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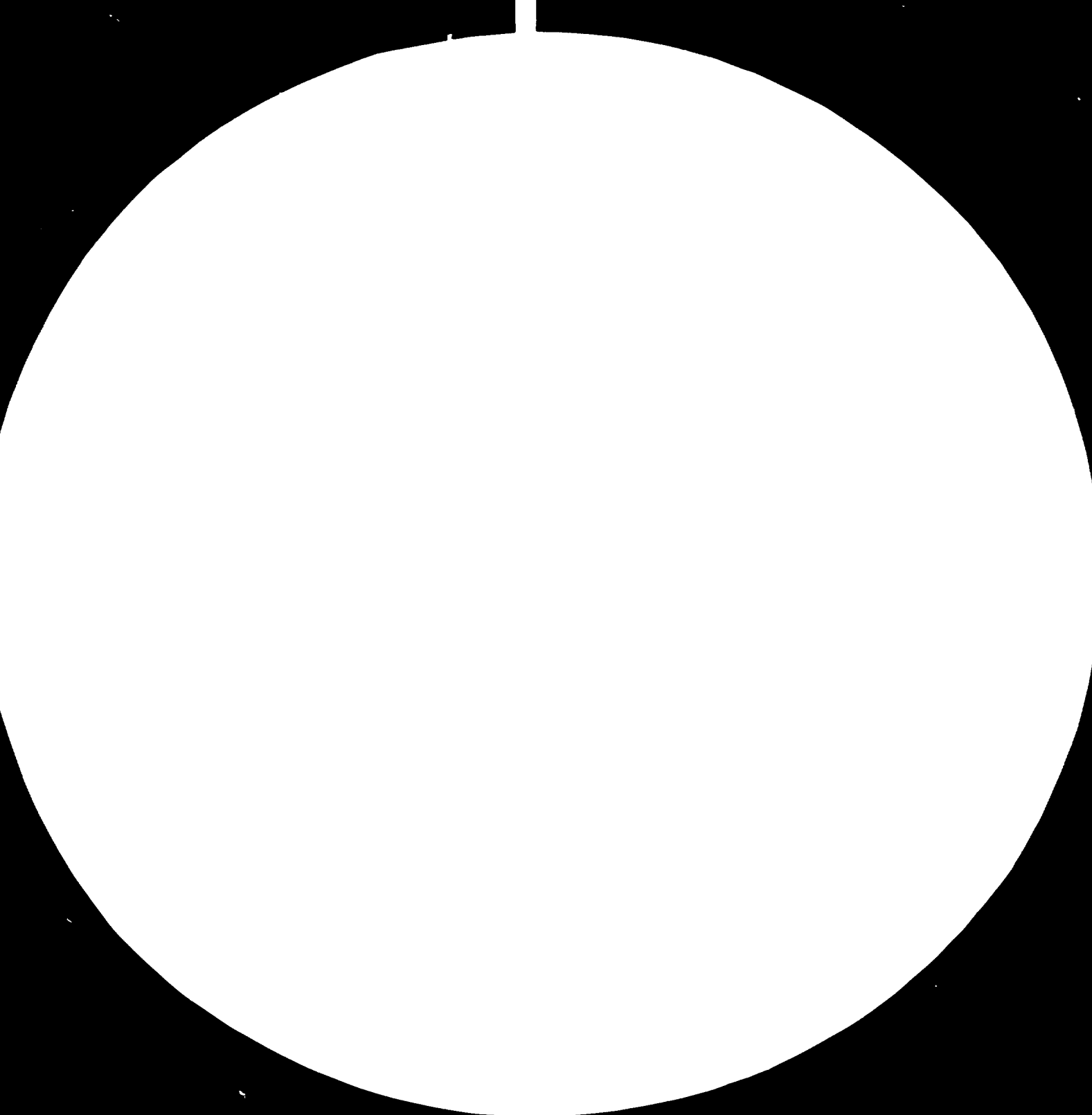

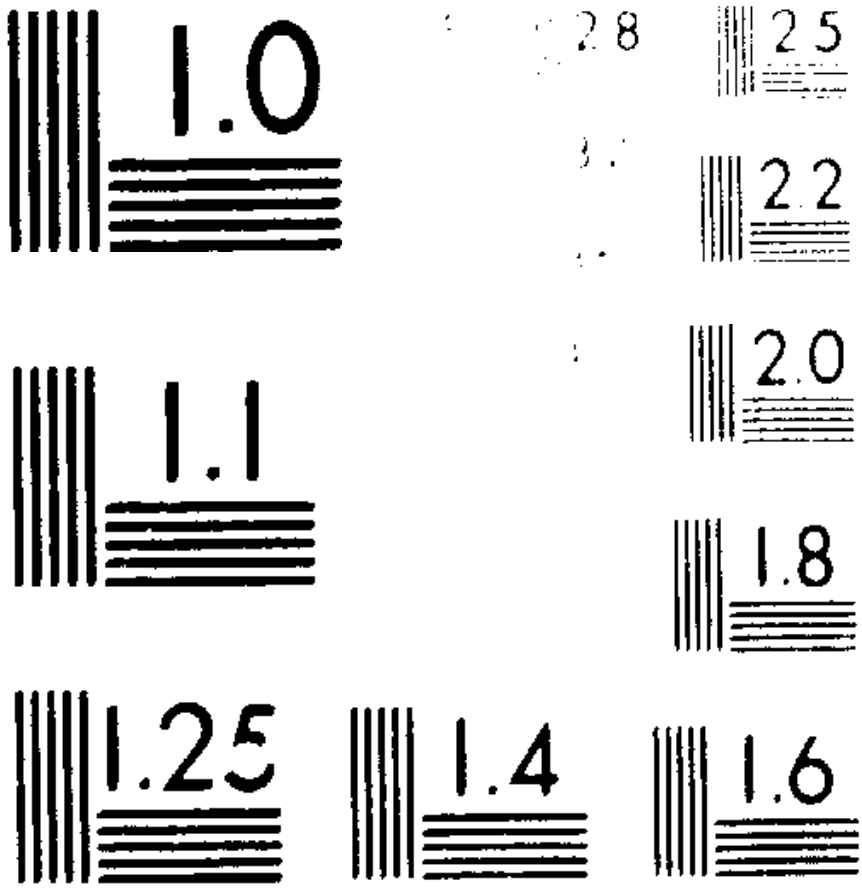
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English

PACKAGING AND PRESERVATION OF FRESH AND PROCESSED FOODS IN MEXICO

DP/MEX/78/011

MEXICO

Technical report*

Prepared for the Government of Mexico
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Chaim Mannheim
expert in the production of packages for fruits and vegetables

United Nations Industrial Development Organization
Vienna

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TABLE OF CONTENTS

SUMMARY

The IMAI and LANFI institutes are presently undergoing a reorganization which should enable them to fulfull their objectives in serving the country in all aspects pertaining to food preservation and packaging . There is a rapid expansion of staff and equipment as well as in much needed laboratory space The present staff has a good basic training but only limited practical experience therefore a program for advanced training at different levels should be adopted as soon as possible. It is highly recommended to draw up a list of pilot plant equipment which is needed to carry out work in food preservation and packaging .

A survey of transport, marketing and distribution systems for 40 products was carried out by LANFI. In order to improve the system an integrated approch is needed which includesall aspects and begins from the farmer and endswith marketing. More experimental work is needed to test transport containers of different design made from different materials. There seems to be a lack of any work in the field of post harvest physicology and technology. Since preservation of produce depends on proper application of these techniques, it is recommended that LANFI should get involved in this area .

It is recommended that an expert is invited to recommend the best ways and means to carry out such a program.

There is a lack of knowledge concerning quality and shelf life of cans and canned foods in Mexico. A detailed plan was drawn up to carry out a survey of canned foods with the aim to identify possible problems . Methods for characterizing packaging materials and establishing shelf-life were reviewed. The overall plans for projects in these areas were

..2

found to be realistic in term of existing facilities and need of local industry.

The program relating to flexible packages for heat processed foods was reviewed and altered in accordance with existing limitations in equipment and materials. Work concerning preservation of acid foods in flexible pouches was started. Long range plans concerning development of retorted products were discussed. Efforts were made to train staff in modern methods of analysis and research by means of in-house lectures. In order to increase ties with industry and other institutes, many visits were made.

In addition a three day seminar of Food Packaging and Shelf-Life was organized. This seminar was attended by about 40 persons from industry and other institutes and about 20 from IMAI-LANFI and will indoubtely bring about more contacts between the institute and the local industry.

1. INTRODUCTION

1.1 Objectives of Project

To give advice in packaging and preservation of fresh and processed agricultural products in general and specifically :

1) Assist in preparing survey of transport, marketing and distribution system of fruits and vegetables in Mexico especially as regards suitablibity of packages which are being used at present.
2) Advise on improved or new transport containers for produce with the aim to reduce losses and suggest work to prolong shelf-life of produce .
3) Assist in characterizing tin plate used presently in food canning industry in Mexico and evaluate quality of products as affected by interaction, with container .
4) Consult LANFI-IMAI and food industry in methods of food preservation and quality control procedures .
5) Advice in substitution of cans by alternative packaging materials such as retort pouches or other flexible plastic materials .
6) Give lectures regarding above subjects and train personnel in relevant methods of analysis .

1.2 Backround

The Mexican Institute of Assistance to Industry, (IMAI) and the National Laboratories for Industrial Development (LANFI) are presently undergoing rapid expansion in human resources as well as physical facilities. This expansion also mandated organizational changes. During our stay the consolidation of IMAI and LANFI into one autonomous institute called LANFI was started .

The emphasis of the institute is to enlarge and complement its activities in the field of packaging and food preservation in order

to be able to serve the country with services such as information, standardization, design, training, testing and quality control and applied research. The above objectives of the institute are of special importance due to the recently adapted national plan called SAM (Sistema Alimentario Mexicano) which puts emphasis on food production and preservation so as to increase supply of high quality and nutritious food products to the population of Mexico. This national policy was adopted due to fact that more than 50 % of the population of Mexico still suffers from malnutrition. In addition increased local food production will reduce the need for food imports and create more jobs in Mexico .

The Republic of Mexico seems to have plenty of land so as to become independent of food imports in the not too distant future. LANFI can play on important role in achieving this national goal .

The present personnel in the packaging department have good basic, scientific and theoritical backround but limited practical experience in packaging science and related fields. Furthermore, only few persons have advanced degrees which are necessary to carry out well controlled experiments .

It is highly recommended to set up as soon as possible a program for advanced training abroad of qualified people, so that in each area there will be one or preferable two people with advanced degrees .

One of the problems encountered during our stay was insufficient laboratory space which slowed down our training program as well as the execution of some research projects. Towards the end of my stay

space was obtained for some of the larger packaging machines as well as laboratory space for the group working on shelf-life and canned food analysis. Furthermore actual work was started on a new building adjacent to the transport laboratory, when this building is completed the problem of space will be less critical. Lack of certain pieces of equipment, some of the relatively inexpensive also hindered progress.

A list of equipment was drawn up and some of it was purchased during my stay in Mexico.

2. Description of work performed

2.1 Introduction

In order to achieve the objectives of the post extensive visits were arranged to fresh fruit and vegetable markets, industry, growers associations, research and educational institutes as well as government agencies. A list of visits is given in appendix 1. The work performed in relation to the specific projects was as following .

2.2 Survey of transport, marketing and distribution system in Mexico

On arrival at the post the institute was completing a study on transport packages for 40 different fruits and vegetables. This study is summerized in 40 reports which describe the amounts of produce produced and their locations, different packaging materials available in Mexico and in the world. There is also a small section on tests performed and recommendations for future action. Unfortunately there was not sufficient time to carry out more tests so as to obtain more - significant results .

In addition to examining above work we visited the following :

a) La Merced in Mexico D.F.

b) Mr. Peter de Baloc FAO expert in products marketing

c) Dr. Klaus Rother, UNIDO expert on commercialization

d) Confederación de Asociaciones Agrícolas del Estado de Sinaloa (CADES) in Culiacán

e) Unión Nacional de Productores de Hortalizas (UNPH) in Culiacan

f) Cartón y Papel de Mexico in Culiacan

g) CIAPAN - Research Laboratory of the State of Sinaloa

Based on above mentioned work, visits and talks we can make the following observations :

1) Produce destinated for export is sorted, packed and shipped using modern methods and containers. However, produce shipped to the local market is not sorted, is packed into unsuitable containers which are over-filled resulting in 20-40% losses .

2) Marketing conditions in Mexico in general, and the District Federal specially, are inadequate. Wholesalers deal only in one or two products, all handling is done manually resulting in excessive and rough handling and further damage to product .

3) New wholesale markets are being built in many areas and there are plans to built a new and proper market for Mexico City .

4) The use of refrigeration for transport of produce is limited to - export and some decidous fruits. We did not hear about any use of controlled or modified atmosphere storage nor any research in this area .

5) The various organizations such as UNPH and CONAFRUT carry out work relating to agrotechnological techniques, varieties etc. but no

work in the field of post-harvest physicology, handling and post-harvest technology .

6) Regarding packaging materials - all those for export are either made only from corrugated board or a combination of board and wood .

Transport containers for the local market are predominatly made from wood .

There seems to be a shortage of corrugated containers mainly due to lack of raw material for this package i.e. liner paper and not due to lack of plant capacity. This point could not be veryfied properly. We were also told that there is a shortage of wood for the wooden boxes and materials become more expensive all the time. The cardboard wood combination container while being strong and suitable for export is expensive and should be replaced with a proper 100 % corrugated cardboard container .

A 100 % corrugated cardboard container can be cheaper than a - - wooden box. Furthermore a cardboard container will give better protection to the produce and reduce losses .

Transfer to cardboard containers will also eliminate the custom of overfilling wooden boxes. The only disadvantage for the carton box is that it is a single trip box while the wooden box, is used several times. However considering large distances between producing areas and markets in Mexico it may not be economically, with rising fuel prices, to return empty wooden boxes over these large distances .

There are no standards for export containers, dimensions and -- design depend on clients demand .

Containers for local market also vary in size and construction We were told that local market demands overfilled containers - which cause a lot of damage and difficulties in handling. This must be overcome by proper education .

7) It was suggested to the team at LANFI to carry out well designed and controlled experiments to investigate various alternatives of containers for produce. Based on results of above experiments standards should be drawn up relating to dimensions as well as performance characteristics .

Design of experiments and setting up standard test procedures was done in cooperation with Dr. Miltz - expert in plastic and transport packages .

8) It was observed that most produce in the local market of Mexico is unsorted and ungraded, Damaged and poor quality produce is mixed with good produce in the field, thus increasing susceptibility to spoilage .

Therefore, in order to improve situation an integrated approach is needed. Solutions must begin in the field continue through the packaging house and include proper grading and packaging, as well as improvement of marketing system so as to reduce handling and speed up merchandising.

In addition application of improved post-harvest technologies including washing, desinfectation application of modified at - mospheres, especially for export products, should be looked into . At present there is no infrastructure for such work in Mexico and it is recommended that LANFI look into the possibility to

set up the necessary infrastructure for such work .

In my lecture at the seminar entitled : "Development and Trends in the Preservation of Produce" I gave the advantages of using modified atmospheres in bulk storage as well as in wholesale and retail packages. These methodsare applicable for produce as well as for meat, poultry and fish and use special permselective primary packaging or transport containers .

For further detail see lecture given in appendix II .

2.3 Characterization of tin plate and evaluation of canned food in Mexico

In order to obtain an insight into the can making and canning industry visits were made to steel manufacturers and can makers .

Unfortunately only one visit could be arranged to a very small and unmodern cannery. Attempts were made to visit other canners but - - without success .

Visits included :

HYLSA - Sceel and tin plate manufacturers in Monterrey

Nueva Modelo in Mexico City - Can maker

Envases Generales Continental in Mexico D.F. can maker

Mexicana de Envases in Mexico D.F. - can maker

Famosa - Fábricas Monterrey - Manufacturers of lids

Industria Conserva - Mexico, D.F. canner

Organizacion Pando - Parent company of several canneries

Based on these visit and supporting information the following observations were made :

There is insufficient tin plate production in Mexico and about 50 % of requirements are imported from all over the world .

Quality of local plate seems to be uneven mainly as regards gauge.

No data area available concerning differences in quality between imported and local tin plate. This point needs urgent clarification and it was recommended that LANFI do this work .

Quality of cans in Mexico seems to be good. This does not mean that there are no problems as claimed by can makers. We found, in the market, cans with poor lacquer coatings on side seams, lacquer peeling and off taste in canned tomato products which could be originating from the lacquer . Several cases of external side seam corrosion we observed. These could be due to improper brushing i.e. removal of excess solder, in the can making plant. In addition in some cases excessive amounts of solder as well as solder splashes were seen on inside of cans. This may result in relatively high amounts of dissolved lead in cans .

It can be prevented by better control by the can maker. In one case we were consulted on a problem of off odors from can coatings . We analysed the problem, using gas chromatography, and suggested a solution which solved the problem .

There is little quality control regarding off flavors from packaging materials mainly due to lack of complaints from clients. Customer service is also very limited .

Due to the absence of any data on shelf-life of canned goods in Mexico and problems related to interaction between containers and products it was suggested that LANFI carry out a study of canned goods in the market with the aim to identify the major factors affecting the interaction between containers and products and shelf-life. The outline of the project agreed upon was :

a) Characterize the cans used for a selected variety of products such as chiles, evaporated milk, tomato products and juice. Tests were to include tin plate analysis, lacquer characterization, headspace analysis, etc.

b) Determine shelf-life of above products using corrosin i.e. tin, iron and lead analyses, lacquer performance, vacumm, etc. as criteria . This in addition to organoleptic analyses i.e texture, color and flavor of products .

We discussed in detail the overall experimental design as regards number of samples, replicates, storage temps, etc. In addition we outlined in detail all the test methods including : tin gauge, seam analysis, lacquer analysis, alloy tin couple test (ATC) and gas headspace analysis using GLC.

In some cases we assisted in building necessary equipment to carry out analysis, for example the alloy tin couple test apparatus

Analysis for products were also discussed and it was decided to include atomic absorption for metal analysis, browning by sepctrophotometry in addition to taste panels. Due to technical difficulties only preliminary tests were carried during this mission. Full tests are scheduled to begin after completion of environmental chambers later this fall .

2.4 Food preservation

At the request of the director of LANFI, Dr. Juan Antonio Careaga, the expert was consulted concerning equipment for a food technology pilot plant in which experimental packages off different types can be made .

In addition specific advice was given concerning development of baby foods for Mexico in order to alleviate the problem of malnutrition. Since these products should reach the low income groups it was suggested not to develop thermally processed foods but rather work on instant dried powdered products with high nutritioned value . It was also recommended to develop foods for pregnant woman. Specific suggestions and plans were elaborated .

2.5 *Flexible packaging for thermally processed foods*

A program to develop alternate packages for tin plate was drawn up and started by Dr. Gilbert .

Shortly after my arrival we started a preliminary project using flexible materials to pack acid foods namely chile and tomato paste. The main object was to train the personnel in proper planning of the experiments and in all methods of analysis, etc. The above acid foods were chosen because they are common in Mexico. Furthermore, acid foods can be processed using simpler and cheaper packaging materials, simpler sealing equipment, without a retort etc. Danger of spoilage is reduced. It was recommended to make thorough studies with acid foods first and only then start working with low acid foods Several combination of heat resistant flexible materials were obtained locally .

A detailed study, including characterization of these materials and shelf-life of products was started towards the end of my stay .

In order to continue this project and work with low acid foods the following equipment is needed :

a) Thermocouples for heat penetration

b) A multipoint temperature recorder

c) A vacumm sealer

d) Cages for existing autoclave and improved temp and pressure controls.

In addition retort pouches form different sources should be obtained. This poject should be carried out with great care and a minium of 18-24 months of study should precede commercial implementation for low acid foods .

Quality procedures for packaging materials, process and products as outlined by Dr. Gilbert should be carefully adhered to. The procedures were reelaborated in my talks with the project leader of this program .

Discussions with potential local producers of the flexible materials were held and promises of cooperation were obtained .

Samples were obtained from local as well as foreign companies. Du - pont promised also to supply specific materials to a local converter for final processing in Mexico .

2.6 Shelf-life of powdered foods

During our stay a project was received for the design of a flexible package for several powdered products .

The implementation of methods given by Mr. Madi and Dr. Gilbert concerning moisture sorption isotherms as well as additional methods were discussed .

An experimental plan to obtain data for the functional design was drawn up and actual tests were started .

2.7 Training

A series of in-house lectures concerning experimental design,methods of analysis, problem solving -etc. were given to the entire packaging group by Dr. J. Miltz and myself .

A variety of subjects relating to plastic materials, cans atc. were covered .

In addition a three day seminar on the topic of Packaging and Shelf-life

was organized during August 27 to 29th .

About 40 persons from industry and universities, in addition to about 20 people from IMAL-LANFI, participated .

Two folders with about 300 pages of lecture notes and reference material were prepared and given to each participant .

judging from questions and comments the seminar was very succesful and certainly will contribute to stronger ties between LANFI and the industry .

(See enclosedprogram for seminar Appendix IV) .

Miscellanous

Since a considerable amount of the work performed in the packaging group requires organoleptic analysis a proper sensory evaluation set up is needed. This requires a small experimental kitchen, taste testing both as well as trained personnel to operate the facility .

3. RECOMMENDATIONS

3.1 General

a) Training
It is recommended to draw up a plan for advanced training of the personnel .

This training program should be divided into three sections .

a) Advanced training at local universities and in local short courses .

b) Short (2-4 months) training periods abroad

c) Advanced training towards masters degrees in various packaging and related fields .

This training program is necessary to enable LANFI to carry out its objectives, whithout assistance of foreign experts in due time .

b) Equipment

1. A specific list of equipment for the packaging laboratory was discussed with the head of the packaging department, UNIDO - Co-Director and is given in appendix III

2. LANFI is getting heavily involved in problems related to Food Packaging there is a great need for a well equipped food pilot plant . Furthermore, with the adoption of the new food expansion plans for Mexico under the jurisdiction of "SAM", LANFI will protably be called upon to assist in product development and functional design of packaging to assure maximum - - shelf - life. This will require good pilot plant facilities. It is thus recommended to assist LANFI in drawing up list of equipment, specifications and potential suppliers for such a a pilot plant .

3.2 Fresh produce packaging and preservation

a) It is recommended to carry out well controlled experiments, with a limited number of fruits, and test the suitability of dif - ferent types of transport containers for the Mexican market .

b) Carry out necessary tests to define characteristics of containers in regard to dimensions and strength.

c) Invite an expert in the field of post-harvest physicology and technology with the aim to iniciate work in this very important area which is not dealt with adequately in Mexico .

3.3 Characterization of tin plate

a) It is recommended to determine quality of locally produced tin plate in comparasion with imported one

b) Survey the quality of a selected variety of canned goods in regard to quality of cans and contents .

c) Determine shelf-life of above canned goods using corrosion as well as product quality as parameters for shelf - life .

3.4 Food Preservation

a) Continue work on shelf-life of powdered products .

b) Commence work on development of inexpensive but nutritious baby food .

c) Draw up list for food pilot plant (see also recommendation 3.1 b)

3.5 Flexible packages for thermally processed foods

a) Continue development work on preservation of acid foods in flexible pouches .

b) Acquire necessary equipment for work with low acid foods .

c) Commence development work with low acid foods .

It is highly recommended not to start work with low acid foods without necessary equipment and leave sufficient time for developmental work before attempting commercialization .

It is estimated that at least 2 or 3 years of experimental work are needed before commercialization can begin .

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A P P E N D I X II

PONENCIA :

"DESARROLLO Y TENDENCIAS EN LA PRESERVACION DE PRODUCTOS PERECEDEROS"

DEVELOPMENT AND TRENDS IN THE PRESERVATION OF PRODUCE

Post harvest losses are one of the major problems in marketing and distribution of food crops. Table 1 illustrates this problem for some crops .

Table 1. Losses from Pests in the Worlds Major Crops

	Losses - percent			
CROP	INSECTS	DISEASES	WEEDS	TOTAL
Rice	26.7	8.9	10.8	46.4
Wheat	5.0	9.1	9.8	23.9
Maize	12.4	9.4	13.0	34.8
Potatoes	6.5	21.8	4.0	32.3
Tomatoes	7.5	11.6	5.4	24.5
Bananas	5.2	23.0	3.0	31.3
Citrus	8.3	9.5	3.8	21.6

Source : World Food and Nutrition Study, Vol. 1 (19) 1977. National Academy of Science Washington, D. C.

In many instances,especially in developing countries the losses exceed 50 % . If one considers that two thirds of the world population still suffers from hunger or malnutrition any reduction in these losses can help in eleviating this problem .

Another major problem which faces all of us today and affects all methods of food preservation as well as many aspects of our lives is the problem of - energy. Figure 1 gives the projected energy costs in the coming decade and these estimates can be considered conservative. This means that we will have to re-examine the use of refrigeration in the preservation of produce and develop less energy intensive methods .

Several systems which can be applied and which use refrigeration were developed;

Atmosphere Generation

Hypobaric (low pressure) systems

Commodity - modified atmospheres

A bulk storage

B. in wholesale or retail packs

Improvements in maintaining product quality in the distribution chain are also due to developments in :

1) Postharvest physiological genetics
2) Chemical control, both exogenous (fungicides, fumigation, dips or - coatings) and engogenous (growth regulators) . and
3) Packaging (carton design and performance, handling and sanitation).

In this talk, developments concerning environmental control, transportation and packaging, primarily will be reviewed .

Modified and controlled atmospheres have been in existance since 1920 and were reviewed recently by Smock (1979) (Hort Review 1:301). Commercial application of controlled atmosphere (CA) is limited to storage of a few selected varieties such as apples and pears and to international movement of other selected varieties inciuding tomatoes and cabbage.

In both, controlled (CA) and modified atmospheres (MA) means that the atmospheric composition surrounding the product is different from that of normal air. Most commonly the changes involve reduced oxygen and increased carbon dioxide concentrations however, in some cases other gases are used. MA differs from CA in the precision of controlling the gas partial pressure. CA is usually used for long term storage i.e. several months, while MA is applied in the transportation and marketing chain or for short term storage .

Hypobaric storage is another type of CA storage in which the product is held under partial vacuum .

Recently the Japanese developed a method called "Green Pack" which uses absorbants, like active carbon, to remove volatiles such as ethylene which emanate from the produce and accelerate maturation and spoilage .

All above mentioned methods are used in conjunction with refrigeration, the extent of which depends on the desired shelf-life for relatively short periods such as transportation. These methods can be applied with little or no refrigeration with very good results .

Various techniques exist to achieve the desired commodity-modified atmosphere conditions. These include waxes or other surface coatings, plastics wrappings, pallet shrouds with diffusion windows, polyethylene or other polymeric liners, manipulation of atmosphere in shipping containers or vehicles and airtight cold rooms for long term CA storage .

Figure 2 illustrates how the manipulation of the environment takes place in a MA or CA system. In this model, three barries are shown: the commodity itself, the package and the storage room or transport vehicle. A dynamic equilibrium will be established between the endogenous gases and the exogenous gases of the surroundings. The pressure differential between internal and external components influences the rate of diffusion in and out of the commodity.

As shown in Figure 3, in an actively respiring product, such as lettuce, the CO_2 gradient from the center to the outer layer can be significant .

The relative tolerances of fruits and vegetables to reduce oxygen and increase elevated carbon dicxide are of great importance when establishing CA or MA conditions for individual commodities. Figures 4 & 5 give some data as summerized by Kadar & Morris in 1977 (Veg Crops series 187 U.ofCalifornia). These are not recommended conditions but rather give levels of oxygen and CO_2 below and above which physicological damage could take place. Exact conditions depend on numerous factors including cultivar differences, degree of maturity, presence of other gases and of course temperature .

Properly used CA or MA can siginificantly extend shelf-life of produce, at same termperatures as compared to normal atmospheric conditions .

Extending shelf life, while maintaining desirable market quality opens the door to more distant markets and allows for increased flexibility in meeting market demands. The potential benefit of CA includes:

Retardation of senescence (ripening and again) and associated physicological and biochemical changes .

Reduced sensitivity to ethylene, which is know to damage various fruits and vegetables by accelerating ripening .

Alleviating or mitigating certain physicological disorders, such as chilling injury .

Reducing the incidence or severity of decay through direct or indirect effects on pathogenens. This is especially true if carbon monoxide is present

in the CA atmosphere .

Controlling insect damage in selected commodities .

However one must remember that CA poses also some potential hazards. This is especially so if O_2 concentrations become too low or CO_2 levels too high. The potential hazards include :

-Aggravation of certain physicological disorders. For example blackheart in potatoes at low O_2 concentrations .

Irregular ripening has been shown in tomatoes when too low O_2 or too high CO_2 levels were used .

Development of off flavors and /or off odors can also occur if improper gas concentration were applied .

In order to meet the challenge of incorporating the vast reservoir of in - formation available on the topic of CA and MA into the wordwide network transportation and storage, an integrated approach by industry, research institutions, government and marketing organizations is obligatory .

One of the major benefits of CA and Ma is the prevention or retardation of senescence. Ethylene (C_2H_4), a natural plant hormone, plays a central role in the initiation and acceleration of the ripening process. It is active in trace amounts (0.1 ppm). The ability to produce ethylene varies greatly among fruits as shown in Table 2. The excess ethylene produced by fruits with moderate to high production rates is a phenomenon of secescence in fruits which exhibit a climacteric rise in respiration. Thus inhibition of ethylene production or its removal during storage by absorbing agents is of great importance in assuring good shelf-life .

Despite many years of research and development, the use of CA is limited to long term storage of apples and pears. However MA is being used to an increasing extent during transport of several fruits including strawberries, tomatoes, sweet cherries and bananas. Table 3 summerizes recommended CA conditions for some commodities. These recommendations must be checked for each individual cultivar and local conditions and there is no doubt modifications may often be necessary .

Figure 6 illustrates how the use of a modified atmosphere during transport only can serve to extend the shelf life during retail and at home .

Figure 7 illustrates the volume for shipments using MA in the U.S. While rail movements have been declining in recent years there are indications that due

to the energy crisis there will be a turnabout in this type of transportation. In the past few years, technology has been developed which allows individual pallet loads to be enveloped in large plastic bags and to be treated with modified atmospheres (Food Eng. 51:165, 1979). These shipments have been particularly succesfull with strawberries but exist also other commodities .
Perhaps the area with the greatest potential and the most dramatic growth in recent years is the use of small packages containing modified atmospheres (Pinto, mod. packaging 52:42, 1979). At the Technion, Israel we also did - considerable work on this subject with tomatoes , strawberries and bell peppers (Saguy and Mannheim IIR Comission Proceeding C2 1973 and J. Food Technology 10:54). We showed that shelf-life of these products could be extended considerably by using permselective plastic films over retail packages .
The concept, called "bag in the box" has also proved succesful in the commercial shipment of fresh chilled chicken and is used in the U.S. This method enabled extension of shelf-life while eliminating the need for ice, thus -- reducing weight and freight costs .
MA can be used both to extend shelf-life and maintain high quality .
Figure 8, schematically illustrates some trade-offs which are optional with M.A. For example for a given shelf-life S_2 can be obtained with M.A., whereas under equivalent transit conditions without M.A. the lower quality of Q_1 would result. Alternatively Q_2 would be maintained only for the shorter shelf-life of S_1 without MA. In table 4 we can see the estimated costs for the various systems available to apple MA .

Table 4. Estimated costs for various modified atmosphere systems

Systems	Cost (U.S. cent/lb product)
Rail cars	0.5
Sea van	0.5 - 0.8
Pallet in bag	1.0 - 1.5
Bag in box	1.0 - 3.0
On situ MA generation	c a 5

Source Food Technology . 34 (3) : 58, 1980

Another important point in commercial use of MA is wether this system is economically justified. An estimate of cost/benefit relationships can be obtained by looking at Figure 9. Any loss/value relationship which lies to the upper right of a given MA cost curve will justify the use pf MA .

Cost of sorting and disposing of damaged product are not incorporated in these calculations. The latter figure shows that value products such as meats, seafood, poultry and strawberries justify the use of MA. In the case of the lower priced commodities feasibility of using MA will depend on the seasonal cost structure .

The first commercial use of modified atmosphere containing elevated levels of carbon dioxide in the handling of fresh meat was in the - shipment of whole chilled beef carcasses from Australia to England in the 1930s.

By 1938, 26 % of beef from Australia and 60 % of that from New - Zealand was being shipped under CO_2 atmosphere (Lawrie, Meat Science 2nd ed. p.196 Pergamon Press 1974). The extension of shelf life for meats and poultry by CO_2 enriched atmospheres is today well established (Wolfe Food Technology. 34 (3) :55, 1980). Though the mechanism effect of CO_2 is still not satisfactory elucidated, it is well known that the gas selectiveiy inhibits the growth of gram negative bacteria. Figure 10 shows a comparison of microbial growth on pork loins stored in an atmosphere enriched with 50 % CO_2 and containing 25% oxygen and 25 % nitrogen with that of comparable loins stored in air both at 1° C. After 14 days the loins stored in air were spoiled, while the - loins in the CO_2 enriched atmosphere showed a satisfactory color and odor. At this point there was a million fold difference in total counts between the types of loins .

Furthermore there is evidence of a residual antimicrobial effect when meat is first stored in CO_2 enriched atmosphere and then exposed to air (Figure 11) (Silliker at al. Meat Sci.195,1977) . This residual effect has also been observed with beef, lamb, poltry and fish . Figure 12.)

In some cases there may be a detrimental effect of enriched CO_2 storage on meat color .

However this can be prevented by adding CO to the atmosphere or treating the meat with CO.

Since vacuum packaging of meats in CO_2 enriched atmosphere is mandatory there always exists the danger of the development of anaerobic pathogens .

There have been no bona fide outbreak of food poisoning traced to such developments, however this potential danger should not be over looked

Hypobaric Storage

Another form of MA storage is Hypobaric storage. This consists of - placing the commodity in an environment in which, pressure, temperature and humidity are precisely controlled. In addition the rate of air changes are also closely regulated. No gas other than air need be supplied in a hypobaric storage system. The local pressure within a hypobaric chamber is important, since the axygen level is directly - proportional to that pressure .

Meat spoilage is also reduced as a result of the effects of the lower oxygen tension on both microbial growth and fat oxidation .

The developments of a commercial hypobaric system has been described by Mermelsteim (Food technology 33. (7) : 32, 1979) .

Results of test comparing hypobaric storage of pork loin in different packaging materials with and without refrigeration are illustrated in Figure 13.

Present standard storage conditions for tahiti limes extend post harvest storage life to only 2 - 4 weeks. This relatively short shelf-life - limits the marketability of this poduct. Table 5 shows that the use of hypobaric storage of limes will lenghthen the shelf-life and thus - extend the marketing season as well as distance. (Spalding & Reeder, J. Am Soc. Hort. Sci. 101 (4): 367, 1976)

Hypobaric storage was also found to increase shelf-life of strawberries by 2 to 3 weeks .

TABLE 2. CLASSIFICATION OF FRUITS

ACCORDING TO THEIR MAXIMUM ETHYLENE PRODUCTION RATE

ETHYLENE PRODUCTION RATE (L/KG-HR AT 20°C)	FRUITS
VERY LOW: 0.01 - 0.1	CHERRY, CITRUS, GRAPE, STRAWBERRY
LOW: 0.1 - 1.0	BLUEBERRY, PEPPERS, PINEAPPLE, RASPBERRY
MODERATE: 1.0 - 10.0	BANANA, HONEYDEW MELONS, MANGO, TOMATO
HIGH: 10.0 - 100.0	APPLE, APRICOT, AVOCADO, CANTALOUPE, NECTARINE, PAPAYA, PEACH PEAR
VERY HIGH: 100.0	CHERIMOYA, MAMEY APPLE, PASSION FRUIT

TABLE 3. RECOMMENDED CA CONDITIONS

DURING TRANSPORT AND/OR STORAGE OF FRUITS

COMMODITY	TEMPERATURE RANGE (°C)	CA		POTENTIAL FOR BENEFIT	EXTENT OF COMMERCIAL USE
		$\%O_2$	$\%CO_2$		
DECIDIOUS TREE FRUITS					
APPLE	0-5	2-3	1-2	EXCELLENT	ABOUT 40% OF U.S. PRODUCTION IS STORED UNDER CA
CHERRY, SWEET	0-5	3-10	10-12	GOOD	SOME COMMERCIAL USE (PALLET COVERS OR BOX LINERS)
NECTARINE	0-5	1-2	5	GOOD	LIMITED COMMERCIAL USE
PEACH	0-5	1-2	5	GOOD	LIMITED COMMERCIAL USE
PEAR	0-5	2-3	0-1	EXCELLENT	SOME COMMERCIAL USE
STRAWBERRY	0-5	10	15-20	EXCELLENT	INCREASING USE DURING TRANSIT
SUBTROPICAL AND TROPICAL FRUITS					
AVOCADO	5-13	2-5	3-10	GOOD	LIMITED COMMERCIAL USE
BANANA	12-15	2-5	2-5	EXCELLENT	SOME COMMERCIAL USE
GRAPEFRUIT	10-15	3-10	5-10	FAIR	NO COMMERCIAL USE
LEMON	10-15	5	0-5	GOOD	LIMITED COMMERCIAL USE
ORANGE	5-10	10	5	FAIR	NO COMMERCIAL USE
MANGO	10-15	5	5	FAIR	NO COMMERCIAL USE
PAPAYA	10-15	5	10	FAIR	NO COMMERCIAL USE
PINEAPPLE	10-15	5	10	FAIR	NO COMMERCIAL USE
VEGETABLE FRUITS					
CANTALOUPE	5-10	3-5	10-15	GOOD	LIMITED COMMERCIAL USE
PEPPERS, BELL	8-12	3-5	0	FAIR	LIMITED COMMERCIAL USE
TOMATOES, MATURE-GREEN	12-20	3-5	0	GOOD	LIMITED COMMERCIAL USE

TABLE 5. CONDITION OF LIMES AFTER 71 DAYS OF HYPOBARIC AND ATMOSPHERIC STORAGE

STORAGE PRESSURE (MM HG)	TOTAL NO. OF SAMPLES[A]		RESULTS: TEXTURE NO. FIRM	RESULTS: COLOR NO. GREEN	RESULTS: NO. DECAYED FUNGI	RESULTS: NO. DECAYED % SALABLE
20	TREATED	14	6	6	14	43
	UNTREATED	15	2	3	15	0
40	TREATED	12	8	6	5	77
	UNTREATED	14	9	9	6	64
80	TREATED	11	11	7	6	100
	UNTREATED	15	14	14	13	87
760 (CONTROL)	TREATED	12	--	--	--	0
	UNTREATED	14	--	--	--	0

A "TREATED" MEANS TREATED WITH BENLATE FUNGICIDE.

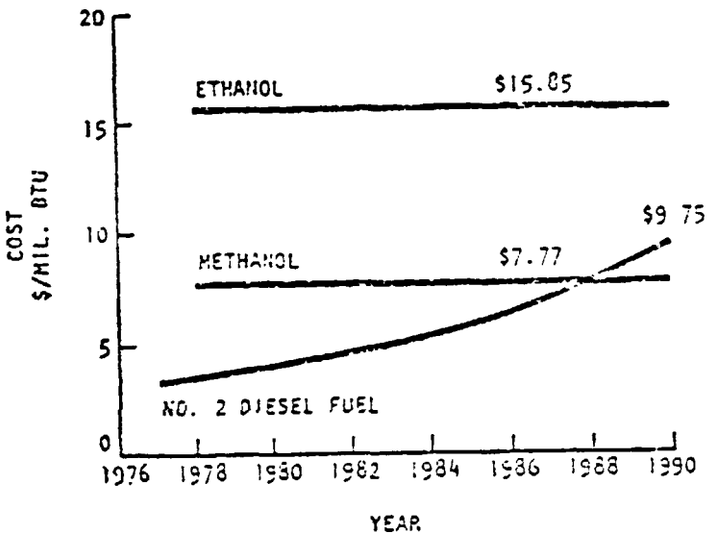


Figure 1. Projected U.S. Energy Cost (In Current Dollars)

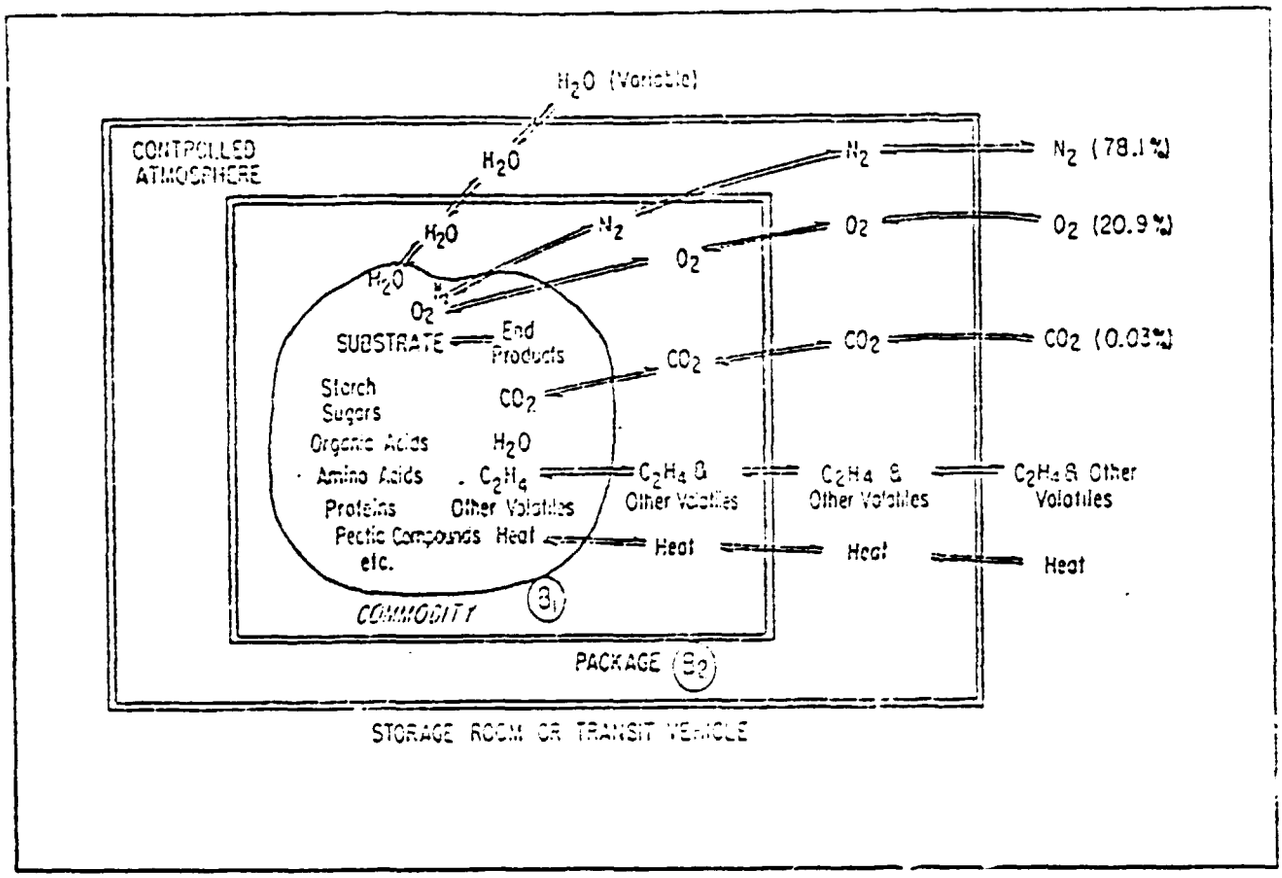


FIGURE 2. Model of a Commodity with a controlled- atmosphere environment

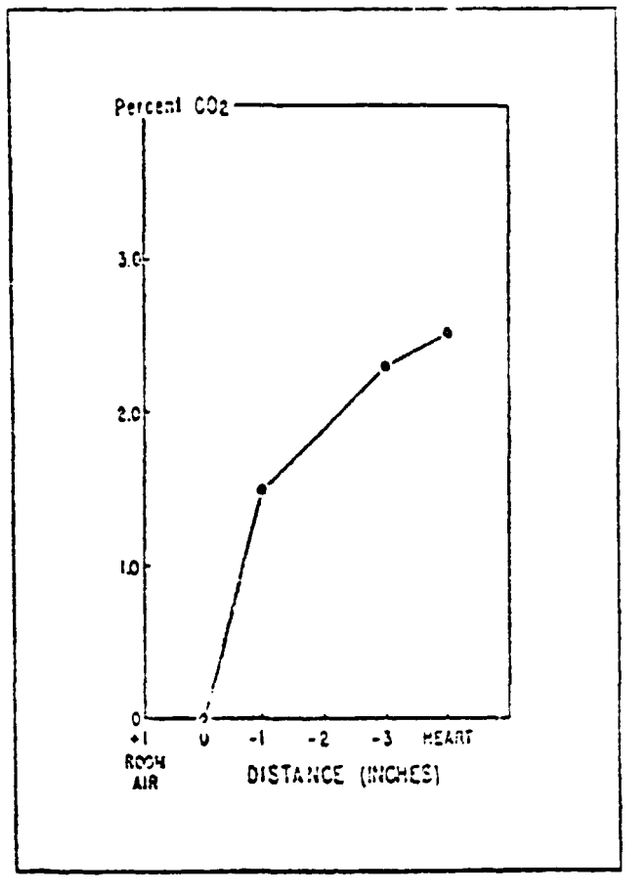


FIGURE 3. CO_2 Gradient within a Lettuce Head

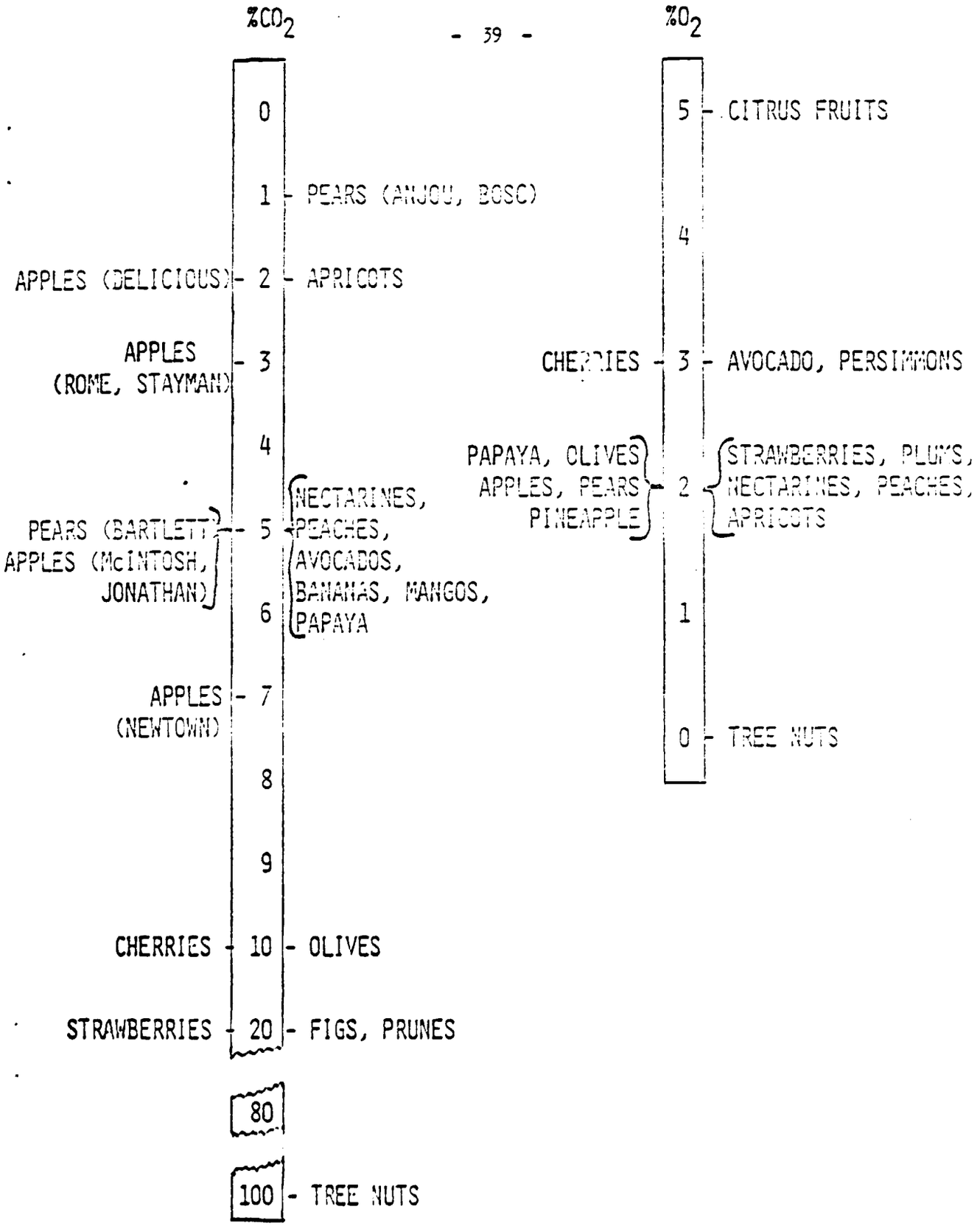


FIGURE 4 . Relative Tolerance of Fruits to elevated CO_2 and Reduced O_2 levels.

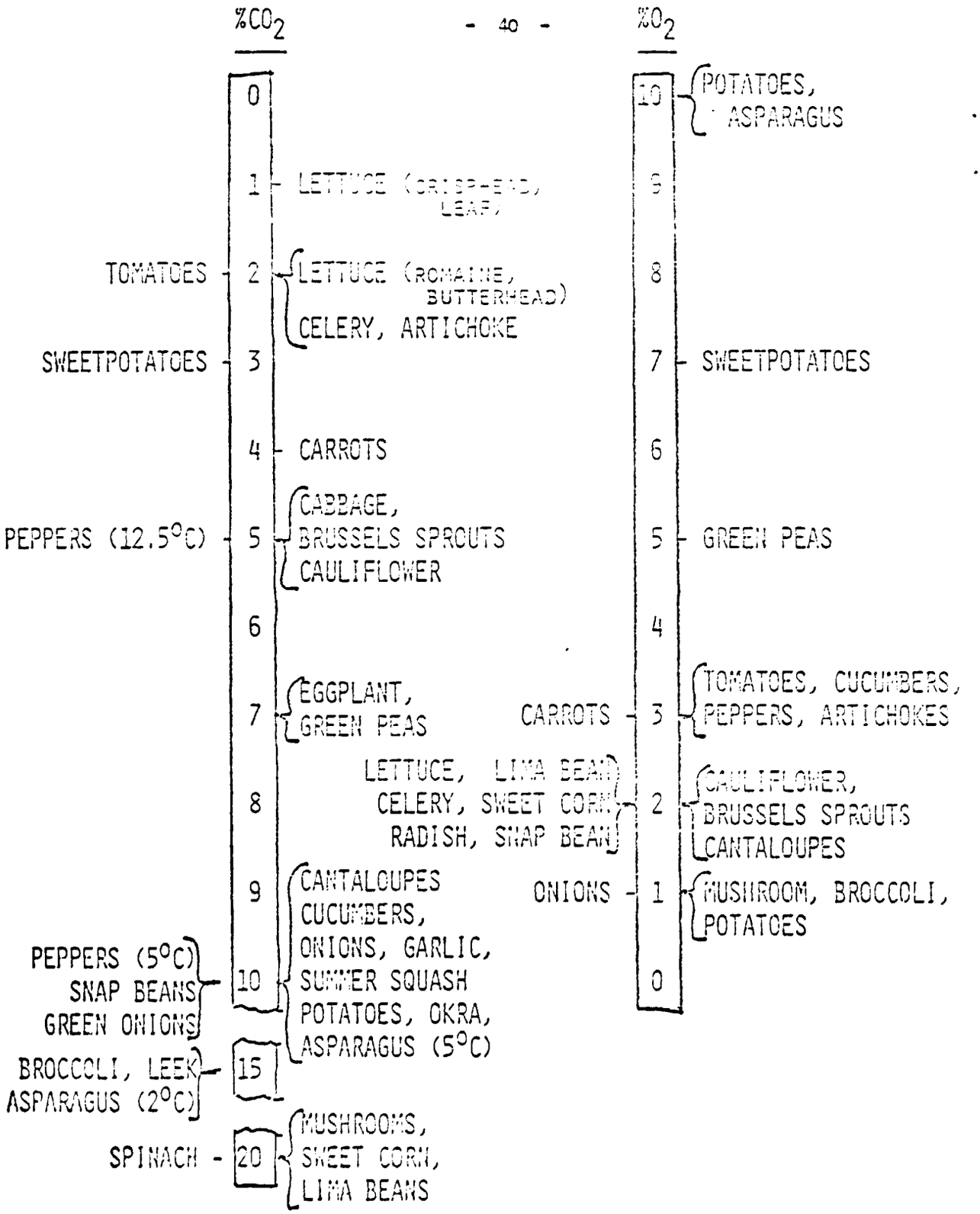


Figure 5. Relative Tolerance levels of Vegetables to elevated CO_2 and reduced O_2

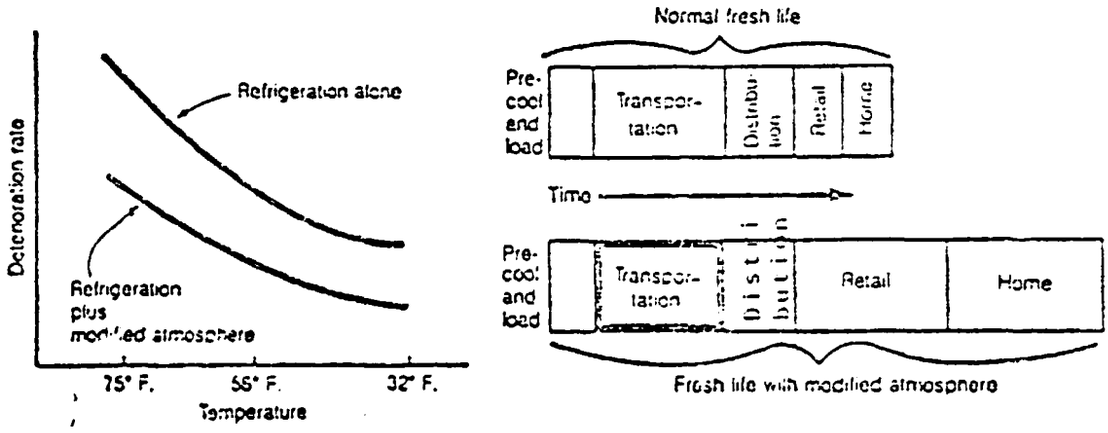


FIG. 6. SHELF LIFE OF PRODUCE WITH REFRIGERATION AND MODIFIED ATMOSPHERE

FIGURE 7. TRENDS IN DOMESTIC SHIPMENTS USING MODIFIED ATMOSPHERES

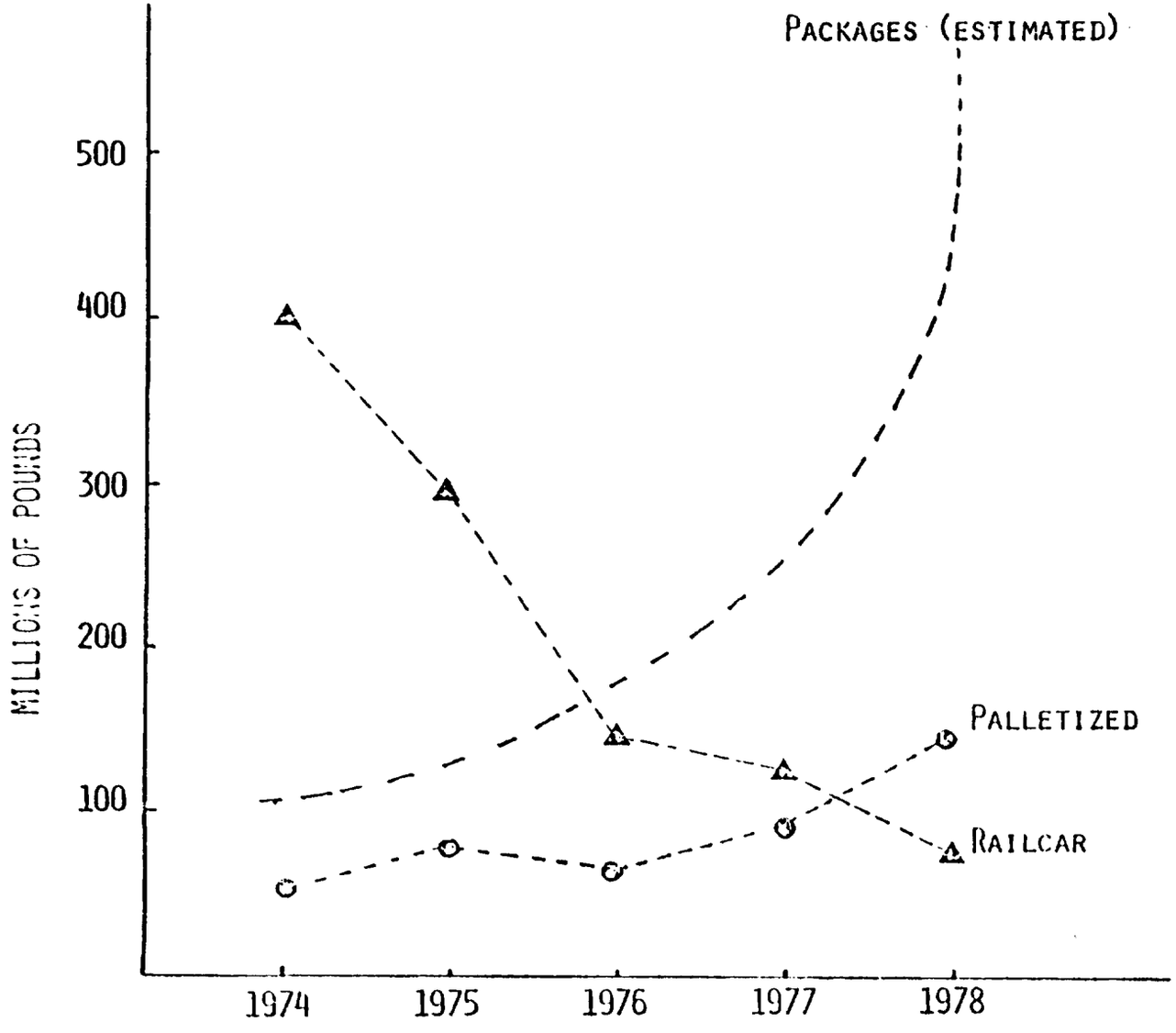


FIGURE 8. TRADE-OFF OPTIONS BETWEEN QUALITY AND SHELF LIFE WITH AND WITHOUT USE OF MODIFIED ATMOSPHERES

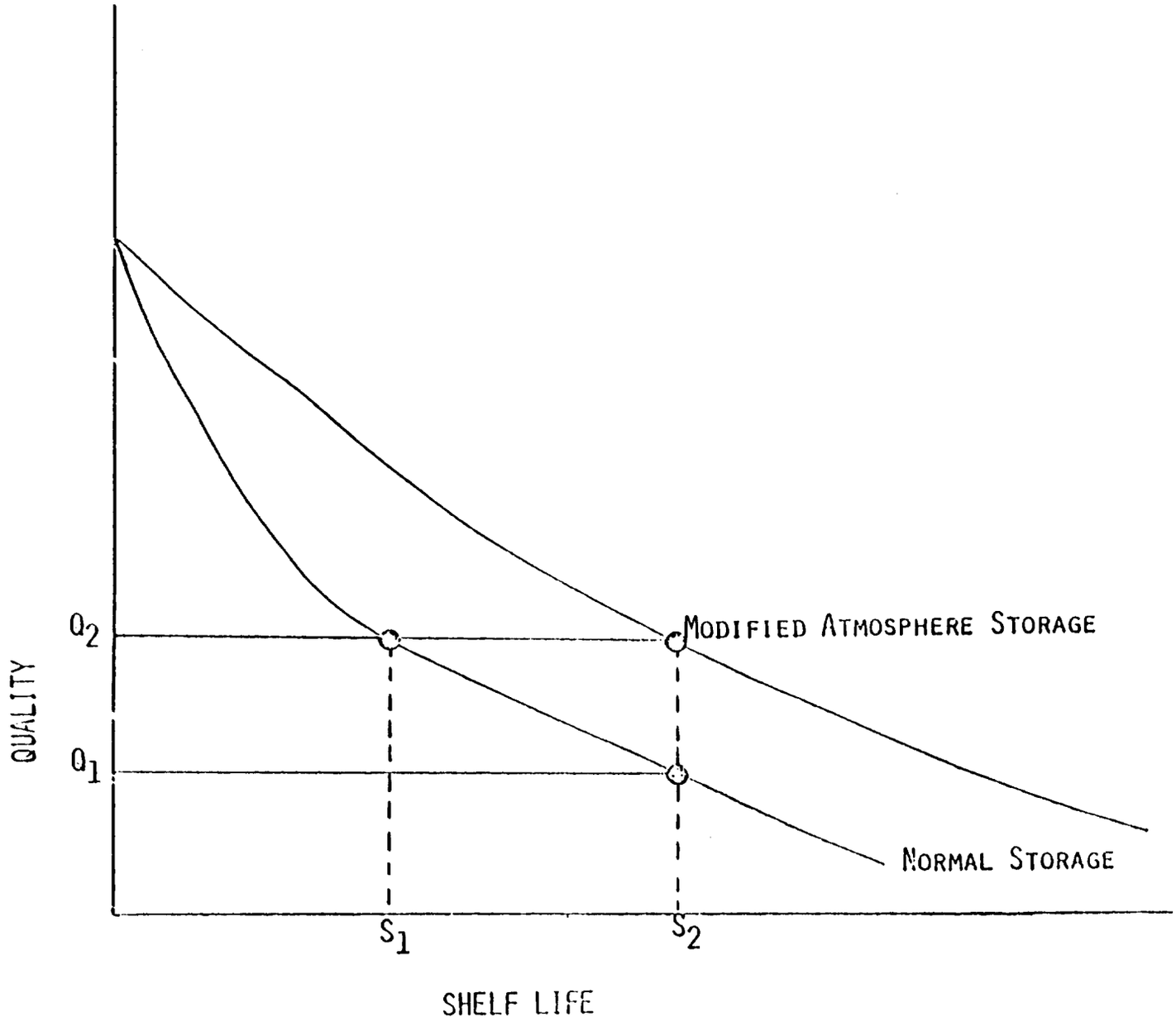
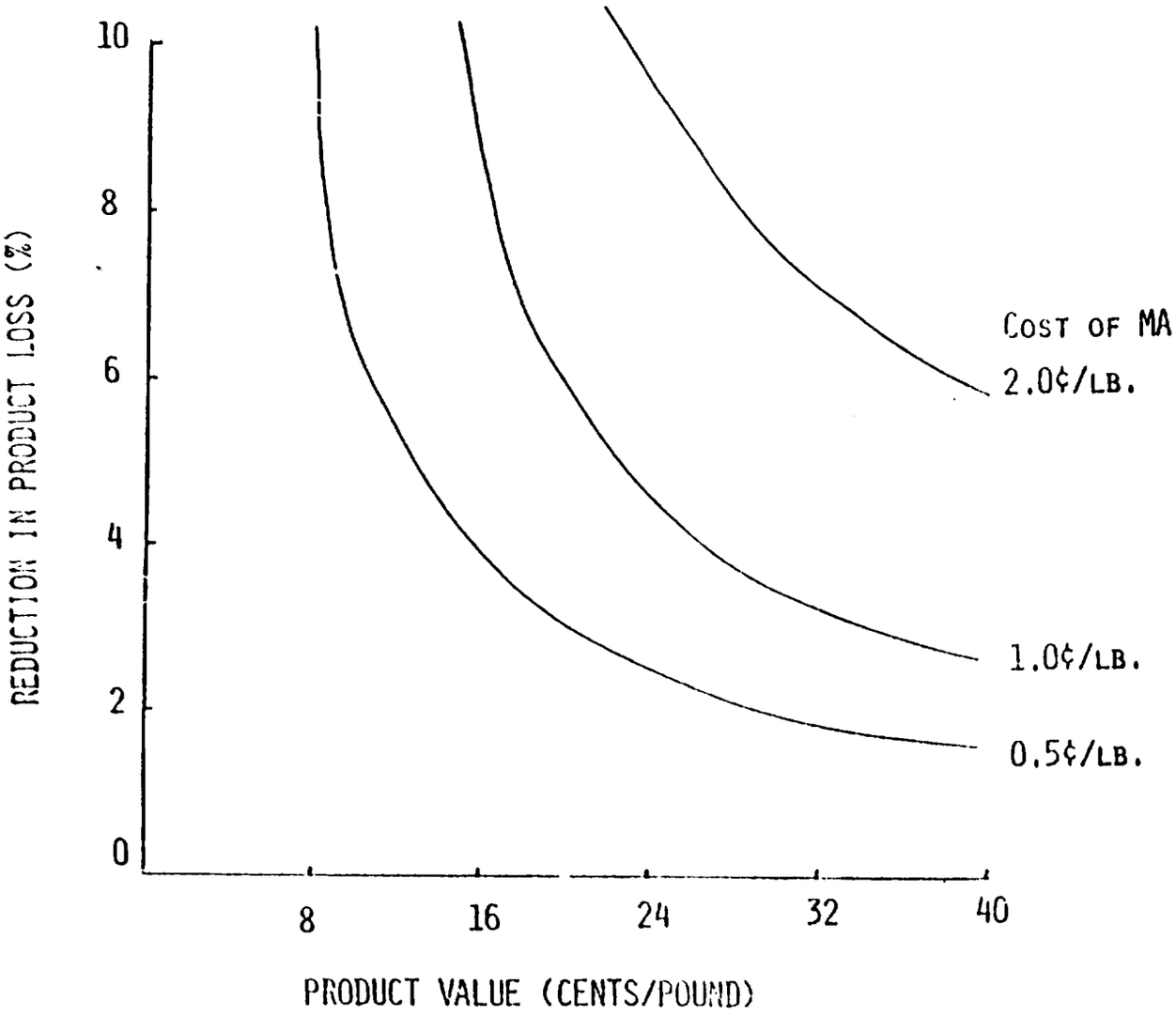


FIGURE 9. COST/BENEFIT RELATIONSHIPS FOR USE OF MODIFIED ATMOSPHERES



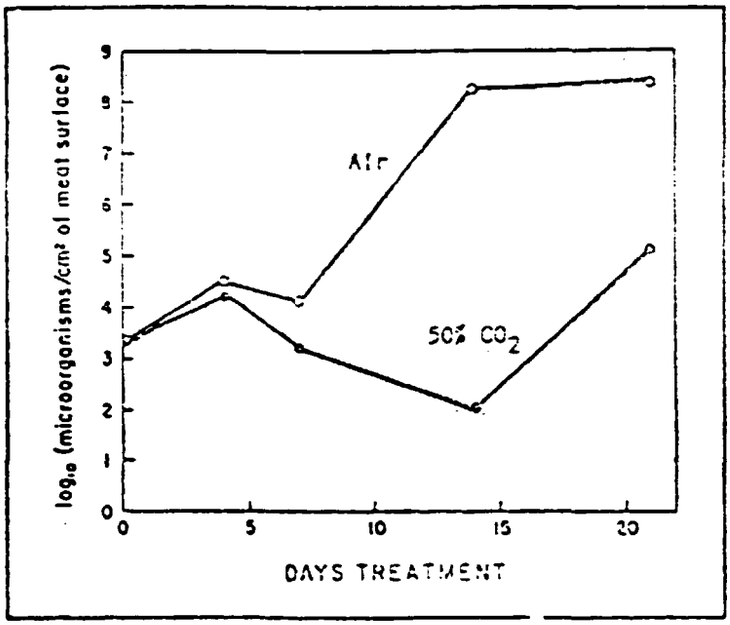


FIGURE 10. Effect of storage in CO_2 enriched atmosphere on microbial growth on pork loins stored at 1° C. (Silliker at.al. Meat Sci. 1: 195,1977)

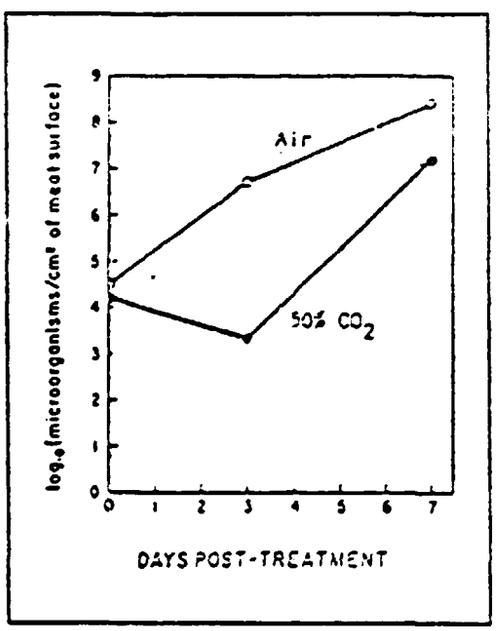


FIGURE 11. Residual effect of storage in CO_2 enriched atmosphere on microbial growth on pork loin stored 4 days with CO_2 at 1°C and then 7°C. (Silliker at al. Meat Sci. 1:195,1977)

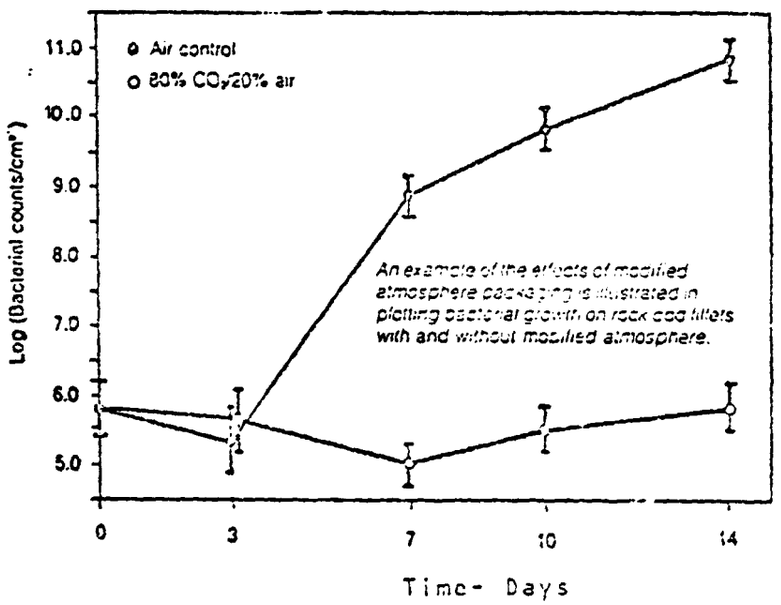


FIGURE 12. The effect of modified atmosphere storage on bacterial growth on rock cod fillets.

LEGEND

1. UNWRAPPED REFRIGERATED CONTROLS
2. POLYETHYLENE FILM WRAP REFRIGERATED CONTROLS
3. PAPER WRAP REFRIGERATED CONTROLS
4. POLYETHYLENE FILM WRAP HYPOBARIC
5. PAPER WRAP HYPOBARIC
6. UNWRAPPED HYPOBARIC

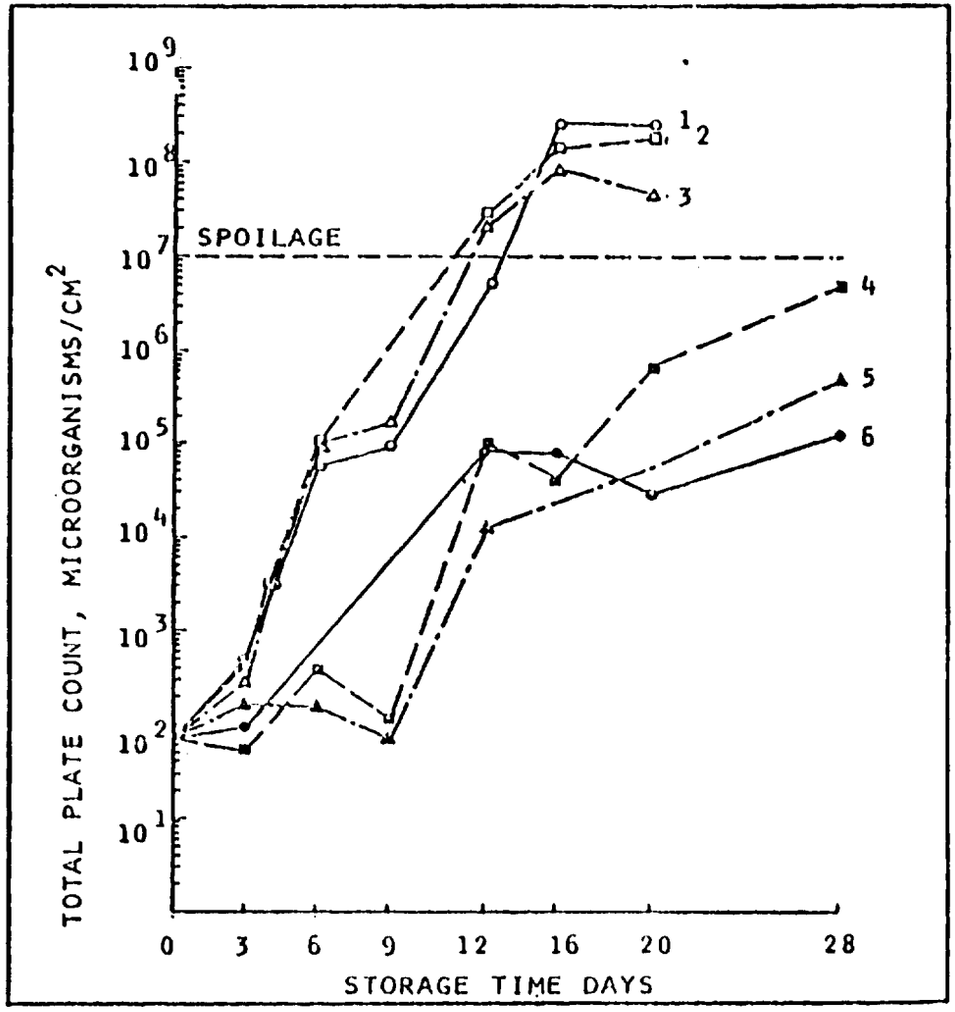


FIGURE 13. GROWTH OF MICROORGANISM IN MEAT UNDER DIFFERENT STORAGE CONDITIONS

APPENDIX III

RECOMMENDED LIST OF EQUIPMENT

Equipment	Estimated Cost (U.S.$)
First Priority	
Multi-point temp. recorder(12 points;0 to 150 or 0 to 200°C range)	3,000
Vacuum pouch sealer	10,000
Vacuum can sealer (Metal Box MB 1A)	12,000
Racks(cages) for pouches	to be made locally
UBBELOHDE viscometers	400
2 vacuum gauges for cans	200
Can pressure Tester-Metal Box Can Hand Tester	200
Micrometer for films with 1/1000 mm	200
WACO can seam analyzer complete with saw	2,000
WACO Enamel Rater	1,000
Magnetic lacquer thickness gauge	300
Falling Dart Impact Tester	3,000
Second Priority	
Oven for Instron	
Autoclave for retort pouches	75,000
Dissolved Oxygen analyzer	1,000
Water Activity analyser (Beckman)	8,000
Hunter Color Difference Meter	8,000

Other facilities

A proper taste testing facility is also urgently needed

APPENDIX IV

1.- NOMBRE DEL SEMINARIO: "Seminario de Envases para Alimentos"

2.- OBJETIVO: Dar a conocer las técnicas empleadas para la determinación de la vida de anaquel, la compatibilidad envase-producto y la simulación de transporte de envases de productos alimenticios.

3.- DIRIGIDO A: Profesionistas e investigadores científicos y técnicos que estén trabajando en la industria de envases para alimentos.

4.- PROGRAMA Y LISTA DE PONENTES: Se anexan

5.- FECHAS Y HORARIO: 27, 28 y 29 de Agosto de 1980
De 8.30 a 12.00 Hrs. y de 13.30 a 17.00 Hrs.

6.- LUGAR: Auditorio de la Cámara Nacional de la Industria Textil (CANAITEX)
Plinio 220, esquina Horacio
Polanco, México 5, D.F.

7.- COSTO 5,000.00 (Cinco mil pesos 00/100 M.N. más el IVA)

Incluye Diploma

8.- INFORMES E INSCRIPCIONES: Lic. Julio A. Blackaller R.
Lic. Margarita Barrientos
Tel. 589-01-99 Exts. 142, 124 y 125

RELACION DE TEMAS Y PONENTES PARA EL SEMINARIO DE ENVASES PARA ALIMENTOS.

	TEMA	PONENTE
(I)	Inauguración	Dr. Juan Antonio Careaga Director General Laboratorios Nacionales de Fomento Industrial Ing. Abelardo Reynosa Vega Director Técnico de los Laboratorios Nacionales de Fomento Industrial
(II)	Introducción	Dr. Chaim Mannheim Investigador del Technion de Israel
(III)	Vida de anaquel de Productos perecederos	Dr. Chaim Mannheim Investigador del Technion de Israel
(IV)	Estructura y propieda- des de materiales poli méricos laminados	Dr. Joseph Miltz Investigador del Technion de Israel
(V)	Visita a los LANFI	Ing.Francisco Muñoz I M A I
(VI)	Materiales flexibles	Dr. Joseph Miltz Investigador de Technion de Israel
(VII)	Permeabilidad, migración Sellado y estabilidad de plásticos	Dr. Joseph Miltz Investigador del Technion de Israel
(VIII)	Vida de anaquel de pro- ductos enlatados	Dr. Chaim Mannheim Investigador del Technion de Israel

	TEMA	PONENTE
(IX)	Efecto de los barnices en la vida de anaquel de productos enlatados	Ing. David Reznick Israel
(X)	Métodos para predecir y determinar la vida de anaquel de productos alimenticios	Dr. Chaim Mannheim Investigador del Technion de Israel
(XI)	Desarrollo y tendencias en la preservacion de productos perecederos	Dr. Chaim Mannheim Investigador del Technion de Israel
(XII)	Evaluación del Transporte y manejo de envases para productos agrícolas	Ing. Olga Arce León I M A I
	Determinación de isotermas de productos alimenticios mexicanos	Q.F.B. Cecilia Rojas I M A I
	Conclusiones y Clausura	Dr. Juan Antonio Careaga Ing. Carlos Rodríguez Caldera LANFI

*grs.

HORARIO PARA EL SEMINARIO DE "ENVASE PARA ALIMENTOS"

DIA / HORA	MIERCOLES 27	JUEVES 28	VIERNES 29
8.30 a 9.00	PONENCIA (I)	PONENCIA (VI)	PONENCIA (X)
9.00 a 10.00	PONENCIA (II)	PONENCIA (VII)	
10.00 a 10.30	CAFE	CAFE	CAFE
10.30 a 12.00	PONENCIA (III)	PONENCIA (VIII)	PONENCIA (XI)
12.00 a 13.30	COMIDA	COMIDA	COMIDA
13.30 a 15.00	PONENCIA (IV)	PONENCIA (IX)	PONENCIA (XII)
15.00 a 15.30	CAFE	CAFE	CAFE
15.30 a 17.00	VISITA A LOS LANFI (V)	MESA REDONDA MILTZ, REZNICK, MUÑOZ, MANNHEIM	CONCLUSIONES Y CLAUSURA