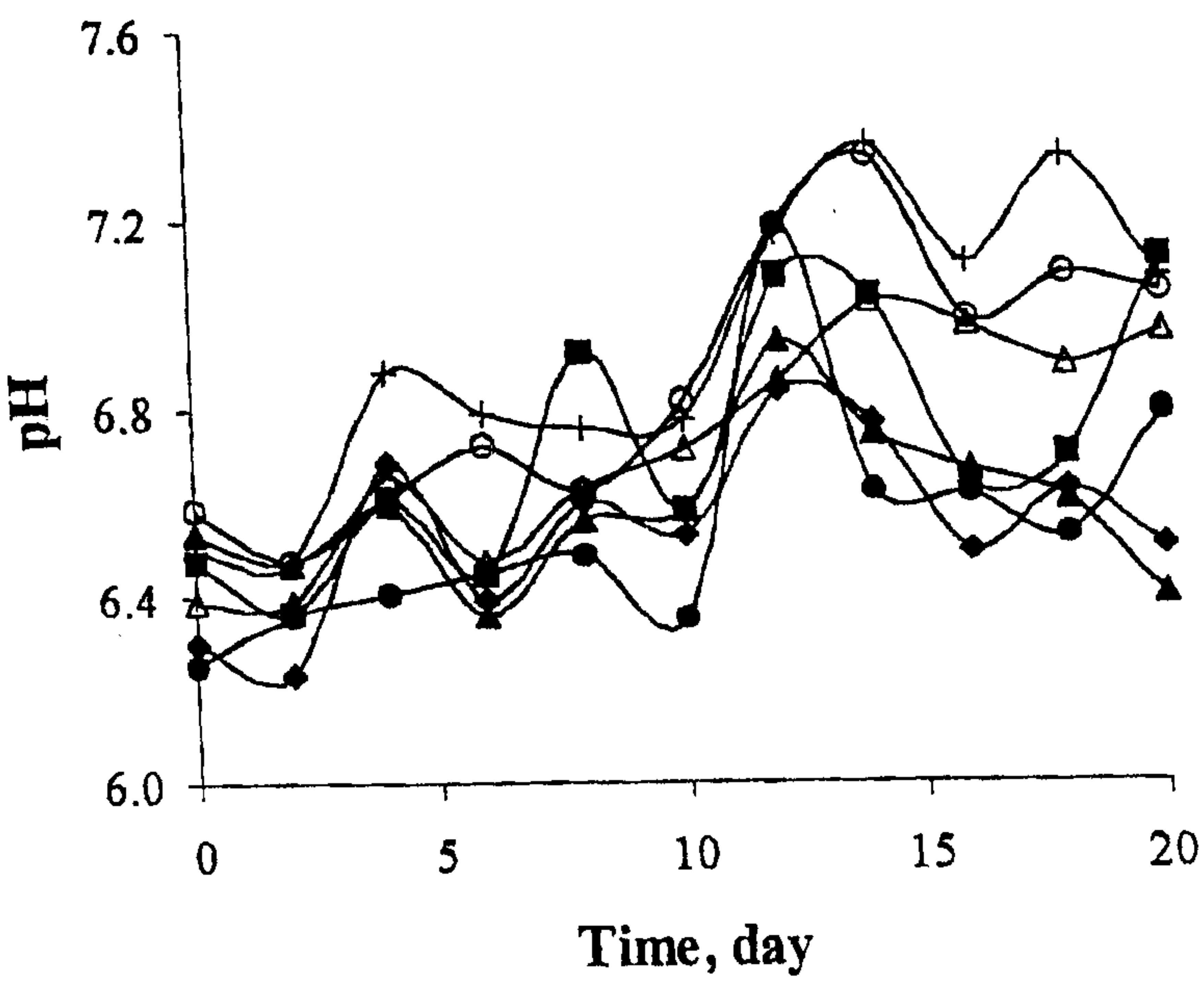


Fig. 4 Mussel drip pH v. time in days

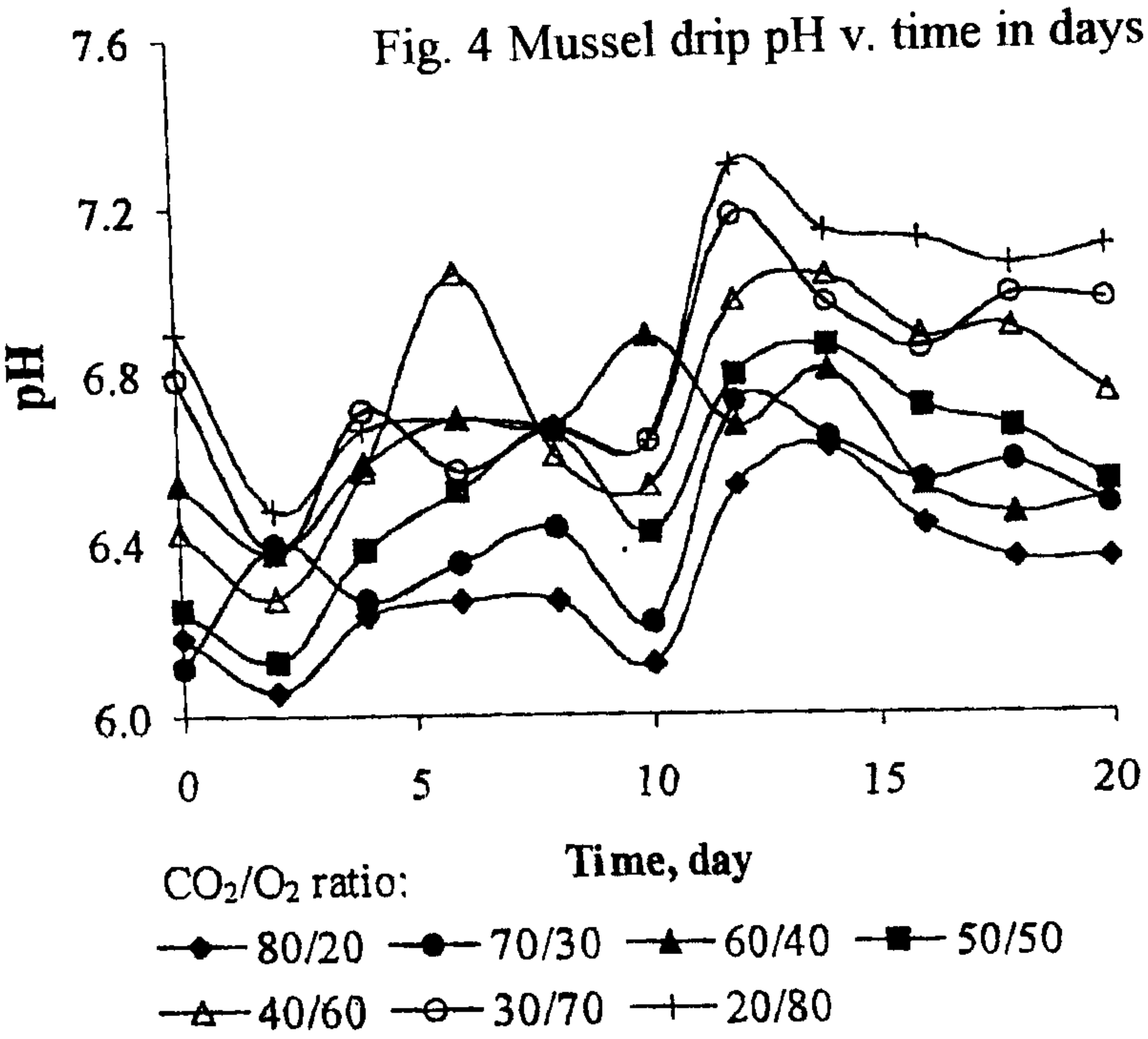
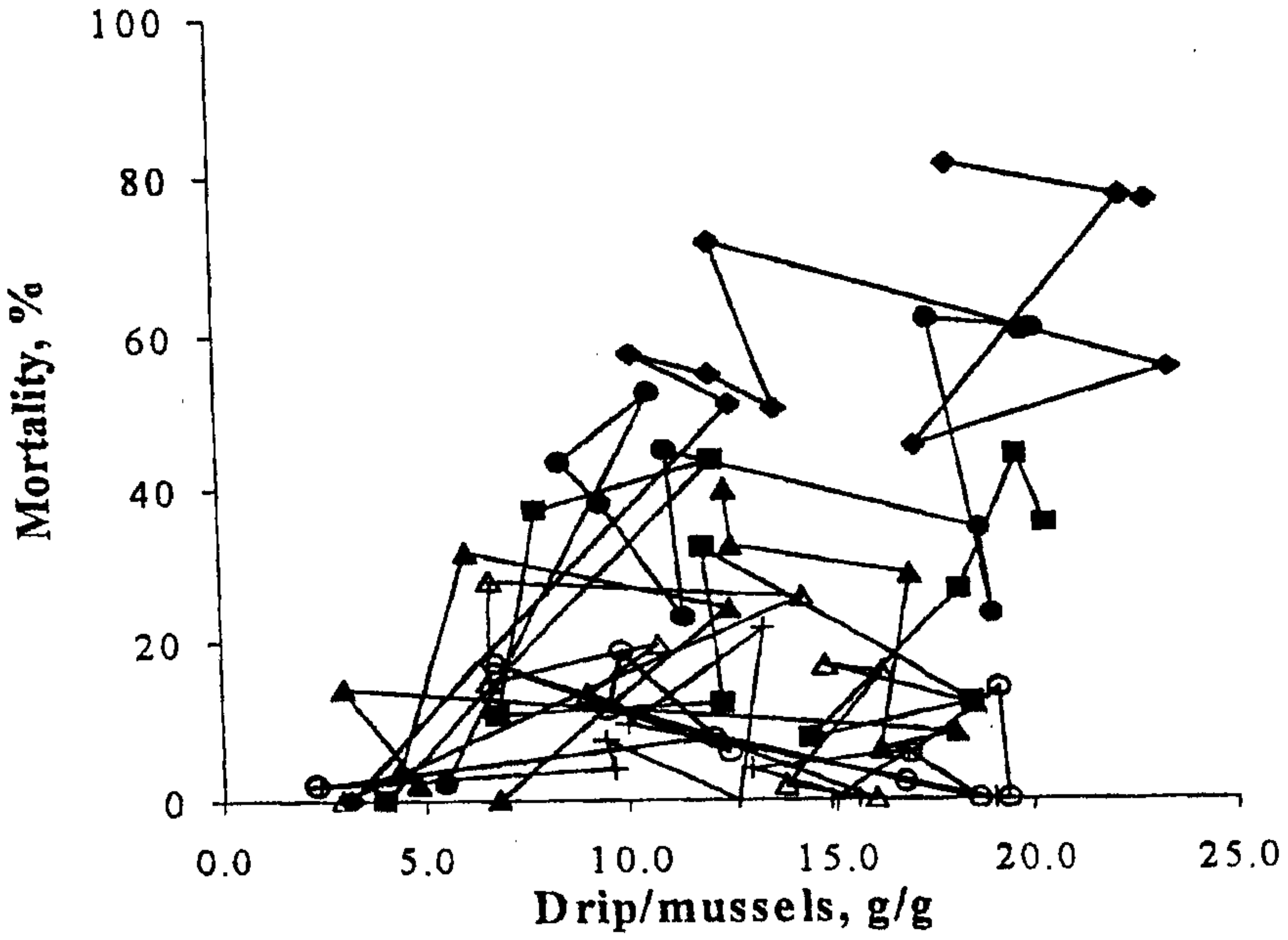


Fig. 5 Mortality & pH of drip vs. drip/mussel



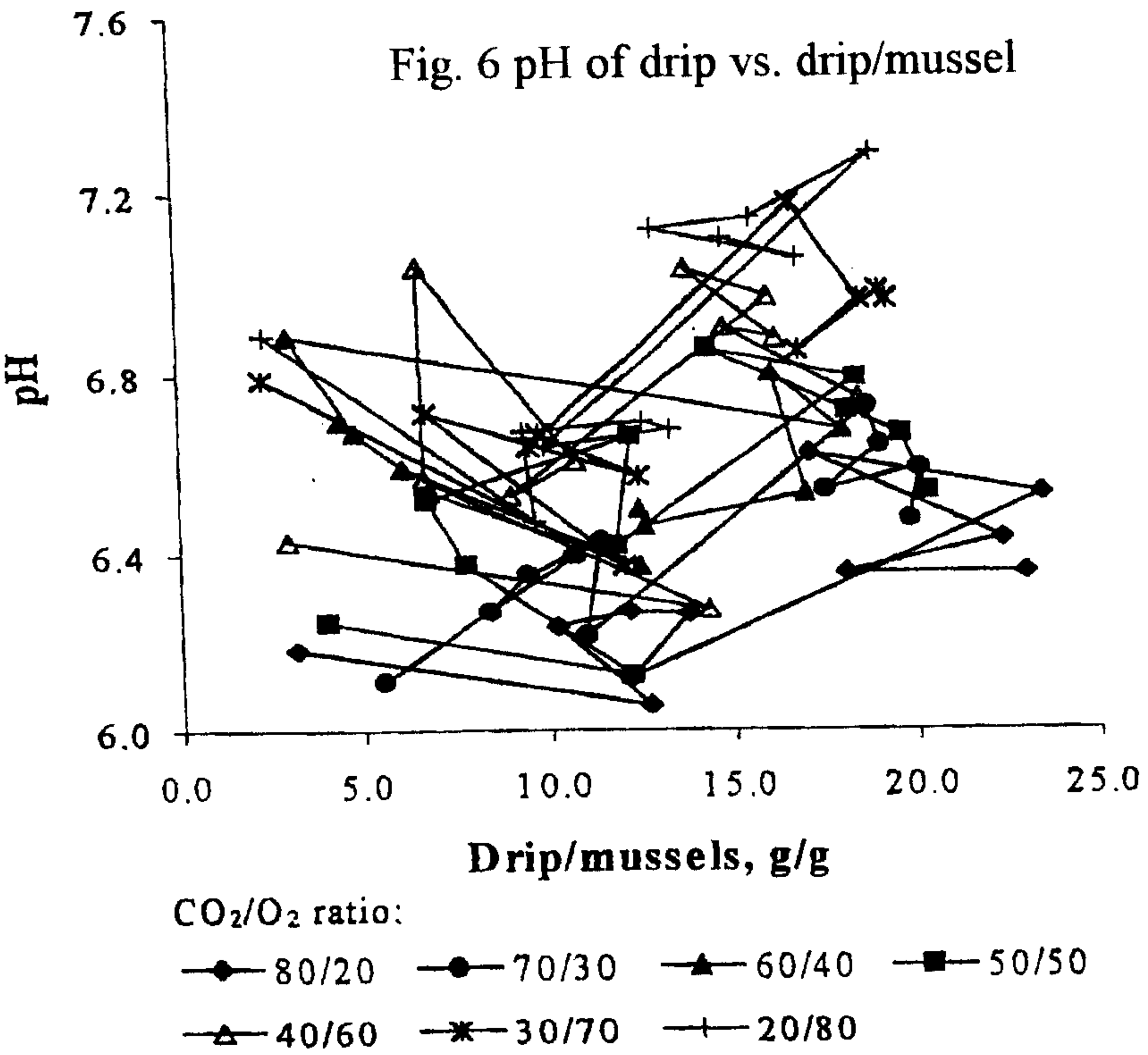


Fig. 6 pH of drip vs. drip/mussel

Flow diagram for MAP packaging mussel