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DP/ID/SER.A/698
20 May 1986
English

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

DP/BRA/82/030

BRAZIL

Technical report: Food packaging material - metal 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 Jochen Hollaender
Expert in food packaging material - metal packaging

United Nations Industrial Development Organization
Vienna

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ABSTRACT

Consolidation of the Existing Capacity of the Institute of Food Technology through the Creation of a National Food Packaging Centre. Project DP/BRA/82/030/11-02/B/31.7.E

The report concerns the mission of UNIDO consultant Jochen Hollaender on metal packaging. The work was performed at the Food Packaging Centre (CETEA) in Campinas (S.P.) from June 28th to July 26th 1985.

The consultant presented seminars and short courses concerning the use of metal packaging for food products. Recent developments in material production, container fabrication and testing were discussed in detail. Special attention was given to welding of cans, properties of lacquers and interactions between food and container material.

In addition an external seminar was performed for participants from several related industries to discuss the main developments.

During the mission material producing, can making and filling industries have been visited to discuss actual problems and developments.

Laboratory work was mainly concentrated to the introduction of several test methods, especially concerning lacquer and can testing.

Running project work was thoroughly discussed. Suggestions were made concerning future project work and needs on complementary equipment.

The consultant recommends to continue the projects of applied research involving the related industries to the benefit of the country.

1. INTRODUCTION

1.1. Job description

Project: DP/BRA/82/030/11-02/B/31.7.E
Post title: Expert in Food Packaging Material-Metal Packaging
Duration: One month June/July 1985
Duty station: Campinas (Sao Paulo), with travel as required

Purpose of the project:

To create a Packaging Centre (CETEA) through the Institute of Food Technology (ITAL) in Sao Paulo with the support of the Federal Agricultural Ministry and the State Agricultural Secretariat in order to increase and ensure sufficient food supplies to the country's population and to increase the export of processed foods, given the rich endowment of agricultural land coupled with the need to alleviate its problems relating to the Balance of Payments.

Duties:

The expert is expected to work with the technical staff of the Centre under supervision of the Project-Coordinator in order to

- organize short courses and internal seminars to the use of metal packaging for food products;

- undertake an appraisal of the existing equipment and projects in this area and elaborate a series of suggestions concerning the need for complementary equipment and new projects to be developed in the future;

- analyse and improve the test methods for metal packages in order to enlarge the capability of CETEA to assist the metal food packaging industry;

- visit the main food and packaging industries in this area in order to detect the main problems;

- organize short seminars and talks to the food processing and packaging industry regarding the most important progresses in this field.

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

Qualifications:

Packaging technologist, with university degree or equivalent experience. Professional specialization in metal packages for food and related laboratory testing.

Languages:

English (Portuguese an asset)

1.2. Background Information

1.2.1. Institutional Food Packaging Research at ITAL

In 1963 the ITAL started its activities as a "Laboratory of Technology" and was established as "Tropical Centre of Research on Food Technology" in 1964 by an agreement between the Brazilian Government and the United Nations Development Programme (UNDP). First research activities have been restricted to the technology of vegetable products, but from 1969 on the research has been gradually extended to products of animal origin, namely diary products, meat and fish. Since its establishment the ITAL has acted as the leading research institution in the country.

The institute was the first institution in the country engaged in pioneer research and technical assistance to the food packaging industry. The Food Packaging Section received further priority in 1969 and its development was aided by national and international institutions.

Since 1982 the activities and facilities have been expanded to put into operation a Food Packaging Centre (CETEA) under the sponsorship of the Government of the State Sao Paulo, the Brazilian Government (FINEP-EMBRAPA) and the UNDP through the United Nations Industrial Development Organization (UNIDO).

The main objective of the Food Packaging Centre is to support the packaging and food industry in Brazil and also to serve as an international training centre to assist Latin America and other countries in this technological matter.

The UN/Brazil Food Packaging Centre project BRA/82/030 attempts to optimize the facilities existing at the ITAL to follow the demands of modern packaging technologies. It was initiated 1982 for a duration of 5 years. Because of limitations in national expertise and equipment international technical assistance is regarded to be an essential contributing factor.

According to the importance of metal packages a metal packaging group was built up within the internal structure of CETEA.

1.2.2. Metal packaging in Brazil

Demands for packaging materials are growing with present annual rates around 4 % closely connected to the growth of urban population.

In 1982 the Brazilian packaging industry was valued at about 3,800 million US$, equivalent to nearly 1,3 % of the gross national product. The total consumption of packaging materials reached about 3 million tonnes, ~ 50 % are used for food packaging.

Metal packaging materials take a market share of around 30 % by value and around 20 % by weight. About 75 % are used for food packaging. The consumption per capita shows remarkable differences. Compared to the total average the economically active population has a 4 times higher consumption.

In Brazil steel based packages play a dominant role by 97 % (tonnage) compared to aluminium. Though aluminium (3 %) seems to be undervalued because of its lower density (volume share ~ 9%), the comparison to world averages (~ 8 % by weight) reflects the importance of steel packaging.

Whereas aluminium food packaging mainly concentrates to the manufacturing of closures, lids, crimped caps, foils and laminates, steel based materials like tinplate, black plate and chromium coated steel (tin free steel, TFS) are involved in can making (90 %) and closure production (10 %).

Due to the traditional high share of vegetable oil cans (about one third of steel based cans) black plate takes a considerable part (18 %) in steel packaging compared to TFS (7 %) and tinplate (75 %).

In 1982 around 3,500 million cans have been used for food products (55 %), vegetable oils (33 %) and beverages (12 %).

2. GENERAL ASPECTS

2.1. Technological features

Steel cannot withstand food aggresivity without protective layers. The production of can material includes a lot of different surface treatments to obtain a sufficient quality. Common processes are tinning, passivation and coating by chromium containing layers and lacquering by natural or synthetic organic polymers. Without organic polymers only tinplate with a sufficient high amount of tin (above 7 - 8 g/m²) can be used for liquid food products.

Aluminium exhibits a natural protective oxide layer, but its stability is only restricted to a pH-range between 4,5 and 8,5. Due to this fact and the possibility of local destruction of the layer aluminium has to be protected by organic polymers to guarantee a long-term resistance.

The application of organic lacquers can be done by coil or sheet coating or by spray processes. To remove lacquer solvents and to achieve a resistant polymer of good adhesion to the metal surface a thermal treatment (curing, stoving) is necessary. With tinplate the maximum temperature is limited to around 210°C, with aluminium there are higher temperatures around 300°C and shorter curing times possible. The dry film weight of the lacquers ranges between 2 and 15 g/m². Different types of lacquers are used depending on the availability of raw materials (natural or synthetic), demands of can making and product compatibility. Actual trends point to synthetic polymers of epoxyphenolic, vinylic and acrylic types.

In the field of rigid containers steel based material have clear cost advantages compared to aluminium.

The stability of cans during processing, transport and retail distribution has to be considered as one of the most important factors in canning practice. Developments point to further steel material reductions in combination with special can wall beadings and base material variations (hardness).

Can manufacturing can be divided in two principal sections, seaming techniques and forming processes.
Seaming leads to 3-piece cans (body and 2 ends) and can be done by soldering, welding or cementing.
Soldering is restricted to tinplate; minimum amounts of tinning around 2 g/m² are required. The solder composition (tin/lead) ranges from pure tin (100/0) to nearly pure lead (2/98), the latter one is required for high speed soldering.

Welding of can bodies developed to a high speed process within the last years. With tinplate further savings of tin below 2 g/m² are possible, the use of toxic lead is avoided. The security regarding to leakages during and after closing operations of cans is enhanced. There is a clear tendency to replace soldered cans by welded ones, this step is performed in many industrialized countries now.

Cementing of can bodies is achieved by the use of thermoplastic natural or synthetic rubbers and adhesives. Because of the lower stability of the seam cementing is not suitable for processed food cans, but there are developments to overcome this problem in some applications (sterilizable cemented TFS cans).

Inside seam protection by organic polymers is an essential need for welded food cans and many types of soldered cans. The protective efficiency depends on polymer types and application modes. Concerning welded cans there is a clear tendency to electrostatic spray application of polyester or epoxy based powders, which gave a complete seam protection after melting by a localized heat treatment.

Forming processes lead to seamless can bodies. The 2-piece can (body and top end) is manufactured by drawing operations (drawing and redrawing) or in a multistep operation (drawing and wall ironing).

Wall ironed cans made of tinplate or aluminium exhibit a reduced wall thickness (material savings). The use is restricted to pressurized products (e.g. carbonated beverages). The possible introduction of pressurized food cans by addition of liquid nitrogen during filling will not allow a clear jugement by fillers or consumers, whether cans are spoiled by microbiological reasons or corrosion swell. This fact is regarded to be an important disadvantage.

Can manufacturing by drawing requires large capital investments. Proper premises are given only by a high demand of a single container type.

2.2. Food/Container Interactions

Today the shelf-life of canned products is related to quality parameters, which include natural quality changes of the products (decrease of sensorical properties like flavour, colour, textur or degradation of nutrients) as well as possible influences by the container material.

Specification and performance of cans, food properties, filling and processing conditions, time and temperatur of storage determine the extent of interactions between food and container material. These interactions may contribute to a limitation of the shelf-life by different ways.

Tin dissolution to an unacceptable amount is possible with unlacquered cans only. Earlier accepted maximum levels of 250 mg tin per kg food nowadays aiming to the range of 100 - 200 mg/kg. Consequently there is a need to take more care on the corrosion resistance of tinplate, on the overall food aggressivity and some special corrosion accelerating food components, on filling, processing and storage conditions.

Lead uptake from soldered cans is regarded to be one of the most critical problems. Beside the fact that lead contaminiation of food may result from other sources, all efforts should aim to minimize this type of interaction. Lead corrosion is restricted to some extent in unlacquered cans (electrochemical reasons) and by the use of mainly tin containing solder, but not in lacquered cans without effective side seam protection. The control of can making practice and testing of cans concerning the lead delivering properties is an essential need.

The use of inside lacquered cans and lower tin amounts on the steel surface support the possibility of localized corrosion mechanisms, which result in iron uptake. Beside the possibility of earlier damage by hydrogen swell or perforation of the can wall iron corrosion is able to affect the taste or colour of the canned product. The level of acceptable iron depends on the sensivity of the product ranging between 0,5 (beer) and more than 100 mg/kg (spized food). Can performance, especially side seam protection, and product aggresivity towards iron have to be balanced.

To minimize interactions between can protecting lacquers and food the applied lacquers must fulfill recommendations concerning the food compatibility. In industrial practice the suitability and many protection properties depend on proper curing conditions. From undercured lacquers migration of residual solvents or lacquer components, which are formed by hydrolysis during processing, may affect the product. The control of curing conditions and testing of lacquered cans on the curing state are important measures to avoid problems in the canning practice.

Outside corrosion of cans is a phenomenon, which may have bad influence on consumer's opinion about the shelf-live of cans, and will result in refusing. This type of corrosion may be created just after production or after relatively short storage time by unfavourable materials, processing or climate conditions. Because of the great economic consequences this problem deserves special attention.

3. WORK PERFORMED

3.1. Working Programme

According to the job duration of one month the mission allowed a stay at the duty station in Campinas from June 28th 1985 to Juli 26th 1985. Stopovers for briefing and debriefing in Rio were not required.

General introduction to the project work was given by the Project Co-ordinator Mr. Luis Madi. The detailed working programme was settled in collaboration with Mr. L. Madi, Mr. R. Soler and Mrs. S.T. Dantas according to the described job duties.

All duties were carried out and the main activities are summarized as following.

3.2. Internal seminars and short courses

Subjects related to the use of metal packaging have been presented from July 11th to 22th 1985 during 22 h.

a. Can material characteristics
   - base materials
   - properties and testing
   - surface characteristics

b. Body making
   - developments
   - welding processes
   - welding seam characteristics
   - wall ironing of tinplate

c. Lacquers
   - types and application
   - seam lacquering
   - lacquer properties
   - lacquer testing

d. Corrosion
   - fundamentals
   - mechanisms

e. Interaction between can and product
   - changes
   - corrosion acceleration
   - lead corrosion

f. Can testing
   - methods
   - ultrasonic method
     - fundamentals
     - applications

g. Special features
   - quality retention of food
   - processing
   - aseptic canning
   - outside corrosion
   - paper label testing
   - aluminium corrosion

All topics have been discussed in very details with the technical staff of the CETEA.

A summerizing manuscript of 72 pages including formulas, tables and diagrams has been submitted for internal use.

3.3. External seminar

The seminar was organized to inform the food processing and packaging industries about recent developments. It was held on July 25th 1985 during 6 h in two sessions entitled

- The importance of varnishes concerning interactions between can and products.

- The reality of welding technologies in can making.

3.4. Laboratory work

Existing equiment was found in an optimal condition to perform experimental work and training of the staff members. Improving and introducing of several test methods have been substantial parts of the mission.

Sample testing included comparative testing of foreign material (German origin) submitted.

Main subjects:

- preparation of free films from lacquered tinplate for IR-identification (Hg-Method)

- lacquer weight estimations from different metallic substrates

- lacquer curing state evaluation by controlled dry heating tests

- curing state evaluation and sterilisation resistance of lacquers by gravimetric methods

- direct estimation of specific migrates (phenolic compounds) in sterilized solutions by UV-detection (trace method) and calibrations

- porosity testing of lacquered sheets and cans

- introduction of the ultrasonic method for electrochemical indication of the corrosion state of cans and can materials; application to
  - early detection of localized corrosion processes
  - breakdown of passivation properties of chromium coated material

  (additional testing cell submitted)

- principle testing device for measuring coupling potentials and low level coupling currents

- principle testing device for electrochemical evaluation of welded seam properties by point potential measurements

- paper label testing

All subjects have been worked out by active participation of the members of the metal packaging laboratory (MPL).

3.5. Visits to the industry

The following industrial companies have been visited:

can material producer

Companhia Siderurgica Nacional (CSN), Volta Redonda, R.J.

can manufacturer

Metalurgica Matarazzo, Sao Paulo
Metalurgica Prada, Sao Paulo
Paoletti, Cajamar, S.P.

filling companies

Paoletti, Cajamar, S.P.
Primo Sohincarol, Itu, S.P.

The visits included round table discussions with the marketing and quality control managers and members of the technical staff.

Main topics:

- developments in can making art
- quality control of cans and material
- lead problem
- lacquer properties
- iron uptake
- welding of cans and seam protection
- collaboration with CETEA

In addition special impressions have been discussed at CETEA/MPL after visits.

3.6. Appraisal of existent equipment and project work

Existing equipment at MPL and common used equipment within CETEA was found in optimal condition to perform scientific as well as applied research. The working facilities and the capabilities of the MPL members represent a high leveled ability to assist the related industries in basic developments and actual problems.

The existing lacquer curing facilities have to be rearranged to guarantee a better exhaustion of volatile solvents.

The running projects have been discussed and critically valued in separate talks. The project work can be summerized as following:

- Comprehensive studies on the corrosion resistance of Brasilian tinplate by conventional tests and electrochemical methods

- Comparative investigations of tin dissolution in unlacquered cans by fruit products under controlled storage conditions and correlated electrochemical in-can measurements

- Analysis of lead content in food from soldered cans facing the lead problem in relation to can performance

- Analytical and sensorical investigations concerning the dissolution of iron by localized corrosion in lacquered beverage cans

- Development of laboratory tests for the routine evaluation of oxide and passivation films on tinplate in relation to lacquer adhesion problems

- Improvement and standardisation of porosity test methods for industrial testing of cans

- Investigation of protective lacquer properties depending on composition, lacquering conditions and metal substrates

- Suitability of lacquered containers for water packing

- Evaluation of welded seam quality depending on material and welding conditions.

The project work reflects to actual problems and needs. During project discussions some methodical aspects have been added. The interpretation of electrochemical results in relation to the practical behaviour of cans was thoroughly checked.

There is no doubt that the gaining experience of this group will contribute to the development of metal packaging in Brazil and Latin America. It is well noted, that the efforts aim to involve the related industries in project works.

4. RECOMMENDATIONS

4.1. Equipment

Though the MPL can be regarded as well equipped for routine and more detailed investigations to assist the food packaging industries there are some essential needs for further equipment:

- stereo-microscope (variable enlargement) suitable for non-transparent objects and metallographic studies, equipped with a camera

- "cold light" source with flexible light tube in combination with the microscope

- device to finish metallographic samples

- electrically powered laboratory retort to simulate sterilisation stress to can material (especially lacquers) and to perform controlled medium-term pack tests on laboratory scale

- surface roughness test equipment to evaluate surface properties in relation to corrosion problems and machinability of materials (suitable Hommel tester)

- microbalance with 0,01 mg resolution (suitable Mettler) for detailed gravimetric studies

- low resistance amperemeter (suitable Keithly) for easy measurements of very low coupling currents to evaluate corrosion mechanisms, or suitable multimeter

According to more detailed research in future the avail ability of a Scanning Electron Microscope is suggested. This equipment easily can be extended to X-ray microanalysis, which offers a lot of detailed information by chemical analysis of surface compositions.

Most of the recommended equipment is of general benefit to all CETEA working groups.

4.2. Project work

The MPL members have to continue electrochemical work on base materials. Gaining experience will lead to a tool of modified applications to actual problems and will offer presuppositions to improve present manufacturing modes. Detailed knowledge of the fundamentals of electrochemistry is essential.

Testing experience concerning physical properties of base materials and metal surfaces and metallurgical knowledge have to be extended. Especially the collaboration with CSN laboratories is recommended.

According to the present state of metal packaging and foreseeable developments the project work has to include:

- Development of a standard test method to estimate the lead delivering properties of cans. A comprehensive study of different can types and performances will give a distinct picture of fabrication measures to minimize the problem of lead corrosion.

- Applications of ultrasonic aided electrochemical measurements to
  - characterize early states of corrosion processes in cans
  - evaluate the corrosion behaviour of can materials
  - characterize the aggressivity of different food products
  - study the corrosion accelerating behaviour of various food components.

- Studies of iron corrosion in lacquered cans and related sensorical effects (food sensitivity).

- Evaluation of the curing state of lacquered materials and cans in relation to sterilization resistance and migrate delivering properties.

- Investigation of outside corrosion problems and contributing factors.

- Studies of the corrosion behaviour of welded seams.

5. CONCLUSIONS

There are clear tendencies in the field of metal packaging concerning further developments and coming problems:

- Lead free cans, welded or made by drawing operations, will substitute traditional soldered ones.

- Material savings point to the increasing importance of lacquers and their protecting properties.

- Material savings touch to the limits of can stability

- Quality of canned products will depend more on can performance and filling practice because of iron corrosion and possible negative effects.

- Export rates of can material and canned products depend on the level of quality.

Brazilian industries related to metal packaging and engaged in export activities have to consider the international trends. The steel and tinplate production is appraised to have a solid base allowing more export activity. But the flexibility to react on changing demands in quality has to be extended. Improved quality assessment and quality control will contribute.

The economic situation of can makers will not allow very rapid technological changes.

Investments in direction to advanced can making have to concentrate first in the field of export packing. But even for traditional types of cans a lot of improvements are possible including improved canning practice to obtain high leveled product quality.

The indigenous market situation concerning metal packaging seems quite stable. Consumer trends to convenience and self service will contribute to a positive development. However, improvements of various steps in handling, retail distribution and displaying are nessecary.

A medium-termed appraisal faces the activities of CETEA/MPL in connection with comprehensive assisting work to improve the existing metal packing practice. Nevertheless there is a need to work for the coming technological changes in this field (e.g. food can welding).