TECHNOLOGICAL MANAGEMENT APPLIED IN IRRADIATION OF FOODSTUFF

Ghobril, Carlos N.[1,2]; Sahyun, Adelia [2,3]**; Sordi, Gian-Maria[2,3];**
Perez, Clarice F.A.[(4)]; Del Mastro, Nelida L.[3]

[1]Instituto de Economia Agrícola - Governo de São Paulo – IEA, São Paulo, SP, Brasil
nabil@sp.gov.br
[2]ATOMO – Radioproteção e Segurança Nuclear S/S Ltda, São Paulo, SP, Brasil
[3]Instituto de Pesquisas Energéticas e Nucleares – IPEN-CNEN/SP, São Paulo, Brasil
[4]Centro Tecnológico da Marinha em São Paulo, - CTMSP, Brasil

ABSTRACT

This paper presents research that is focused on technology management applied to the technical and economic viability for the installation of a multipurpose irradiator in Vale do Ribeira (Sao Paulo state). The regional characteristics and the emergence of irradiation techniques applied to the food industry together with concepts of technology management are included. The methodology uses bibliographical, qualitative and quantitative research, with analysis supported by statistical and economic techniques. The research concludes that the introduction of irradiating foodstuff is technically and economically viable and recommended that more studies about banana irradiation and Brazilian consumer acceptance to irradiated food is carried out.

Key Words: foodstuff irradiation, banana sterilization, budget in foodstuff irradiation

1. Introduction

The rapid growth of world population and consequent increase in food demand have led to a need to improve technologies to ensure safe delivery of food supplies. The difficulty in addressing a wide range of international quality standards has been more a limiting factor to the free trade among nations which aggravates the global balance with respect to the supply and demand for food. Developed countries have been demanding more sophisticated products not only in quality but also diversity, pushing the market to offer products on very elaborate forms of presentation and appearance. Food, besides the function of nurturing also has a cultural and symbolic role, and its appearance can influence its acceptance by the consumer.

The radiation processing of food can prevent the proliferation of microorganisms that cause food spoilage, such as fungi and bacteria by changing its molecular structure. However such processing, may also slow down the ripening of fruit and certain vegetables by altering the physiological processes of plant tissues. The irradiation of food can increase the shelf life of many foods at competitive costs, while providing an alternative to using fumigants and chemicals, many of which leave a residue [1].

The possibility that products generated during irradiation could be harmful to health has long been an obstacle to the acceptability of foods subjected to irradiation. However, the World Health Organization (WHO) issued a 1999 document in which it is established there are no harmful health effects in irradiated foods even when exposed to high doses [2]. The Joint Expert Committee on Irradiated Foods, formed by experts from FAO (UN agency for food and agriculture), WHO and IAEA (International Atomic Energy Agency), concluded in 1980 that irradiation of any food with a average total dose of up to 10 kGy presents no risk or require additional toxicological tests. It also stated that even the maximum dose does not generate nutritional or microbiological problems [3].

Beside the methods and techniques of processing and food preservation, irradiation technology has been increasingly used in pursuit of improvements in quality and productivity. Although unknown to most of the population, research on food irradiation dates back to the early twentieth century, with the first American and British patents being granted in 1905 for the use of ionizing radiation to kill bacteria on foods [4].

Food irradiation facilities do not accumulate radioactive waste. The food irradiators, in the form of electron accelerators, use electricity and do not produce radioactive elements. The range radiators using radionuclides as an energy source, Cobalt-60 or cesium-137, which decay becoming nickel and barium, both are non-radioactive. The activity of these sources decreases with time, and are typically recharged when activities reach between 6-12 percent of the initial level. Radioactive materials that feed the radiators are transported in sealed capsules that are designed, in accordance with international standards developed by the IAEA "Regulations for Safe Transport of Radioactive Materials." Large amounts of materials are sent safetly and securely to supply approximately 200 irradiators installed around the world, which are used to treat a variety of products. Over a 20 years period, approximately 190 million Curies of Cobalt 60, in 870 separate shipments from Canada, were completed without any radiological risk to the environment or release of radioactive materials. This excellent safety record of transport, also seen in the United States (U.S.) and other countries, far exceeds those of other industries that perform transportation of hazardous materials such as toxic chemicals, oil or gasoline [3].

It is interesting to note that concern about food safety has been progressively increasing worldwide, especially in developed countries, raising more discussion about irradiated food, to the extent that more than ever the characteristics and advantages of irradiated food is publicized and studied [5]. The consumer has developed over time to become more discerning when choosing food, preferring products judged to be safer. According to recent research, consumer behavior is changing in the U.S. in relation to irradiated food and a significant opening of the market for such products is expected. This change is related to the growing number of cases of diseases caused by bacterial contamination, which has attracted the attention of consumers, researchers and authorities to technologies which provide food security. Diseases arising from

food represent a great risk to human health and are a major cause of reduced economic productivity, and increased costs associated with medical treatments derived from such diseases. Irradiation can help in controlling these pathogens, and more information on the benefits to consumers will increases the acceptability of irradiated food products.

The FAO estimates that about 25% of food produced worldwide are lost after harvest due to the action of insects, bacteria and rodents. Accordingly, irradiation can contribute to the reduction of these post-harvest losses and reduce dependence on chemical pesticides [4]. In developing countries, it is expected that this loss is much higher than the average international standards with up to 50% of food products perishing rapidly, especially in hot climate countries. There are also problems of inefficiency associated with the storage and transportation systems together with Epidemic control deficiencies in agriculture, such as fresh fruits such as bananas.

Decisions to irradiate food were influenced by the adoption in 1983 of an international standard dealing with irradiated food adopted by the Codex Alimentarius Commission, a joint body of FAO and WHO, responsible for issuing regulations on food to protect consumer health and facilitate sound practices in food trade. The interest in the irradiation process is growing, due to large losses of food by infestation, contamination and deterioration, in addition to frequent quality restrictions imposed on international trade that will increasingly demand higher food quality and good presentation. In addition, there are phytosanitary restrictions imposed by importing countries, with the increase of restrictive regulations or total ban on the use of chemical fumigants used to control insects and microbes in food [4]. The irradiation process is not able to solve all the problems of food preservation, it cannot turn rotten food to fresh healthy food, and it is not suitable for all types of food, but it can solve specific problems and complement other food industry technologies

The acceptance of irradiated foods by the consumer in general is a complex issue, encompassing social, legal, cultural and, above all, accurate information. There is, by a large part of society, the false impression that irradiated foods would not be well accepted, because there would be a natural aversion of the people about everything involving radioactive material which is often associated to the nuclear industry. The response of populations which have been offered irradiated products does not support this assumed perception. Several studies conducted in the U.S., Europe and other parts of the world have shown good results and indicate a growing acceptance of irradiated foods, provided they have been offered to consumers with the information concerning the security and quality of food [6].

2. Methodology

This research was aimed at evaluating the technical and economic feasibility of installing a food irradiator in the Ribeira Valley. To achieve it, methodological procedures have been established through literature review, field research and economic analysis and statistics.

The work raised many obstacles that had to be overcome. Regarding the theoretical framework, limitations arose from the difficulty of systematization of information regarding some issues of this study. Often there was more than one view on the issues and these were sometimes qualitative in nature, sometimes complementary but often conflicting. Regarding field research, operational difficulties come from the lack of respondents in relation to the issue of food irradiation and even in relation to technology management.

The methodology used to determine the economic feasibility of installing a food irradiator in the Ribeira Valley was one of determining the internal rate of return on investment, with estimated costs and revenues according to criteria that attempted to capture the potential conditions prevailing in the area.

Information about the cultivation and marketing of crops of banana and tea were obtained through research by the Institute of Agricultural Economics. The EDR of the Secretariat of Agriculture and Supply of São Paulo in the registry, which is responsible for the Ribeira Valley and with the Secretaria de Defesa Agropecuária, MAPA. International trade figures were obtained from the United State Department of Agriculture, USDA and FAO. The vectors of production, market prices and still considered took into account interviews with producers and researchers, and predicted the actual conditions to establish the costs and revenues associated with this activity.

The required study of the costs involved in setting up a food irradiation facility, as well as possible revenue, was conducted through interviews with producers, exporters and researchers, and quotes with key suppliers.

Scientific knowledge is largely unknown [7]. To address the complexity of the model and the relationships between its components, as well as details of the competitive environment that is investigating, a strategy was developed from field research in two distinct macro level stages:

- An exploratory stage, with the overall objective to understand the logic that drives the competitive strategies of companies in the industry and its interaction with the priorities of their markets;
- A descriptive confirmatory step, with the aim of searching directly with the producers of the Vale do Ribeira, characteristics of their production and deployment prospects of technology management as a tool in the pursuit of regional development.

In this context, development of methodological procedures of this scientific work, divided into two essential and complementary components: (1) statistical analysis of surveys, and (2) the analysis of technical and economic feasibility of the project [6].

As prerequisite statement, the research was conducted under the first exploratory qualitative approach, followed by a stage of field research and quantitative analytical descriptive. The reality is that if you want to conceptualize multiple and complex issues, it requires a variety of different techniques to establish the information.

In exploratory research, we investigated in greater depth and from a qualitative analysis, several themes related to this work, such as irradiation, the potential of the Ribeira Valley, characteristics of banana production, domestic and foreign markets of banana, technology management, legal and environmental aspects, seeking to understand the interactions between the variables in the research model. This step led to a conceptual validation of the data produced in the literature review and subsequent refinement of the operability of its constructs.

In the next stage of field research techniques were used for quantitative analysis. To obtain the data, we used the method of cross-sectional survey, characterized by gathering information with a sample of the population suitable for descriptive studies used to determine the degree of association between variables [8, 9].

Data analysis was performed using the non-parametric statistics, verifying associations between key constructs and their relative importance in relation to technology adoption.

The research strategy assumes that the qualitative and quantitative methods are not opposed nor mutually exclusive, although they differ in shape and emphasis but complement each other in order to reveal the fullest extent possible, the connection of the variables involved in terms of why and how they occur and if this is as a result of their interaction. The combined use of these two methods makes the research more robust because it reduces the effects of specific problems associated with each method if used in isolation [10].

A key aspect of qualitative research is the representativeness of the data. The most important thing is not to obtain a large number of people or cases because it assumes that every manifestation of this phenomenon is an invariant aspect that makes this phenomenon and is assumed distinct from other procedures and research aim to reveal. The criterion should be the search for representative data, ie the selection of subjects and contexts in which the experience of the phenomenon being studied is to occur [11].

The interviews were conducted with the theoretical basis, seeking to exploit the intelligence experts in the elucidation of the incompatibilities and inconsistencies found in the literature.

Data analysis was done using the technique of content analysis, from the perspective of semantic analysis, ie, which seeks to obtain units of meaning: "This is not to cross to achieve significant meanings … but achieved through meaning or significance (manipulated), other meanings "[12].

Like any other food processing, irradiation adds costs. The estimated costs of implementing this technology with the goal of pest insects are estimated between 0.50 and $ 5.00 per ton. However, irradiation also brings benefits such as lower losses, earnings quality and, often, open markets with the improvement in the quality of the food [13]. The loss reduction alone can offset the costs of treatment.

It became necessary to complete a thorough study of all direct and indirect costs involved in setting up a irradiation facility, as well as its revenue such as: considering the possibilities of

breakage, maintenance costs, adversity of any sort, considering that an installation of this kind will provide long term aggregated economic and given that the economic use and societal need for food irradiation is increasing and therefore becoming more financially viable. All these aspects should be considered in a cost-benefit analysis, determining the feasibility or otherwise of this investment compared to alternative investments available, according to the economic concept of opportunity cost. This financial analysis was made based on criteria for comparing the internal rate of return on this investment over the hurdle rate from domestic and international aspects associated with risk.

The analysis of technical feasibility was based on literature review and interviews with researchers. The evaluation criteria must necessarily examine the technical feasibility, economic viability and relevance in relation to legislation and regulations.

3. Conclusions

The main conclusion of this study indicates the technical and economic feasibility of the project, although more specific studies are recommended on the irradiation of bananas and the Brazilian consumer acceptance of irradiated foods.

The survey addressed a current and relevant, as demonstrated by the eloquent expressions of the group of respondents who expressed great interest in the subject.

Although the legislation of several countries allows the irradiation of food and there is vast scientific knowledge in the subject gained from decades of research, the factors that represent the limitations of adopting the technology are related to its cost in relation to the market potential for the food and acceptance by consumers.

According to the information provided, it can be concluded that the irradiation of food in the coming years should be expanded but it may not be universally adopted. The trend is the spread of technology, particularly in countries that have an important agricultural economy, such as Brazil. Moreover, various restrictions on chemicals used in post-harvest and food industry will increase the viability of this process.

Irradiation has different results for each agricultural product undergoing such treatment. These results can be excellent for some products and not suitable for others. Even irradiation of the same product may present different results, depending on the variety treated, the dose and its rate, stage of maturity and other factors impacting on the merits of applying this technology. Specifically in the Ribeira Valley the product of greatest interest to Irradiation is bananas, for which we found some inconsistent results regarding its effectiveness to promote delay ripening and improvement in its food quality. The majority of results found in the literature show promising results, especially for the variety 'Nanica', which is predominant in the region. Thus, we conclude the technical feasibility is apparent whilst, noting that one should undertake more research efforts so that results can be more accurate and reliable.

In the competitive and globalized market in which we live, small details can mean the difference between failure and success of a business. Able to sell products outside or before the time (delay sales) can mean a significant gain in some cases receiving higher prices. For some agricultural products, double or triple increases in value for the same product can be achieved depending on the time of their marketing. This timing may be the result of appropriate mechanisms of control of the ripening process of fruit, resulting

from the irradiation of food, allowing longer storage times of these products in order to yield higher profit margins. In addition, irradiation can also promote the reduction of costs, allowing the transport by ships (in place of the aircraft) for export.

The economic viability analysis presented, based on market assumptions, resulted in favourable results in terms of economic and financial aspects in the assumed project horizon of ten years:

¬ Time of return on investment (pay back) discounted: 5.23 years

¬ Internal Rate of Return (IRR): 17.96% PA

¬ Net Present Value (NPV): U.S. $ 1,288,693.97

Through these analyzes, we also conclude the economic viability of the enterprise, since it satisfied the conditions laid down

Under the conditions presented in the international market of agricultural products and facing the imminent increase in the marketing of irradiated foods, it is proposed to prepare a development opportunity not only regional but also on a national basis. The paper presents evidence that shows the responsibilities of both government and private sector in pursuit of exploiting competitive advantages of our country.

The limitations of this study have already been explained based on geographic coverage and verification of assumptions used, which may be affected by changes in macroeconomic or consumer behavior for irradiated foods, knowledge of which is today the object of numerous studies, without, however, conclusive results because it is a strange subject to the majority of the population and new to science. Finally, the research found the proposal to develop a food irradiation industry to be technically and economically feasible and indicates a possible way for regional development. The issue faced by Ribeira Valley is not only economic growth, but development, set to grow with changes, including not only the economic aspects but also social and cultural which need to be addressed in a qualitative and quantitative.

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