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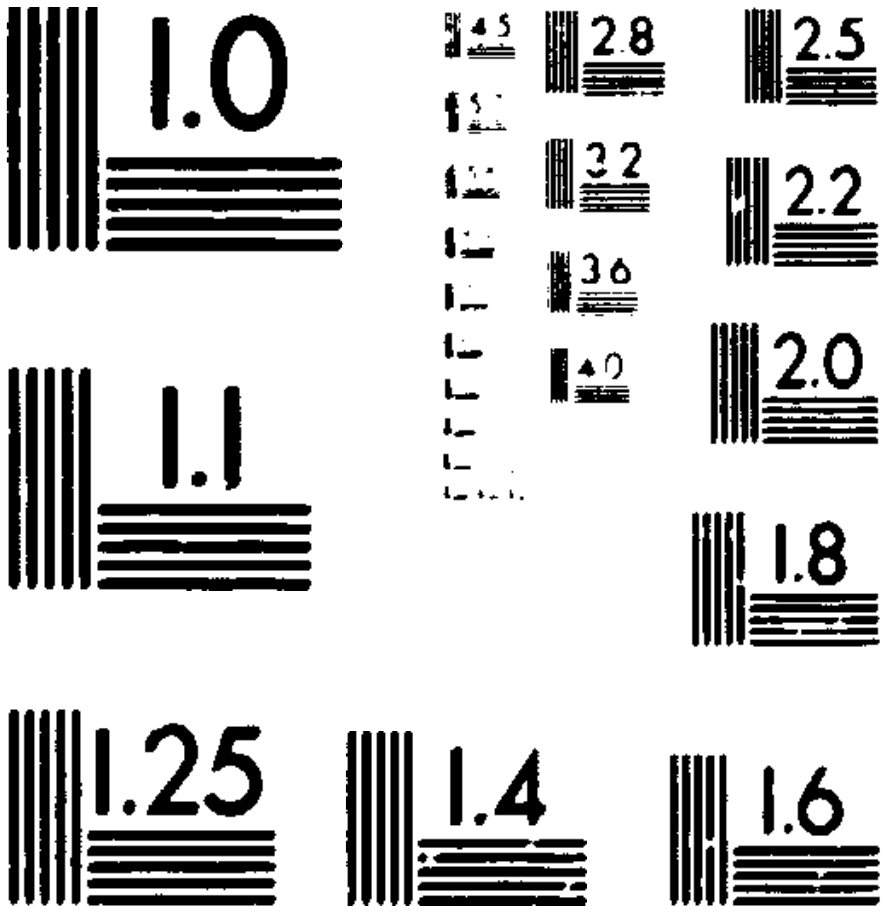

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28 September 1984
English/Spanish

CONSOLIDATION OF CAPACITY OF INSTITUTE OF FOOD TECHNOLOGY THROUGH CREATION OF A NATIONAL FOOD PACKAGING CENTRE

DP/BRA/82/030

BRAZIL

Technical report: Consultancy on glass packaging*

Prepared for the Government of Brazil
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Hendrikus de Waal,
Expert in Food Packaging Material - Glass

United Nations Industrial Development Organization
Vienna

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ABSTRACT

The expert was at ITAL - CETEA from june 5 to june 29, 1984. His senior counterparts were Mr. Roger Marcel Soler and Mr. Roberto Lopes Xavier, with whom he enjoyed an excellent cooperation.

Lectures were given to 22 engineers of the packaging department of ITAL, covering glass manufacturing, properties, technical design aspects, performance tests and quality control.

A one day seminar was organised, attended by several people from the glass - and food industry and other organisations.

A visit was arranged to a glass container industry and discussions were held with representatives from food-and beverage plants.

The duration of the mission appeared too short to arrange more visits to factories. In the future this activity should be given a high priority, with visits preferably to be arranged before or up on the arrival of consultants.

Practical training in glass packaging testing was arranged with the available equipment. In addition 2 quality evaluation tests were carried out on assignment from industry.

Recommendations were made for additional equipment, based on a survey of most needed activities.

Recommendations were also made for additional training abroad, including theoretical training at the University of Sheffield and practical training at the TNO glass laboratory in the Netherlands.

Proposals were made for future activities of ITAL in the field of glass packaging, including comparative design studies to reduce the number of different designs now in use for each product.

Suggestions were also made for projects on closure systems and shelf-life of certain products.

The continuation of UNIDO support in the field of glass packaging is highly recommended.

INTRODUCTION

A. Project Background

The Institute located in the city of Campinas started the activities as a "Laboratory of Technology' on January 27 1963, with the inauguration of the new facilities.

On December 18 1964, it was established as the "Tropical Center of Research on Food Technology", as a result of an agreement signed between the Brazilian Government and the United Nations Development Programme the executors being the Government of the State of São Paulo (Secretariat of Agriculture), representing the Brazilian Government, and the Food and Agriculture Organization (FAO), representing the UNDP.

On July 14 1969, the "Tropical Center of Research on Food Technology" became the "Institute of Food Technology - ITAL", coordinated by CPA (Coordination of Agricultural and Animal Husbandry Research) of the Secretariat of Agriculture of the State of Sao Paulo.

Up until 1969, ITAL dealt only with the technology of products of vegetable origin, but from that year on the research was gradually extended to products of animal origin, namely dairy, meat and fish. A dairy pilot plant was put into operation in 1974, followed by the meat and derivatives pilot plant in 1976, both in Campinas. Firally, a pilot plant for fish and marine products was set up in 1978, in the city of Guarujã near Santos.

The present staff of ITAL includes 13 Ph.D, 40 M.Sc., 21 graduate specialists and 27 graduates. Technical aid staff adds 52 administrative, and general supporting staff 192.

The physical installations in Campinas is represented by 23,000 square meters of buildings located in an area of 101,500 square meters, whereas in Guarujã the Institute has 8,600 square meters and a constructed area of 750 square meters.

Since the establisment in 1963, the Institute of Food Technology has acted as a leader in its field in Brazil, and is acknow-

ledged as one of the best research Institutions in this area.

In 1965, the Tropical Center of Research on Food Technology was the first Institution in Brazil engaged in pioneer research and technical assistance to the food packaging industry. By that time, only basic quality control tests were carried out by a few packaging industries. Recently, more industries, institutions and universities are giving some contribution to this field.

The priority received by the Food Packaging Section in 1969 made ITAL the leading Institute in this particular area of activity in Brasil.

At the moment the Section comprises of four experienced M.Sc., one specialist, three graduates and three technicians. In the near future this staff will be significantly increased to face the commitments of this new project (BRA/82/030).

Packaging demand in Brasil is growing very fast, especially in the food packaging field which took 64% of the metal package, 60% of plastic, 40% of paper and corrugated and 75% of glass in 1979.

Besides the increasing consumption of packaging materials, the technological aspects are becoming more and more important today in Brazil. As a consequence of the fast rate of industrialization that the country experiences, the need for new and better packaging was hampered due to a series of problems, like the lack of know-how, information support, trained human resources, research facilities and so forth.

ITAL's packaging Section has followed the demand of the Brazilian industry in such a way that in 1982 it expanded its activities and facilities through an integrated programme to put a Food Packaging Center into operation, under the sponsorship of the Government of the State of Sao Paulo, the Brazilian Government (FINEP-EMBRAPA) and the United Nations Development Programme (UNDP), through the United Nations Industrial Development Organization (UNIDO). The main objective of the Food Packaging Center is to up-scale support to the packaging and food industry in Brasil and also to serve as an international training Center to

assist Latin America and other countries on this technological matter.

The UN/Brazil Food Packaging Center project is identified as the project BRA/82/030, with a duration of five years, with a total of 1.512 million dollars plus Brazilian investments of 476.835 million cruzeiros.

Part of the contribution in dollars is supplied by the Interamerican Development Bank cooperation programme with the Brazilian Ministry of Agriculture Agency EMBRAPA.

Basically, the project tries to optimize and make use of the food packaging nucleus already existing at the Institute of Food Technology - ITAL.

B. Objectives of the Mission

Up on arrival at the duty station, the original job description was discussed wich Mr. Roger Marcel Soler, head of the Department, and Mr. Roberto Lopes Xavier, responsable for Glass Packaging Section; Mr. Madi, the Unido Project Manager, was not in Brasil during this mission. It was agreed to include training of personnel in available equipment and to make an appraisal of this equipment.

The following activities were included:

1. Presentation of a 25 hours internal course on properties of glass and glass containers, manufacturing of glass containers, testing and quality control.
2. Appraisal of the main equipment already available in the centre and drawing of specifications for additional equipment for testing of glass as food packaging material.
3. Training of personnel of the centre in the available testing equipment.
4. Visits to industries, glass producers and users of glass packaging in order to assess the main problems.
5. Analysis and orientation of present and future projects on glass packaging at CETEA.

6. Assist the centre personnel in the solution of specific problems put forward by the food and packaging industries.

7. Prepare a final report in English, setting out the findings of his mission and recommendations to the Government on further action which might he taken.

RECOMMENDATIONS

1. Continue and expand glass packaging activities in ITAL.

2. Arrange to receive and install additional glass testing equipment, recommended in Annex III of this report.

3. Purchase additional literature on glass and glass packaging, as recommended in Annex IV of this report.

4. Arrange scholarships for at least one engineer to Sheffield University, to TNO glass laboratory in the Netherlands and AGR, USA for further theoretical and practical training.

5. Inform the glass and food industry about the activities of the new glass packaging laboratory in ITAL by arranging visits to industries, organising seminars, offering practical training courses on quality control of glass packaging to the food and beverage industry and publishing in relevant Brazilian magazines, specialised in glass, food and packaging.

6. Prepare a manual for quality control procedures to present to the Brazilian packaging industry.

7. Take an active part in official programmes on standardisation and recycling of glass containers.

8. Prepare an evaluation test programme on existing designs for products packed in glass containers with the aim to make recommendations for reduction of the number of designs in use.

9. Prepare further test programmes on closures for glass containers, including permeability, corrosion, product shelf life, etc.

10. Select candidates for additional personnel for the glass laboratory in ITAL.

11. Arrange to incorporate glass packaging to a larger extend in ITAL activities in food processing. Comparative studies could be made between packing of fruits, vegetables, etc (e.g. chiles, tomatoes, mayonaises) in cans, glass and plastic materials. Glass could also be used as a reference material in the study of metal contamination from cans.

I. ACTIVITIES AND OUTPUT

A. Introduction

The present mission was the first in the field of glass packaging under the UNIDO - programme. For that reason, much emphasis was placed up on theoretical and practical training of personnel in all aspects of glass packaging. Practical training was possible, since ITAL had purchased and installed glass container test equipment in an earlier stage before this mission.

Visits were made to glass and food industries to obtain information on the needs and problems of the brazilian industry concerning glass packaging. However, since the duration of this mission had been reduced to one month, this activity could not receive the attention it should, in the expert's opinion.

Discussions with visitors to the institute and with participants of a seminar on glass packaging organised at ITAL during the expert's presence, were helpful to partly overcome this disadvantage.

With the information obtained, a general set up could be made for the future activities of ITAL on glass packaging, including further training, selection of additional equipment and proposals for future work programmes.

B. Lectures, training and seminar

A training course of 5 half-days was organised at ITAL, covering the following subjects:

- composition of glass and raw materials
- manufacturing of glass containers
- physical and chemical properties of glass
- technical design aspects of glass containers
- physical and chemical testing and quality control of glass containers.

A list of ITAL - personnel, attending this course, is given in Annex I. The full text of this course, including copies of all figures, was handed out to the participants. One lecture was presented on june 20, at the Federal University of São Carlos at the department of materials engineering, where under the supervision of Dr. Edgar Dutra Zanotto research is carried out on glass and ceramics. The subject of this lecture was "Pointers for research and development in the glass container industry".

On june 27 a seminar was organised at ITAL on glass packaging.

The expert presented 3 papers at this seminar, one on technical aspects of design of glass containers, one on properties and new developments and one on quality control and standardisation of glass containers.

The seminar was attended by 34 persons, including representatives from glass, food and packaging industries.

A practical training programme was set up and carried out by ITAL personnel directly involved in glass testing, including calibration of equipment, sampling methods and use of military standards 105D and 414 inspection schemes, test procedures and presentation of test results.

All the available test equipment was used in this training and since the glass packaging section already has most of main testing equipment installed, a good training programme could be carried out. It was a most pleasant experience to observe

the strong motivation of the personnel in this department.

C. Visits to industry and further contacts

The glass container industry in Brasil includes 5 companies. Beverage and food containers are produced primarily by Cisper and Santa Marina both connected to foreign groups (Owens Illinois from USA and St Gobain, France respectively). A detailed break down of market shares and total production figures is given in Annex II.

A visit was made to the Cisper plant in São Paulo. Although not in all respect a modern, up to date glass plant, a good quality product could be made with the available machines and furnaces if a strict quality assurance schedule were applied in all parts of the process. There is room for improvement here. Ware spacing in the annealing lehr, for instance, was far from optimal, which may result in high stresses or even checks in the glass.

Job runs last on average no more than 4 days. This sets a limit on over-all efficiency and on the exploitation of in-line inpection equipment.

The reason is that the variety of designs is rather high in Brasil. More standardisation of designs is needed and ITAL could contribute by selecting the best design for each product on the basis of comparative testing.

From discussions with representatives from food and beverage industries, it appeared that breakage numbers on filling lines vary extremely. Values between 0,04% (which is up to international standards) and 0,25% are mentioned. This last figure is far too high for efficient production and since filling speeds are due to increase, more problems may be expected in the near future. Especially the smaller glass companies deliver too much defective ware.

Visits were also made to IPT in São Paulo and to the Federal University in São Carlos.

In IPT technological development work is done by a small group under the supervision of Dr. Collin Graham Rouse, mainly on (processing of) glass fibers and flat glass. Some contact with this group is advisable.

The glass department of the University in São Carlos, under supervision of Prof. Dr. Edgar Dutra Zanotto does valuable research on nucleation and crystallisation and the development of waste- and rock based glasses and glass ceramics. They are well equiped and regular contacts are advisable, also since the Dr. Edgar Zanotto expresses a great interest in the activities of the new glass laboratory in ITAL.

D. Standardisation

Standardisation of glass containers is a relatively recent activity of ABNT, the Brasilian Standardisation organisation. In 1983 standards on returnable containers for beer, softdrink, mineral water and spirits have been published, including designs for beer and soft drink with tolerances on main dimensions, test methods and specifications for strength.

During the expert's mission a first meeting was organised by ABNT to form a permanent commitee for standardisation of glass containers, with sub-committees for all products. Glass - and food industry will be represented in these commitees and also ITAL will be member.

The standards published up to now, conform to international standards to a fair degree.

The development of more standards on design could be a useful future activity for these committees.

II - UTILIZATION OF THE RESULTS OF THE ACTIVITIES

For a new activity, which the field of glass packaging is for ITAL, an immediate utilisation can hardly be expected. However, ITAL did make a start in this field already some time before this mission.

One employee, Mr. Roberto Xavier, received training in two of the larger glass companies in Brasil and some vital equipment was purchased.

Good contacts have been made with some glass - and bottling industries.

What is lacking is the experience with this kind of work, on a practical level as well as in planning of test programmes.

In this respect the expert's presence was highly beneficial, since during the mission ITAL acquired its first two assignments to perform quality tests an new designs, one from a leading beverage company and another one from a glass container company.

The expert was able to advise on the test programme and to include these tests in the general training programme.

This shows that the activities in this mission can be put into immediate utilisation.

It also shows that the interest of industry in this new activity of ITAL is a reality and that it is of the utmost importance that the personnel of ITAL receives an in-depth training abroad to be able to answer the demands from the industry in Brasil and to give support to new developments as soon as possible.

Also the fact that ABNT has initiated activities on standardisation of glass containers supports this view and is another opportunity to utilise the results of the activities of this mission. Job runs have in the Brazilian glass industry an average duration of no more than 4 days, which means an important loss in efficiency and increases costs.

If would be beneficial for the Brazilian economy if the number of designs in glass packaging could be decreased by further standardisation of container types. ITAL can give an important contribution here by carrying out an evaluation programme an existing designs for certain products packed in non-returnables, make a comparison of their suitability and present the results to government and industry. For a proper

execution of such a programme financial support from the government or another source seems indispensable.

III - CONCLUSIONS

The expert's survey indicates that there is a need for ITAL-activities in Brasil in the field of glass packaging.

20% of the national consumption of packaging materials consists of glass, but, on the other hand, its consumption per capita is 10 times lower than in the United States and is expected to grow in the near future.

Traditionally glass packaging has been returnable to a high proportion, especial y for beer and soft drinks, representing 45% of the total bottle market, to a total of 424 million units yearly.

Single trip glass bottles were recently launched for beer and within a few months from now, one way soft drink containers will be introduced.

This may put considerable pressure on production capacities of container glass companies.

It may be expected that those companies that up to now did not specialise in packaging for high volume products, will try to enter this field. This might be beneficial for the general situation in glass packaging, since the field is now dominated by one company only.

On the other hand does the glass industry in Brasil, possibly with the exeption of Cisper, lack the necessary know-how and quality assurance system to produce high quality glass containers as was shown in the comparative tests performed at ITAL in the expert's presence and put forward in discussions with bottling companies.

Breakage numbers on filling lines are in some cases higher than acceptable for good efficiency.

ITAL could provide technical assistance to the food and beverage industry by performing input quality control tests on purchased lots, evaluation tests on existing designs and general performance tests on new designs. Programmes of this kind were executed for a leading beverage company and for a glass factory during the expert's mission, which might indicate the considerable interest of the industry in this activity. Especially the smaller bottling companies could profit, since they generally have no facilities for input quality control. Also, a manual for quality control procedures could be prepared by ITAL and presented to the food and beverage industry.

ITAL know-how could also be useful in technical discussions between glass suppliers and their custumers and in the preparation of standards to reduce the influence of the glass suppliers in these discussions.

In a later stage, ITAL could provide assistance to glass manufacturers, specially the ones that do not receive foreign know how, by performing technical design studies, relations between strength, glass weight and distribution, etc.

Also, the study of adequate closure systems should be taken up at ITAL. A first programme of this kind is already in operation.

Indispensable for these activities is the availability of adequate testing equipment and further training of personnel, preferable in foreign specialised laboratories, to be followed by regular training by foreign experts at ITAL in the coming years.

The expert has prepared a list of additional equipment, attached to this report as AnnexIII, recommended for ITAL.

A subdivision has been made in most urgent, urgent and less urgent items. It also includes suppliers and price estimates if available.

Good basic training on glass is provided by the Glass Department of the University of Sheffield, United Kingdom.

Usually there is a 10 week-course, starting in october. Also in the case there is no special course organised, proper theoretical training is available during this period for "occasional students".

Practical training can be provided by the Glass Department of the Institute of Applied Physics TNO - TH in Delft, the Netherlands, specialised in quality control and testing of glass containers. Two weeks would be a minimum duration for this.

Two specialised short courses on glass containers(3 1/2 days each) are regularly organised by American Glass Research, Butler, Pa. ; USA Details are available at ITAL.

For further study, a list of books, providing background information on glass is included in this report a Annex IV.

Annex I

"CURSO SOBRE FABRICAÇÃO E PROPRIEDADES DE EMBALAGENS DE VIDRO PARA PRODUTOS ALIMENTÍCIOS E BEBIDAS"

LISTA DE PRESENÇA

1- Assis Euzébio Garcia
2- Carlos Alberto Sakoda
3- Christianne de Vasconcelos Affonso
4- Claire Isabel Grígoli de Luca Sarantópoulos
5- Edina Hiroko Takemura
6- Elí Espinoza Atencia
7- Eliete Vaz de Faria
8- Eloísa Elena Correa Garcia
9- Gislene Capovilla
10- Gláucia Bodelon Francelin Camargo
11- Jane Barbutti
12- Lea Mariza de Oliveira
13- Lúcia Beatriz Rondina Guedes
14- Maria Celina Camargo
15- Marisa Padula
16- Nelson Hiroshi Maruyama
17- Nilson Monteiro Silvestre
18- Paulo César Simel
19- Pedro Francisco Moreira
20- Roberto Lopes Xavier
21- Roger Marcel Soler
22- Valéria Delgado de Almeida Anjos

Annex II

GLASS PACKAGING

1 INTRODUCTION

Traditionally glass packaging has been important in Brasil due to the high proportion of returnable glass bottles for beer and carbonated drinks. It is estimated that Brasil has probably one of the largest returnable glass bottle markets in the world. This is not hard to understand when we note that Brasil ranks fourth in world consumption of carbonated beverages althougn the per capita consumption is very low at 28 litres.

Another interesting aspect of the Brasilian market is the housewife's preference for transparent packaging. This must partly explain the trend towards glass for tomato products and the glass manufacturers have developed glass packaging which can be reused as drinking glasses.

- Raw Material Supply

The raw material, soda ash, is supplied exclusively by the Companhia Nacional de Alcalis, but considerable quantities have to be imported to meet demand.

Supply Of Soda Ash

Tonnes (000)	1978	1979	1980
National production	121	119	176
Imports	183	199	203
Apparent consumption	304	318	379

- Glass Production, Conversion And Market Share

Tonnes (000)	Nominal Capacity	Production 1982
Cisper (Owens Illinois)	440	250
Santa Marina (St. Gobain)	170	150
Wheaton	60	50
Nadir Figueiredo	60	80
CIV	160	80
Total	890	610

Cisper specialize in packaging for high volume products such as beer bottles and carbonated beverages. Santa Marina also manufacture bottles but participate in the small bottle market. Wheaton specialize in small bottles, Nadir Figeuiredo in the small jar market and CIV make bottles and jars.

In addition there are a number of smaller glass makers but their market shares are not significant.

The total market for converted products in 1982 was broken down by weight as follows:

Bottles - 400,000 tonnes
- Cisper 60%
- Sta. Marina 30%
- Nadir Figueiredo) 10%
- CIV)

Jars - 80,000 tonnes
- Cisper 52%
- Sta. Marina 32%
- Wheaton 16%

Small Bottles - 70,00 tonnes
- Wheaton 60%
- St. Marina 32%
- Cisper 5%

Small Jars - 60,000 tonnes
- Nadir Figuerido 80%

The identified replacement markets were:

(Million Units)

Bottles	- Beer	225	Jars	- Mayonnaise	94
	Carbonated beverages	199		- Tomato products & jams	11
	Wine	117		- Bottled fruit and veg	44
	Aguardente	100		- Soluble coffee	93
	Spirits	113		- Baby food	45
	Pine disinfectant	113			
	Fruit juices	69			
	Mineral water	6			
Small Bottles	- Pharmaceuticals	23	Small Jars	- Tomato extract	130
	- Condiments	22		- Caramelized milk	55
	- Fragrances	5		- Cheese spread	35

- **Packaging End-Use Markets For Glass**

CONSUMPTION: 1978, 1982, 1990							
Tonnes ('000)		1978	1982	Annual % Change 1978/82	1990	Annual % Change 1982/90
Bottles	Food	348.6	354.3	+ ½	376.5	+ 1
	Non-Food	47.1	48.3	+ ½	66.4	+ 4
TOTAL		395.7	402.6	+ ½	442.9	+ 1
Small Bottles	Food	5.6	6.0	+ 1½	7.9	+ 3½
	Non-Food	42.7	61.1	+ 9½	105.0	+ 7
TOTAL		48.3	67.1	+ 8½	112.9	+ 7
Jars	Food	50.8	70.5	+ 8½	112.6	+ 6
	Non-Food	7.5	8.8	+ 4	15.7	+ 7½
TOTAL		58.3	79.3	+ 8	128.3	+ 6
Small Jars	100% Food	52.5	61.0	+ 4	93.6	+ 5½
TOTAL		52.5	61.0	+ 4	93.6	+ 5½
Total Food		457.5	491.8	+ 2	590.6	+ 2½
Total Non-Food		97.3	118.2	+ 5	187.1	+ 6
TOTAL GLASS		554.8	610.0	+ 2½	777.7	+ 3

- **Trends In Demand For Glass Packaging**

In the beer and carbonated beverage markets, the trend has been at best static and it will probably be some time before carbonated beverages again reach 1980 levels. Beer was production limited until 1980 but the recession has resulted in static demand and as no new investments are anticipated in the near future, the likelihood is that beer will again become production limited.

Wine, aguardente, fruit juices, mayonnaise and sophisticated tomato products will all grow 30-40% over the next 5 years, while traditional products such as caramelised milk and cheese spread will show only 2-3% per annum growth. Tomato ketchup is expected to grow considerably over theperiod.

The question regarding glass packaging is the introduction of single trip packaging in the beer and carbonated beverage markets. Tin plate cans have not made significant inroads into the market yet but the introduction of two piece aluminium cans which should be cheaper than tin plate, plus changing consumer habits, may change this. Single trip glass bottles for beer were recently launched but will probably only achieve a small market share due to their high price.

The PET bottle for carbonated beverages has been a possibility for some time. The inconvenience of returning glass bottles plus a trend towards home consumption should make PET a more attractive alternative. This is discussed in detail in Part II, Section 1.7.

International Comparisons

Brasil's per capita consumption of packaging is very low compared with developed countries and indicates a large potential. However, if consumption is related to the economically active population of 43.8 millions, the figures relate quite well to those of Italy.

INTERNATIONAL CONSUMPTION OF PACKAGING MATERIALS
(kgs per capita)

	Brasil		USA	Benel.	France	Germ.	Italy	Neth.	UK
	Total Pop.	Ecnmclly Active							
Plastics	2.4	7.1	11	17	11	13	8	11	8
Paper	3.4	10.1	19	21	14	14	15	22	14
Fibre board	6.2	18.3	70	24	29	23	18	28	24
Paper board	1.8	5.3	33	7	11	12	7	12	12
Steel	4.7	13.9	30	16	10	8	7	17	18
Aluminium	0.2	0.6	4	1.5	1	1.5	0.7	1.2	1
Glass	4.7	13.9	47	40	39	41	28	34	35

In the forecast period all these consumption per capita figures are expected to increase, and there will be some alteration in the balance between them.

For example steel packaging, particularly tinplate, despite its relatively high cost has a high consumption per capita largely due to the harzardous

Annex III

List of additional equipment, recommended for quality control and testing of glass packaging in ITAL.

Nº	Name	Use	Supplier	Price estimate	Remarks
	Most urgent				
1	Set of equipment for dimensional control of glass containers	Measurement of: -height -diameter -finish -perpendicularity - out-of-roundness -bore -finish on-dulation -wall thickness of narrow mouth containers	Boers en Co Instr. en App. Fabriek Van Heekstr.34 3125 HN Schiedam. The Netherlands or if available local suppliers	Total (for all apparatus required): appr.$7.500,-	For calibration metal disks and bars have to be ordered or made
2a	strain gauge meter with strain gauges	Measurement of stress distribution in container wall during internal pressure, thermal shocks, vertical load (static test)	Peekel	Appr.$3000	Needed for design evaluation studies(does not include impact)
	or: (preferably)				
2b	strain gauge tester with high speed strain meter, peak height meter and storage oscilloscope	Measurement of stress distribution in container wall(static and dynamic test)		Appr.$15000	Like 2a, but includes impact Detailed information available at TNO, The Netherlands

Annex III (continued)

NO	Name	Use	Supplier	Price estimate	Remarks
	Most urgent				
3	Set of standard glasses for optical transmission	Calibration of spectrophotometer	Institut National du Verre 10,Boulevard De Fontaine B-600 Charleroi Belquim	Appr.$2000	Range 300-1000nm
	Urgent				
4	Polarisation microscope with Berek or Babinet compensator	exact measuremet of cooling stress and inhomogeneities in glass container	Leitz, olympus or equivalent	Appr.$4000,-	Preferably with interchangeable objectives. Enlargement appr. 25 - 300 times
5	Glass grinding and polishing equipment	Preparation of glass samples for microscope, optical transmission,etc.	Buehler Ltd 2120 Greenwood Street Evanston Illinois USA or Panambra Av.Gen.Queiroz 150 - S.Paulo	Appr.$7500,-	Including felt and grinding and polishing material
	Less urgent				
6	Hot end coating meter	Thickness of hot end coating on containers	AGR	$4675	complete with coupling liquid
7	Tilt table	lubricity test for cold end coatings	AGR	$1325	

Annex III (continued)

NO	Name	Use	Supplier	Price estimate	Remarks
	Less urgent				
8	Liquids for matching refractive index of glass	Quick comparison of refractive index mainly for identification of glass fragments in food	Chemical supliers	Appr.S1000	See for details ASTM test F 128- 68
9	Finish hot end coating meter	Thickness of hot end coating on the finish of glass containers	AGR	S3470	With coupling liquid. Used mainly for corrosion study of crown corks by hot end coating

Annex IV

List of books on glass and glass packaging

1. "Le verre dans les industries alimentaires", P. Cardon, Publ. by Cie. Française d'Editions, Paris 1974.

2. "Packaging in Glass", B.E. Moody, 1977(2nd Edition) Publ. by Hutchinson, London.

3. "Verpackung von Lebensmitteln", R. Heiss, 1980 Publ.by Springer - Verlag, Berlin, New York (Chapter 4.6)

4. "Handbook of Glass Manufacture" F.V. Tooley, 1974 (2 volumes) Publ. by Books for Industry, New York.

5. "Properties of Glass" H. Rawson, 1981 Publ. by Elsevier , Amsterdam.

6. "Glass, Natur und Eigenschaften", H. Scholze, 1980 Publ. by Springer Verlag, Berlin (also available in English).

7. "Glastechnische Fabrikationsfehler", Jebsen - Marwedel and R. Brückner. 2nd or 3rd Ed. Publ. by Springer Verlag.

8. "Optical properties of glass", I. Fanderlik, 1983 Publ. by Elsevier, Amsterdam.