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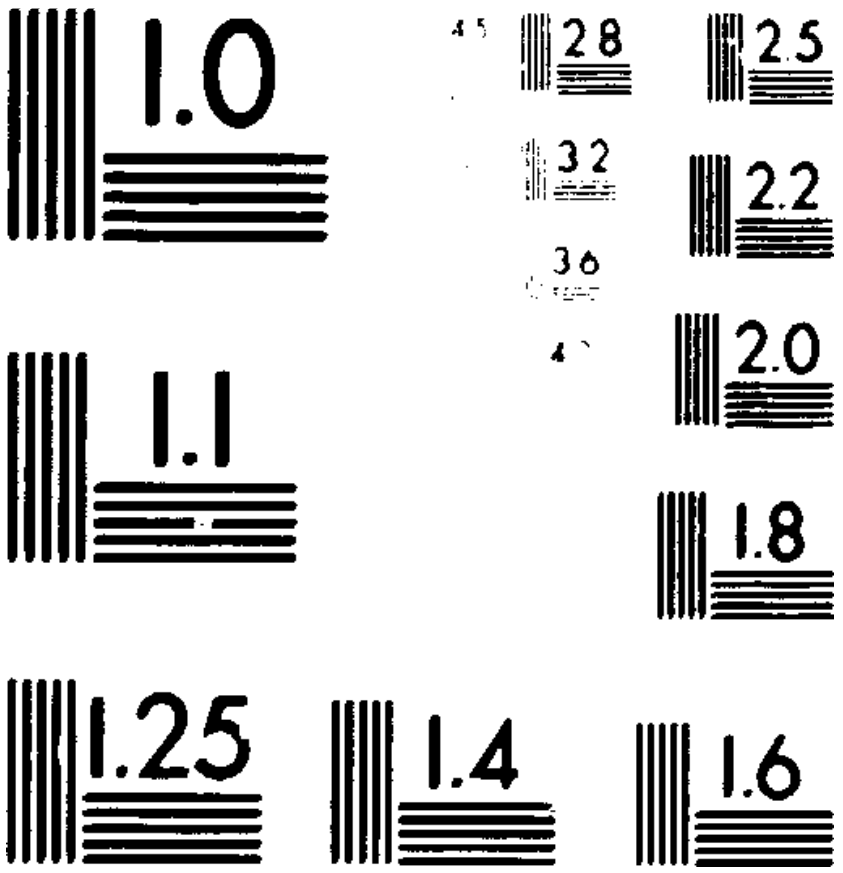

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CONSOLIDATION OF CAPACITY OF INSTITUTE OF FOOD TECHNOLOGY THROUGH CREATION OF A NATIONAL FOOD PACKAGING CENTRE

DP/BRA/82/030

BRAZIL

Technical report: Shelf life of food products*

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 Roberto Massini
Expert in the shelf life of food products

United Nations Industrial Development Organization
Vienna

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EXPLANATORY NOTES

- The average value of the local currency during the period of the mission was: 1,490.CO Cr$ for 1,00 USA$

- ITAL = Institute of Food Technology in Campinas SP - Brasil

- CETEA = Food Packaging Center at the ITAL

- MPL = Metal Packaging Laboratory

- ECCS = Electrolytic chromium/chromium oxide coated steels, formerly TFS (Tin Free Steels).

- D&I = Drown-and-Ironed, 2-Piece can

- D&D = Draw/redraw, 2-Piece can.

ABSTRACT

Consolidation of the Existing Capacity of the Institute of Food Technology (ITAL) through the Creation of a National Food Packaging Centre.
Project in Brazil DP/BRA/82/030/11-04.

The report concerns the mission on shelf life of food products, carried out between 25 April through 27 May 1984 by the UNIDO consultant Roberto Massini, at the Food Packaging Centre- CETEA in Campinas SP - Brazil.

The consultant presented a short courses on the electrochemical corrosion of metal food cans, as related to the container and the food product characteristics, and worked with the Metal Packaging Laboratory staff to assess the best test conditions for the evaluation of metallic material corrosion performance by using electrochemical equipment .

The consultant also presented a seminar on the latest developments in food processing and filling techniques, and a seminar for participants from food packaging and packaging industries on the welded side seam cans, and the eletrochemical tests now carried out in the Center. Despite the very short time available, the training would enable the Metal Packaging Group to start up some research programs related to the main packaging problems.

Regarding equipment the Metal Packaging Laboratory should be complemented with some lacquering facilities as soon as possible. Any attempt to continue the involvment in research works with food packaging and packaging industries is strongly suggested, as well as a permanent relationship with similar laboratories.

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INTRODUCTION

A. Job description

DP/BRA/82/030/11-04/31.7.E

Post title	Expert in shelf life of food products
Duration	One month
Date required	April 1984
Daty station	Campinas (São Paulo), with travel as required

Purpose of project

It is the prime Government objective to increase and ensure sufficient food supply to the Brazilian population. Furthermore, given the rich endowment of agricultural land coupled with the need to alleviate its Balance of Payments problems, the Government seeks to increase export of processed foods.

Packaging is a significant tool in the Government's ability to achieve either of these goals, so much that the importance of improved packaging has been explicitly stated in the III National Basic Plan for Science and Development (1980-85).

The Institute of Food Technology (ITAL) in São Paulo, being the main institution addressing the issue of packaging, has undertaken to create a Packaging Centre with the support to the Federal Agricultural Ministry and State Agricultural Secretariat.

National Expertise and equipment is limited, consequently international technical assistance is being requested to ensure that the Packaging Centre will be staffed and equipped with the most modern and appropriate technology in this field.

Duties

The expert is expected to work with the technical staff of the Center under the supervision of the Manager of the Project and the Director of the Institute of Food Technology, to develop the following activities:

1. Short courses and seminars of the main aspects that affect the shelf-life of canned products.

2. Appraisal of the existing equipment in the Center and suggestion for the complementation for the laboratory of shelf-life on canned products.

3. Installation and operation together with the technical staff of CETEA of the corrosion equipment in the Metal Packaging Laboratory.

4. Analysis and improvement of tests for metal packages in order to enlarge the capability of CETEA to assist the metal packaging and food industry.

5. Visits to the food and packaging industries as well as supermarkets and distribution centers in order to detect the main problem of shelf-life of canned product.

6. Direct assistance to the food and packaging industry together with the personnel of the Center.

7. Appraisal of the main projects of the Center in the area of shelf-life of canned products.

8. Short seminars and talks to the food packaging and packaging industries regarding the most important advances in the field.

The expert will also be expected to prepare a final report setting out the findings of the mission adn recommendations to the Government on further action which might be taken.

Qualifications

Food processing technologist, with university degree or equivalent experience. Professional specialization covering the fields of food processing and packaging technologies with extensive experience in shelf-life of food products.

Languages

English, Portuguese an asset.

B. Previous experience

Since 1982 the ITAL's Packaging Section is expanding its activities and facilities through an integrated programme to put into operation a Food Packaging Center (CETEA) under the sponsorship of the Government of the State of São Paulo, the Brazilian Government (FINEP - EMBRAPA), the United Nations Industrial Development Organization (UNIDO) and United Nations Development Program (UNDP).

In 1982 the writer was two months at the ITAL's Packaging Section as EMBRAPA consultant, and on that occasion he acquired some knowledge of Brazil's needs in the specific field.

Faced with the Brazilian trade characteristics, the canning of processed foods may be regarded as the most suitable way for the agro-industrial development in the short and medium term perspective. Also in connection with the half-raw fruit products export, the hot (if not yet aseptic) filling in metallic drums appears very promising.

It may be pointed out that the bad name acquired by the canned foods is due to the surviving of empiric manufacturing practices and of absolute plants in the most developed countries too. Nevertheless the new industrial facilities may be planned making use of the most modern can making, filling, and processing technologies, that allow to keep safe food products without remarkable loss of nutritional and organoleptic characteristics, for an adequate length of time and in a not very expensive way.

It this view the writer at the end of the former visit at ITAL gave some suggestions mainly in the metal packaging area, for the future CETEA working addresses and laboratory facilities.

C. Working program

At the beginning the job duration was one month, including travel time, 2 days briefing and one day debriefing in Vienna, as well as 2 days stopover in Brasilia. Afterwards the duration of the mission was extended three days while debriefing in Vienna and stopover in Brasilia were not required, this allowing a stay of 4 weeks at the duty station (from 30 April to 25 May).

According to the scheduled job duties, was agreed with the Project Coordinator Mr. Luis Madi that the following activities would be carried out:

1. Short course for the CETEA technical staff on the theoretical and practical aspects of the corrosion processes inside metal food cans.

2. Seminar for the CETEA technical staff on the latest developments in food processing and packaging, with in detail references for the aseptic techniques.

3. Appraisal of the existing equipment in the MPL, and suggestion for the complementation.

4. Instalation and operation together with the MPL technical staff of the just arrived equipment for electrochemical tests.

5. Visits and talks to the packaging industry, tinplate and Cr-TFS makers and the São Carlos University's Electrochemistry Department.

6. Direct assistance to some food and packaging industries together with the personnel of the CETEA.

7. Appraisal of the main projects of the CETEA in the area of processed foods packaging.

8. Talk for participants from food packaging and packaging industries regarding the welded side seam cans and their quality control techniques.

Language to be used: Portuguese

D. Work performed

All the forecasted activities were carried out, except the visits, to the São Carlos University and the tinplate and Cr-TFS maker (it was not possible to agree on suitable reporting dates). However with members of the second one a meeting at the ITAL's CETEA was organized.

The main objectives of the activity were attained, and the MPL technical staff was allowed to undertake some experimental investigations well fitted with the Brazilian packaging addresses, by using modern and appropriate facilities.

RECOMMENDATIONS

1. Taking into account the metal plates lacquering and curing facilities already purchased, the MPL can be considered well equiped for the routine assistance to food packaging industries, as well as for some more comprehensive investigations. But the acquisition of a small double seamer, and of an electricity powered small retort is advised, as the making use of correspondent industrial equipments at the ITAL's food processing sections is very time consuming.

   It would be also helpful to replace the existing low enlargement stereo-microscope with one suitable for non-transparent objects viewing and well equipped with a camera.

   For the medium term, the acquisition of a Transfer Function Analyser is suggested. This aparatus is very suitable for protective layers evaluation, but must be directly connected to a personal-computer, otherwise the data analysis would be excessively slow.

   In a not very distant future the research programs will need the availability of an Electrons Scanning Microscope, possibly joined with a X-ray Microprobe.

2. The MPL members just trained for the new electrochemical apparatus usage must undertake a comprehensive analytical work on the Brazilian packaging materials and finished metal food containers. The purpose of these investigations is to establish some quality standards for the present manufacturing modes, and above all to guide their improvements. It will be somewhat useful a periodic exchange of samples and analytic data with other laboratories.

3. Those responsible for the corrosion and corrosion protection research must well penetrate the fundamental electrochemistry, despite of the fact that it is a quite complex subject. By this way the best profit will be taken from the forecasted (stages at some Brazilian and foreing centers, as well as from the graduation courses.
   Some suitable books were recommended for acquisition.

4. Making sure that the discretion will be observed about any private industrial problem, the co-operation with foodpackers and packmakers must be a basic objective in all the research programs.

ACTIVITIES AND OUTPUTS

A. Background information

The majority of cans for foods and beverages is still produced all over the world from traditional tinplate, that is a thin sheet of carbon steel coated with pure tin on both faces. But when we talk about tinplate, it is necessary to take into account an evolution in industrial processes of tinplate manufacturing and in the structure and performance of tinplate as such.

At the beginning of the production and use of tinplate, relatively thick layers of tin were relied on for corrosion resistance purpose, while mechanical properties and formability mainly depend on the base steel. On the contrary, today a modern tinplate must be regarded as a heterogeneous material also on the surface. In particular, the coating weights were progressively reduced begining from the last quarter of our century for both technical and economical reasons, mainly owing to a world-wide introduction of industrial continuous electrotinning processes. However, the reduction of the thickness increasesthe layer porosity. As a consequense, when a tinplate can is filled with an acidic food, its corrosion resistance is mainly dependent on both the steel base composition and the porosity of the $FeSn_2$ alloy and tin layers.

The use of lacquered tinplate for the inside of cans allows more tin saving, but the organic films, which must be very thin for a good mechanical performance, are always characterized by some porosity and ionic permeability. Moreover, a secondary porosity may result from the can-making processes.

Generally speaking, inside a plain or lacquered tinplate can filled with an acidic food product, the corrosion process may lead to some tin and/or iron dissolution, relating to the both composition of the food and to the physico-chemical characteristics of the tinplate. This corrosion process may lead to unacceptable changes in the food and/or in the appearance of the can; in other words it determines the so called "shelf-life", defined as the maximum period of time over which a commercial pack is still considered acceptable.

In the past, a food pack was considered acceptable until being either hydrogen swelled or perforated. Nowadays, the shelf-life is defined by quite different parameters, which are related to the food quality. From the corrosion point of view, a tinplate pack is considered "failed" when the tin content in the food is higher than 150-200 ppm and the iron content is higher than the double of the initial one, according to some international recommendations. Moreover, a tinplate pack is also considered "failed" when some changes in the characteristics of the food and/or damages in the inside of the can occur.

Aluminium and TFS replaced tinplate to some extent for technical or economical reasons. Aluminium should be more expensive, but may be easly drawn and ironed to create 2-piece cans (without side joint or seam) the walls of which are very thin. This kind of can is suitable for carbonated drinks, but not for processed foods. However the 2-piece D&I cans are now also obtained from tinplate, as well as the easy-open ends, which formerly were only from aluminium. On the other hand, TFS and above all ECCS are cheaper than tinplate, but their use is limited by the less easy solding and welding and by the impossibility of ironing the ECCS are mainly used for can ends and for D&D cans. The laters must be necessarly narrow and are economically suitable only in small sizes.

The aluminium and the ECCS can be corroded by acidic foods or beverages at a greater rate than tinplate, but they are used only in lacquered form and their affinity to organic enamels is quite good.

Brazil producesper year about 450,000 tons of tinplate .The present output capacity is 600,000 tons, but will get to one milion in the next years independently upon the internal trade trend. Namely this great increase is justified by the very good export chances, resulting from the steel-making crisis in developed countries (in particular, the old USA industrial facilities became non economic). However it may be emphasized that the quality standards will play a great role in concreting this export chances.

Also the Brazilian food packaging industry can develop well besides the internal consumption increase, because of the export ; in particular that of some tropical fruit product. The quality standards and the shelf-life of these goods depends on container

characteristics as well as filling and processing tecniques, but for the most typical Brazilian products it is not available any foreing experience.

The possibility of packed product lead pickup from the side seam solder is one of the most critical points in the traditional 3-piece can. Although it is well recognized that non food sources are mainly involved in the blood lead absorption, the manufacturing of alternate cans is the forced way for the canmakers all over the world.

The D&I or D&D 2-piece cans, even if made by tinplate, are lead--free. But they cannot completely take the place of the 3-piece cans, and above all require a large capital expense for the lines installation. In Europe the 3-piece soldered cans are being quickly replaced by tinplate 3-piece welded cans. For the most part, welded can line can be the same as a soldered can line, thus the capital expense is correspondingly small. This style container appears to be the most suitable for Brazil also.

Non-metal alternative food containers require aseptic lines for processing and filling, a more careful handling, and a more rapid commercialization. Proper use of this type of containers must be supported by long term technological investigations and trade changes.

B. Short course on electrochemical corrosion

The wet corrosion inside a metal food pack may be more or less a complex process depending on the metallic material and food product composition. However the corrosion mechanism always includes an oxidation-reduction reaction at the metal/electrolyte interface. This reaction may be seen as the sum of two electrode half-reactions: The oxidation of the metal by electrons loss, and an electron-equivalent reduction of any chemical species is characterized by a reversible potential more noble than the metal oxidation one. This potential difference is the electromotive force (EMF) of the corrosion process. The corrosion rate to such thermodynamics corresponding depend on the polarization degree of the two electrode half-reactions (polarization being the potential energy dissipation in electrochemistry).

One corrosion process may be thermodynamically or cinetically activated or inhibited by little changes in metal and/or electrolyte composition. When the metallic surface has an heterogeneous composition (as tinplate and ECCS), it may be regarded as an aggregation of short circuited galvanic micro-couples. The mix-potential theory, allow to understand the effect of the reciprocal polarization between the different components of the polielectrode. A metal with a higher free-corrosion potential is cathodic and so is more or less protected by the increased corrosion of an other metal acting as preferencial anode in the couple.

The electrochemical theory of electrode reactions permitted the development of some rapid tests for evaluating the corrosion process of electrode electrolyte systems and for determining their corrosion current values too. Coulombmetric, potentiostatic, and potentiodynamic polarization techniques are commonly used. Impedance analysis through a.c. polarization was available more recently.

Inside a food can the first days after filling are characterized by a fast corrosion rate, owing to the cathodic depolarization effect of the initial content of oxygen. When this activator has been completly reduced by the food product oxidation and by the corrosion process itself, the corrosion rate maintains at a much slower value. Nevertheless, corrosion current differences as low as few nA/cm^2 may cause considerable differences in the pack shelf-life.

For evaluating the compatibility between a food product and metal can, packaging tests give a direct shelf-life measure , but they are very time and money consuming. On the other hand, conventional electrochemical tests are carried out with experimental conditions quite different from that inside a food can, giving current values ten or hundred times larger.

In the past years the writer developed a potentiodynamic test which, by using a hermetically sealed cell with a high metal surface to electrolyte volume ratio, showed a very good simulation of the corrosion process in the inside of food and beverage cans. The test allow to compare the corrosion resistance of different lots of metallic material and/or the aggressiveness degree of various kinds of filling products. The corrosion resistance may be measured for metal samples plain or laquered. But for the laquered ones is now in developmenta new a.c. polarization test, by using a Transfer Function Analyser, that appears very promising for protective layers investigations.

The short course on electrochemical corrosion was presented during 20 h from 7 to 25 May.

Without a previous knowledgment of electrochemistry and solid-state fundamentals, the presented matter is difficult to understand Neverthless, the MPL' technical staff showed an active participation.

C. Operation of the new electrochemical apparatus

The AMEL-Metalloscan is composed of a Potentiostat/Galvanostat unit, a Function Generator, an Electrometer, an Interface with linear and log ranges, a Y/t-Y/X Recorder. After the installation, only a very easy setting of the electrostatic paper holder was required.

The Metalloscan being a versatile apparatus, various electrochemical tests were experimented together with the MPL' technical staff.

In the galvanostatic mode, the apparatus may be used as an accurate coulombmeter for measuring the free-tin and alloyed-tin layers in tinplate, as well as for the metallic chromium one in ECCS samples. This allowed the proper settling of an automatic chromium measuring device (named Chromatic), which before could not be used. The coulombmetry of chromium in the very thin passivation layers of tinplate was also attempted, but without a further operative conditions adjustment only a qualitative evaluationmay be attained.

In the potentiostatic mode, the Metalloscan can be well used for IEV measurements (Iron Exposure Value test, presented by M. Tsurumaru and others at the II International Conference in London, 1980). The test was proved to be very suitable for the quality control of plain or lacquered tinplate sheets, cans, ends, and caps. During the mission was also found that analogous tests can be developed for the tin exponsure in lacquered tinplate, the iron exposure in plain and lacquered ECCS, and the metal exposure in lacquered aluminium.

In the potentiodynamic mode the apparatus was extensively used for PR (polarization resistance) and corrosion current measurements, by using the cell and the operative conditions previously developped by the writer. Some experiments were carried out for testing the corrosion resistance of several plain tin plate samples, as well as of 4 different side stripe coatings in samples cut off from welded cans. It resulted that the tinplate corrosion process may be very different for the same trade specifications too. Moreover was possible to find that the epoxy side stripe is highly protective, while the efficiency is lower in the order for the organosol, acrylic, and epoxy-phenolic enamels. It must be pointed out that the epoxy enamel was applied in powder, and

the others were solvent-based. The organosol performance, a good protective effect at the first which progressively decrease by the time, is probably due to some water absorption with consequent ionic conductivity.

At the end of the practical training, three members of the MPL were able to carry out autonomously the described electrochemical experiments.

D. Seminar on metal packaging

The expected CETEA development concerns the applied research in the field. The Center will act as an interface between academic knowledges and food packaging and packaging industries practical problems. A critic part in this role is the know-how transfer function. The Center must be able to draw out the main common needs from particular firm experiences. Possible solutions may be selected by means of technical and economical analysis., well evaluating previous experiences carried out in other countries, but always looking to the more general national development policy lines.

The seminar was organized for industrial technicians with the main to expose the new MPL facilities and work programs. This task was well accomplished by the MPL responsible.

The expert presented information on the 3-piece welded can as the european canmakers answer to the in food lead content regulamentary enforcement actions. Some information about the welded can manufacturing and usage were given, as well as suggestions for reducing the food lead migration in the soldered can. The expert also presented the electrochemical tests now carried out in the MPL and their relevance respect to industry problems.

The participation of members from all the interested industrial branches has been very encouraging. Positive suggestions on the topics under discussion resulted from the informal talk session, proving that the work programs well fit with industrial exigences.

E. Seminar on food processing and packing

For the same raw products being used, the shelf-life of a processed food is very dependent from the industrial operations, as well as storing and retail conditions. The first affecting the initial quality grade, and the others the quality degrading rate. However the container plays a quite important role.

An informal seminar on the latest development in food processing and packing was presented to the CETEA technical members. The discussed topics may be syntetized as follow:

- Thermobacteriology fundamentals and sterilizer equivalent effect calculations.
- Sanitary and commercial security levels and heat penetration measurements and calculations.
- Processing conditions scheduling, as related to food product and manufacturing characteristics.
- Reducing the adverse effect of the heat treatment for the same sterilizer equivalent effect, by rotating retort or flat container HTST processing.
- Aseptic processing and filling in metal, plastic, and composite containers.
- Storage temperature and oxygen permeability dependence of the processed food shelf-life.

The seminar was presented during 6h in 2 days.

F. Appraisal of the main projects

By means of separate talks the expert critically examined the MPL projects, as well as those of the other CETEA laboratories pertaining the food products shelf-life. These work programs can be summarized in the following way:

- One year over investigation on the corrosion resistance and other surface characteristics of the Brazilian tinplate, by using conventional and electrochemical tests.
- Investigation on the lacquer peformance (enamels protective behaviour), as depending by composition and laquering conditions. These evaluation will be carried out by means of conventional and electrochemical tests.
- Development of some laboratory tests for assessing the passivation film composition in tinplate.
- Appraisal of welded cans from Brazilian metallic and lacquering materials and their compatibility with Brazilian typical food products.
- Test methods development and standardisation for glass pack closings hermeticity.
- Shelf-life evaluation for processed non food products packaged in aluminum containers.
- Determination of the differential pressure limits in thermal processing of aluminium packed foods.
- Shelf-life of some representative food products in ECCS containers.

The expert approved all these projects with only marginal adjustment, and well appreciated the general effort accomplished to involve the related industries from the planning phase itself.

G. Other activities

The expert visited a canmaking industry and discussed with the marketing and quality control managers about the welded can and the related MPL project.

A direct contract with members of the Brazilian steelmaking industry was possible the day before the Seminar for external participants. In this contact was proposed the active participation of the tinplate producer in the tinplate corrosion project.

The expert helped the MPL staff in the assistence to a canmaker for a lacquer adherence problem in processed meat cans.

The expert delivered to the MPL staff copies of the following transparencies prepared during the mission:

- N. 27 relating to the electrochemical corrosion course;
- N. 12 relating to the metal packing seminar;
- N. 35 relating to the food processing and filling seminar.

H. Conclusions

Despite of the very short time, the mission was accomplished in all the scheduled duties with relevant outputs.

This was possible due to an uncommonly efficient organization and the good working ability of all the MPL members.

The expert can point out that a great development was performed at CETEA, since the 1982, and not only related to building and laboratory facilities.