ISSN 1010-1365

FAO AGRICULTURAL SERVICES BULLETIN

156

Food engineering, quality and competitiveness in small food industry systems

with emphasis on Latin America and the Caribbean

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FAO
AGRICULTURAL
SERVICES
BULLETIN
156

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2004

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ISBN 92-5-105250-6

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Preface

Consumers in both developing and developed countries demand high quality wholesome food products, at reasonable prices and which are to their full satisfaction. They also need to be protected from food-related illnesses and producers, handlers, processors and traders obviously benefit from increased consumer confidence and related sales. For these reasons all countries need to ensure that the supplies of food are not only acceptable and adequate from the point of view of nutritional and health aspects, and timely and opportune in terms of quantity, availability and affordability, but also of optimum quality and safety. A number of food control strategies have been proposed and carried out to ensure the quality and safety of food from production to consumption. FAO, as a specialized agency of the UN system dealing with the multiple aspects of food quality and safety, has developed activities through the years providing policy advice, generating and disseminating information and executing projects for building national capacity and helping the countries to ensure a safe and wholesome food supply. Recently, an institutional "Strategy for a Safe and Nutritious Food Supply", addressing key elements of policy advice, capacity building, technical assistance and required actions toward this end has been under development. This strategy is based on the food chain approach to food safety and quality including nutritional aspects.

Recognizing that considerable work on many issues has been undertaken, and that strategies must not be static, and further, that in order to be useful it is essential to evolve from strategy to action, this paper was conceived. Also, taking advantage of the domain of the mandate of the Agricultural Support Systems Division and its Agricultural and Food Engineering Technologies Service, it was recognized that often the engineering aspects are not usually addressed, as part of the multidisciplinary, multifactor context which in real life determines a given degree of quality and safety of specific products within food systems. In other words, it may be the case that the demands and requirements from the markets are known; the norms, regulations and standards are established and maybe even harmonized; the food control system requirements are defined and their implementation is pursued; risk analyses are performed, some quality assurance methodologies and tools are known and training events are carried out. However, in practice, the small agroindustry may not find a feasible way to modify the engineering and technology variables of the manufacturing process without losing money. That is, for the small industry it is not only a matter of willingness to meet markets demands, or to apply quality and safety assurance tools such as Standard Operating Procedures (SOPs), Good Manufacturing Practices (GMPs), general principles of hygiene, Hazard Analysis and Critical Control Point (HACCP); or to comply with quality standards; or to benefit society with a safe food supply. It is also a matter of how to use their technological assets, old fashioned and simple or modern and advanced ones, in a cost-effective way, to make a profit and stay in business.

This work proposes to utilize the systems approach to establish the analytical context for all factors affecting food quality and safety, and hence food industry competitiveness, and identify the engineering variables intrinsic to the food industries and their environment and which, once improved, will make the sector more competitive. Food safety and quality, as well as enterprise productivity, will also necessarily improve once they are seen as systemic products, as will sustainable natural resource use and environmental protection. The approach of this paper is to comprehend that the food industry is a system which is part of, and contributor to, bigger systems, and to focus on the food engineering and technology factors as essential components of quality and food industry competitiveness. The document presents a conceptual methodological proposal whereby any strategy based on the above approach will make it possible to identify and address the priority needs of the small food industries sector in Latin America and the Caribbean, but more important, to respond efficiently and effectively to those needs through sound action. The ideas proposed in this work address, from the food engineering and technology perspective, the complex issues faced by small food industries in today's markets, where high quality and safe foods are demanded by consumers and all businesses, no matter how big or small must be competitive to succeed and survive.

The preparation of this document was carried out by the author as a Food Industries Officer in the Agricultural and Food Engineering Technologies Service, Agricultural Support Systems Division, within FAO's Strategic Framework Medium Term Plan 2002-2007, under Programme 214A4 "Agribusiness Development". This work also was carried out under Programme 214A9 "Enhancing Food Quality and Safety by Strengthening Handling, Processing and Marketing in the Food Chain", also the responsibility of the same Division, as part of FAO's Medium Term Plan 2004-2009. The material for this document is derived from a paper presented by the author at the Expert Meeting on Quality and Competitiveness in the Rural Agro-Industry in Latin America and the Caribbean through the Efficient and Sustainable Use of Energy, carried out in Pátzcuaro, México, November 25–28 2002 by the above-mentioned Division of FAO, with the collaboration of the Interdisciplinary Group for Appropriate Rural Technology (GIRA), and the National Autonomous University of México (UNAM).

This document is intended for policy-makers, agricultural economists, marketing specialists, managers, researchers, NGOs, extension professionals, food engineers, agroindustrial engineers, food technologists, nutritionists, and food quality and safety systems specialists, with the hope that they may find useful ideas for their work towards helping countries achieve safe and high quality food supplies.

Acknowledgements

Thanks are due to Geoffrey Mrema, Gavin Wall, Doyle Baker and François Mazaud for their management support to this work and related activities within the Regular Programme under the responsibility of the Agriculture Support Systems Division of FAO. The author wishes to acknowledge the review, constructive comments and important suggestions from John Dixon, Andrew Shepherd and Antonio Pérez. The editorial work of Cadmo Rosell, the translation into English by Julie Rice, the formatting work by Lynette Chalk and the administrative support from Pauline Gouyou-Beauchamps, Teresa Danieli, Larissa D'Aquilio, Claudia Bastar, Ann Drummond, Donna Kilcawley, Rosemary Petrucci and Angela Scappaticci are gratefully acknowledged.

Chapter 1
Introduction

THE CONTEXT

Latin America and the Caribbean (LAC) is a region of developing countries with an average Human Development Index of 0.777, whereas the value for the highest-ranking country in the world in the year 2001 was 0.944 (UNDP, 2003). This Index is a summary appraisal of human development and measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight); and a decent standard of living, as measured by GDP per capita (adjusted by purchasing power parity, in US dollars) which serves as a surrogate for all the dimensions of human development not reflected in a long and healthy life and in knowledge. Many Latin American countries rank below the average value. Mean annual household income is very low, and within the region 77 million people (15.1 percent of the population) are living on the equivalent of less than one US dollar per day (1999 data according to UNDP, 2002). These people are probably confronting low food availability and therefore have low *per capita* daily dietary energy intakes, and belong to that sector of the population with low levels of nutrition. In several Latin American and the Caribbean countries over 15 percent of the population is undernourished. That is to say, their right to access to safe food in appropriate amounts and of the right quality is undermined. As a result, there are 53 million undernourished people in Latin America and the Caribbean, approximately 10 percent as a proportion of the regional population (FAO, 2004a). In eight countries in the region, at least ten percent of children under the age of five are underweight for their age group. Nine countries have less than 2 500 kcal/person/day of dietary energy supply (FAO, 2002a). Table 1

TABLE 1
Selected social and economic indicators for Latin America and the Caribbean

Country category	Life expectancy at birth (years)	Education index	GDP* per capita	Human develop-ment Index	Rural population (% of total)	Under-nourished people (% of total)
Developing countries	64,4	0,70	3 850	0.655	59,2	18
Latin America and the Caribbean	70,3	0,86	7 050	0.777	24,2	12
High-ranking human development countries	77,1	0,95	23 135	0.908	21,7	--
High income countries	78,1	0,96	26 989	0.927	20,6	--

* Purchasing power parity in USD; data for 2001 except under-nutrition (2000), adapted from UNDP, 2003.

compares selected indicators describing the prevailing situation in Latin American and the Caribbean with those in other countries.

It is known that a population with a high prevalence of hunger also has high rates of mortality for infants and for children under the age of five, and that life expectancy is lower. Hunger, undernutrition and food insecurity have a negative impact on the economic and human development situation in such societies. Arguably, this is inherent in the poverty syndrome, with upstream and downstream effects, in a self-catalyzing cycle where poverty generates undernutrition and malnutrition, which in turn increase poverty, and so on in a vicious circle.

The economically active population in agriculture is 7 percent in developed countries, 54 percent in developing countries, and 19 percent in the LAC region; agricultural exports relative to agricultural GDP are 64.1 percent for developed countries, 18.3 for developing ones, and 43 percent for the LAC region. However, the region has the highest rate of agricultural exports as a share of total exports (FAO, 2004a). There are other non-food indicators that give a clear idea of the state of development of a given country or region. As an example, regarding technology diffusion and creation indicators, the LAC region has an index of 162 telephone mainlines, 160 cellular telephone subscribers, and 49 internet users per 1 000 people, and 49 percent manufactured exports (in relation to merchandise exports), whereas countries with high human development indexes have 511 telephone mainlines, 529 cellular telephone subscribers and 328 internet users, all per 1 000 people, and 81 percent manufactured exports. The region has been affected by disasters, weather events, social and political conflicts and external economic processes. There has been very poor access to markets and services, and many services still need to be developed or improved. Economic growth, development and food security are linked to agricultural production in almost all countries (UNDP, 2003).

Nevertheless, Latin America and the Caribbean has five of the ten richest countries in the world in terms of biodiversity, forests, humid areas and renewable water resources are in the region, which is a globally important region in a number of crops, with yields above the world average. According to Dixon *et al.* (2001), the LAC region has one of the most diverse and complex range of farming systems in the world, with at least sixteen major distinct farming systems. Regional trends indicate that the LAC region is important or getting strong in world trade in a range of commodities. Also, cereal, fruits and vegetables, and oil crops are areas with growing trends in terms of yields and production. Ironically, self-sufficiency regarding cereals seams to be declining slightly. The region has gone through an intensive process regarding structural adjustment and economic liberalization. Among the potential strategies for poverty reduction are diversification, including a shift into off-farm employment, income generation and added-value activities such as processing and agroindustries, including quality aspects. These would result in increased small farm competitiveness (Dixon *et al.*, 2001).

From the mid-1980s, the characteristic socio-economic policy climate featured trade and currency liberalization, reduced public sector intervention, and marked efforts to increase competitiveness through greater private sector participation. However, lagging agricultural trade liberalization plus farm protection and support policies in the industrialized countries, combined with trade barriers such as sanitary and phytosanitary regulations, agricultural tariffs and subsidies were major obstacles for the development of agricultural exports in Latin America and the Caribbean. Despite this, agricultural exports have slowly improved in the region due to demand from import partners, but the recent economic slowdown in developed countries has affected trade in this highly agriculture dependent region. As described above, this situation points to the importance of focusing policy and strategy on the development of technological, managerial and marketing capacity to enhance value addition in farm products through the development of the agroindustrial sector and marketing infrastructure alike.

This paper has the objective of proposing a detailed systems analysis approach to the food industry as part of agricultural systems, so that quality and competitiveness may be enhanced in an efficient and sustainable manner. It is mainly intended as a conceptual support for agricultural and agro industry planners and strategy builders, but also for sector policy makers and leaders who are responsible for designing and implementing effective programmes and projects for agro industry development. However, the paper may also be useful for researchers, technology transfer experts, and managers, since it permits to see the agro industry from the viewpoint of an engineer considering the engineering aspects as an essential and interrelated aspect of the agro industry, but together with other economic, management, marketing and political aspects which comprise the food industry and the agricultural sector. The paper analyses food industry competitiveness in Latin America and the Caribbean, and proposes that by utilizing the systems approach to establish the analytical context for all factors affecting enterprise competitiveness, and by identifying and improving the variables intrinsic to the food industries and their environment, it is possible to make the sector more competitive. Food safety and quality, as well as enterprise productivity, will also necessarily improve once they are seen as systemic products, as will sustainable natural resource use and environmental protection. Although the economical and marketing factors need to be addressed, this paper focuses mainly on the technological and engineering factors as essential components of quality and competitiveness. This is done so that the approach is illustrated from the technology and engineering viewpoint. For this purpose, after reviewing some general characteristics of food industries, the agrifood sector is seen as a system composed by many sub-systems, and the systemic nature of competitiveness and quality are analysed. From this the paper presents a conceptual methodological proposal whereby strategies based on the above approach will make it possible to identify and address the priority needs of the small food industries sector in Latin America and the Caribbean, and respond efficiently and effectively to these needs through sound action. A few "hands-on" application examples are given at the end.

MAIN CHARACTERISTICS OF THE FOOD INDUSTRY SECTOR

An analysis of quality and competitiveness in the small food industry requires standardized terms and concepts to avoid ambiguity and streamline the analysis. It is also important to briefly review some of the typical technical characteristics of the sector which differentiate it from the other industrial sectors.

The food industry belongs to the manufacturing industries group known as agroindustries, agricultural processing or agroprocessing industries. These characteristically receive raw and intermediate agricultural sector materials, process them, and produce food for human consumption, or semi-processed materials which will in turn serve as raw materials for other processes. The food industry, by definition and by its very nature, adds value to and stimulates agricultural production, contributing to market expansion and generating collateral activities and industrial services. Generally speaking, the agroprocessing sector or agroindustries transform raw material from fields, forests and even aquatic resources, and therefore comprise many and varied types of activities. The sector ranges from industries with very simple processes and few operations, mostly handling fresh, semi processed, or simply-processed goods, to those turning out products with extensive modern technological inputs, and which may also be labour and/or capital intensive. The specific feature of the sector lies in the biological nature of its raw materials, once an integral part of living organisms and hence perishable. Agricultural raw materials are also often seasonal, and subject to geographic, environmental and climatic variations, plus diseases and contaminants, which can occasion substantial losses. All of the foregoing demands careful agroindustrial production planning and organization and excellent coordination between producers and processors (FAO, 1997).

Like any other industrial activity, agroindustries have a so-called "upstream" linkage, relating all stages of the food chain prior to industrial processing, and a "downstream" linkage for the post-process stages.

Post-harvest grain drying and storage operations, for example, belong to the first group, whereas transport, logistics, bread-making (with reference to flour) and retailing belong to the second. The technical and economic relations linking the food industries are further distinguishing characteristics (Castro and Gavarrete, 2000). In other words, a given agroindustry has processes linking them to external agents, and internal processes linking their component factors among themselves. Therefore, the agro-processing sector as such is related to the production sector, to the supporting sector (transport, storage, logistics, industrial services), to the marketing (retailing, wholesaling) sector, and to the final processing, food preparation, and consumption sector.

The level and degree of technology, sophistication and innovation in productive processes, the capital investment compared to manpower use, the size of the investment, the scale and annual capacity of operations, the total number of workers and their distribution by level of training, the degree of organization and the managerial style are further distinctive characteristics of the sector. Normally, combinations of various criteria are used to define a certain type of enterprise within the sector, such as the number of workers, the level of productive technology, the relation between manpower and machinery, and the type of organization (Cuevas *et al.*, 2003). Micro enterprises, for example, have been defined as based on very simple technology with sizable inputs of manual labour, ten or fewer workers, and a simple organizational system (Figuerola, 1995). In other countries, it is considered that micro businesses are those with five or less people involved including the owner/manager, or even three or less. Logically, the classification into micro, small, medium and large is conceptually related to the national and local economic, technological and social context, and in practice it usually differs from country to country.

The terms "agroindustry", "agroprocessing industry" and "agrifood industry" exclude industries producing industrial or agricultural equipment and machinery or chemical inputs for agriculture (FAO, 1997). In this paper the term "industry" does not necessarily connote a previously established scale or size of operations, or complexity or cost of installations and equipment, but refers rather to the principles, methods and objective characteristics of a given industrialized production activity.

TABLE 2
Selected food industry compelling issues

Typical consumer demand trends	Small-scale food industry challenges
➢ Safe foods ➢ Product sensory quality ➢ Ease of access ➢ Take-home meals ➢ Healthy foods and ingredients ➢ Foods and ingredients not harmful to health ➢ Fresh or minimally processed products ➢ Lifestyle-complementary foods ➢ Increased consumption of fruits and vegetables ➢ Novel food combinations ➢ One-dish-meal foods ➢ Fast and impulse-purchase foods ➢ Foods that help consumers keep in shape ➢ Foods with high specific cultural value	➢ Renewed concern for and importance of guaranteed food safety ➢ Renewed concern for and importance of guaranteed food quality ➢ High or specialized quality rules, regulations and standards ➢ Global markets and economies, economic and production pressures from smallest to largest markets ➢ Niche markets (organic foods, healthy foods, spices, foods for special groups). ➢ Foods with components produced by modern biotechnology (genetically modified organisms) ➢ Need to help reduce greenhouse gas emissions, protect natural resources and the environment, and promote sustainable use of fuel sources ➢ Need to combat the stereotypes that make rural micro and small-scale food industries just big commercial kitchens as opposed to an entrepreneurial activity for processing raw materials into high-value products, an activity which can be improved through good engineering, technological, managerial and marketing practices

Adapted from Cuevas (1998).

Any agroindustry sector can generate undesirable environmental impacts, including emissions, toxic substances and solid and liquid wastes, not to mention the potential for natural resource degradation or unsustainable use. Admittedly, food chain activities are generally less energy-intensive and release less CO_2 per unit of product than other industrial activities, but energy efficiency must also consider the need to develop and use “clean” energy technologies to avoid aggravating problems of environmental quality and climate change (FAO 2000a).

As for the surrounding economic context, the agroindustrial sector has been affected by trade liberalization and economic opening, rapid technological change in data handling and dissemination, and the new global market rules, just like all other economic activities. The current social and economic conditions in Latin American and the Caribbean agroindustries in general and the small food industry in particular confront the sector with new challenges and new consumer attitudes, which will have to be successfully tackled and solved (Cuevas, 1998). Consumer demands and market conditions are thus key factors in the food industry context, as in the wider agroindustrial context. The following table summarizes these factors.

There are many studies on characteristics and conditions in the agroindustrial sector, including the food industry, in various parts of the world. See the work of Boucher (2000), Boucher and Riveros (2000), Boucher *et al*. (2000), FAO (1995), Hartmann and Wandel (1999), IICA (1990), Lubowa and Steele (2000), Marsden and Garzia (1998), and Riveros *et al*. (2001), for example.

Chapter 2
The agrofood sector as system

WHY SYSTEMS AGAIN?

Bellinger (2002) simply but effectively defined a system as a whole which maintains its existence through the mutual interaction of its parts. A system is a set of relationships and interactions which are in turn responsible for the characteristics emerging from that system. To put it another way, a system is a set of parts and their interlinked relationships which make up a complete unit (Heylighen, 2003). The principle of emergence creates a situation whereby systems have properties not necessarily shared by their individual parts, or properties which may not occur with other types of interactions. The behavior patterns of systems are among these properties. The core parts of the definition of a system, therefore, are its interactions, and these are thus its most important characteristics. According to this approach, also called the cybernetic approach, the whole is described not only in terms of its parts, but also and mainly in terms of the arrangements and configurations of its links and relationships (Heylighen, 2003).

Systems are made up of subsystems and are in turn subsystems of one or more other systems. All systems share certain common characteristics, are subject to the systems principle and to be understood must be studied in terms of their complete nature, not simply any one of their parts (Bellinger, 2002). The same author indicates that in the systems context, a model is a simplification of reality intended to promote understanding and knowledge. For this reason, a model leaves out certain details, and may be very simple (or very complex if many details are left in). A model is a good model if it helps to develop understanding and knowledge of the thing we are trying know. The simple and most basic model shows the relationship between cause and effect, but this is actually a very limited way of understanding how systems really operate. According to Bellinger, to conceptualize and to express a relationship one must indicate that a relationship is not necessarily “linear”, and the concept should include the characteristics of the relationship, and the interactions which are dynamic in nature. An entity may be an effect or factor external to the system and be in turn part of another system.

In systems analysis, we need to understand the relationships or links between entities, which in turn may or may not affect other relationships with other entities, and even the actual nature of each entity. There may be circuit links, in which interactions are such that an entity or action is added to another entity or action, producing a result which in turn promotes more than the original action or entity (reinforcing circuits). Alternatively, there are interactions in which an action promotes the solution of a problem or the achievement of an objective, so as to reach equilibrium between two entities or actions (balancing circuit). It must be remembered that there can be “hidden” circuits or relationships, that there are time lapses between events, and that the effects of interactions may be cumulative (Bellinger, 2002). Some enzyme systems behave like this, as do some social systems.

One way of representing systems (see Figure 1) is through the absorption of inputs in order to achieve “something” or to transform, process, and thus produce outputs (products) which may be desired objectives, proposals, things or situations (Sauter, 2000), or even measures of performance (Dixon, personal communication, 2004).

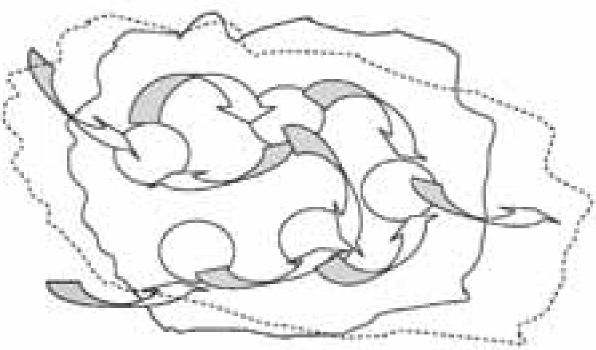
According to this approach, five elements must be considered in defining systems (Heylighen, 1998; Sauter, 2000): inputs (what comes into the system from outside it), outputs (what leaves the system and goes outside it), the process (transformations occurring within the system), boundaries (which define the difference between the system and its setting), and the environment (context, medium, scenario, ambit, setting, surroundings), which is that part of the world that can be ignored in systems analysis, except where it interacts with the system. These may include elements such as people, technology, capital, materials, data, regulations, and so on. Also considered further essential elements of systems theory are system hierarchy, system state, information and the orientation toward a global purpose. If the nature of the processes (what happens inside the system) is not known, than the so-called black box concept is applied (the box in Figure 1 would simply be painted full black). Processes

FIGURE 1
Process-based system model

or interrelationships are not known or understood, nor, often, are the components of the system. A typical example of this is when fuel consumption in an agricultural chain and the production of CO_2 (inputs and outputs) are known, but what is not known, or is ignored, is the pattern of consumption, the internal flow and the consumers (components and relationships). Another example, starting to relate the systems approach to food quality and safety, is when policy makers request from food industries the delivery of high quality products (outputs) without paying attention neither to the inputs (raw materials, services, etc.) nor to what is going on in the industry-business itself (processes).

The interacting components of a system may be subsystems of this same system, and may be related and interacting in different ways. One simple way of representing this is shown in Figure 2, which illustrates both the difference between the so-called “white box”, or, better, the “transparent box”, with subsystems interacting within the “dynamic” boundary of the larger system, as opposed to the black box concept. Note that the arrows linking the ellipse-shaped subsystems represent the interaction or interactions between them, which are dynamic in nature and therefore not represented as straight solid lines (Heylighen, 1998). The full line representing the boundary in a given moment or set of circumstances, evolves dynamically to another boundary (the dotted line) for a different moment or set of circumstances, as a result of the principles governing systems.

FIGURE 2
Dynamic model of transparent “box”



Lastly, all the above concepts lead to the consideration that systems have hierarchical structures with different levels. From the top level one has an overall view but ignores the smallest parts, whereas at the bottom level one looks at many small interacting parts, without taking in the structure as a whole at its other levels. The systems structure is the set of complex relationships among its components and subsystems which in the long run determines the outcome and common purpose of the system as a whole. These are generally considered open systems. It should be pointed out that complex systems have a set of characteristics and properties that lie beyond the scope of discussion of this paper. In any case, as mentioned, models are needed to simplify the reality, and to know about and understand a given system or subsystem.

The advantage of the application of systems analysis, which is derived from systems theory, is that the principles apply to any type of system, as to any type of organization. Organizations, being systems, are subject to their governing principles for aspects such as decision-making, pinpointing problems, and maximizing control (if at all possible) and operation of the system (Heylighen and Joslyn, 1992; Bellinger, 2003). The systems approach, which is a way of thinking or mental stance focused on understanding how things work, behave, interrelate and are structured (in a word, how systems operate), is essential for those trying to device strategies and execute actions in order to increase competitiveness in the food industry. Logically, we also need to understand the basic systems concepts for effective and efficient application to an understanding of the complex nature of food systems. In the real world, such as in a farm, an agroindustry or a food retail business, the systems approach is essential, understanding that the principles of systems apply to them. Once this is understood, we can develop interventions to bring about the desired changes, and ensure that these changes persist (Bellinger, 2003). This can be perceived as real control over the system. It basically consists of choosing the inputs and knowing the effects, parameters, and influences on the behavior of the system which can change its state or outputs as desired (Heylinghen, 2003). From the engineering viewpoint, this would consist of distinctively identifying the independent variables and transforming them into dependent variables, for a given set of parameters, boundaries and restrictions. However, there may be systems which are composed of coordinated networks with no overall control (Dixon, personal communication, 2004). The physical world offers many examples of such systems.

SYSTEMS APPROACH TO THE AGROFOOD INDUSTRY

The FAO concept of food security says that food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences (that is, that satisfies people's quality and cultural preferences) for an active and healthy life on a continued and sustainable basis (FAO, 2000c). Within the agroindustrial sector, rural and urban food industries are major actors in agrifood systems, and can therefore have a positive impact on food security, provided they have the capacity to offer safe, high-quality food to consumers on a sustainable basis, and to help boost the incomes of processors and producers. Agri-food enterprises range by scale from those narrowly linked to the immediate post-harvest stages of primary production to the most highly developed, largest-scale enterprises. Processing micro enterprises comprise a link between the two extremes (Figuerola, 1995). The food industries are also one economic sector where men and women alike are active participants in the production process.

Social and economic progress in the rural sectors of developing and transition countries is closely bound up with innovation and competitiveness in the agrifood sector in both domestic and international economies and markets. Competitive advantage is largely dependant on a series of factors, including conditions of demand such as meeting local market requirements, and the pressure they exert on the demand for safe, quality products (Castro and Gavarrete, 2000). Correspondingly, competitive strategies reside in the development of managerial systems that permit compliance with consumer standards, regulations and expectations for product quality and safety, all under favorable economic conditions. Where agrofood industries are competitive, they clearly make a decisive contribution in terms of increasing food availability by delivering high quality, nutritious, wholesome and safe food products, and thus enhancing food security.

However, food purchasing power, food distribution and physical access to food also need to be improved, as do living conditions, particularly for people living in rural areas. This calls for integrated, multisectorial approaches based on complete agrofood systems and subsystems (including the economic, social and environmental aspects) as the basis for strategies, policies and decision-making.

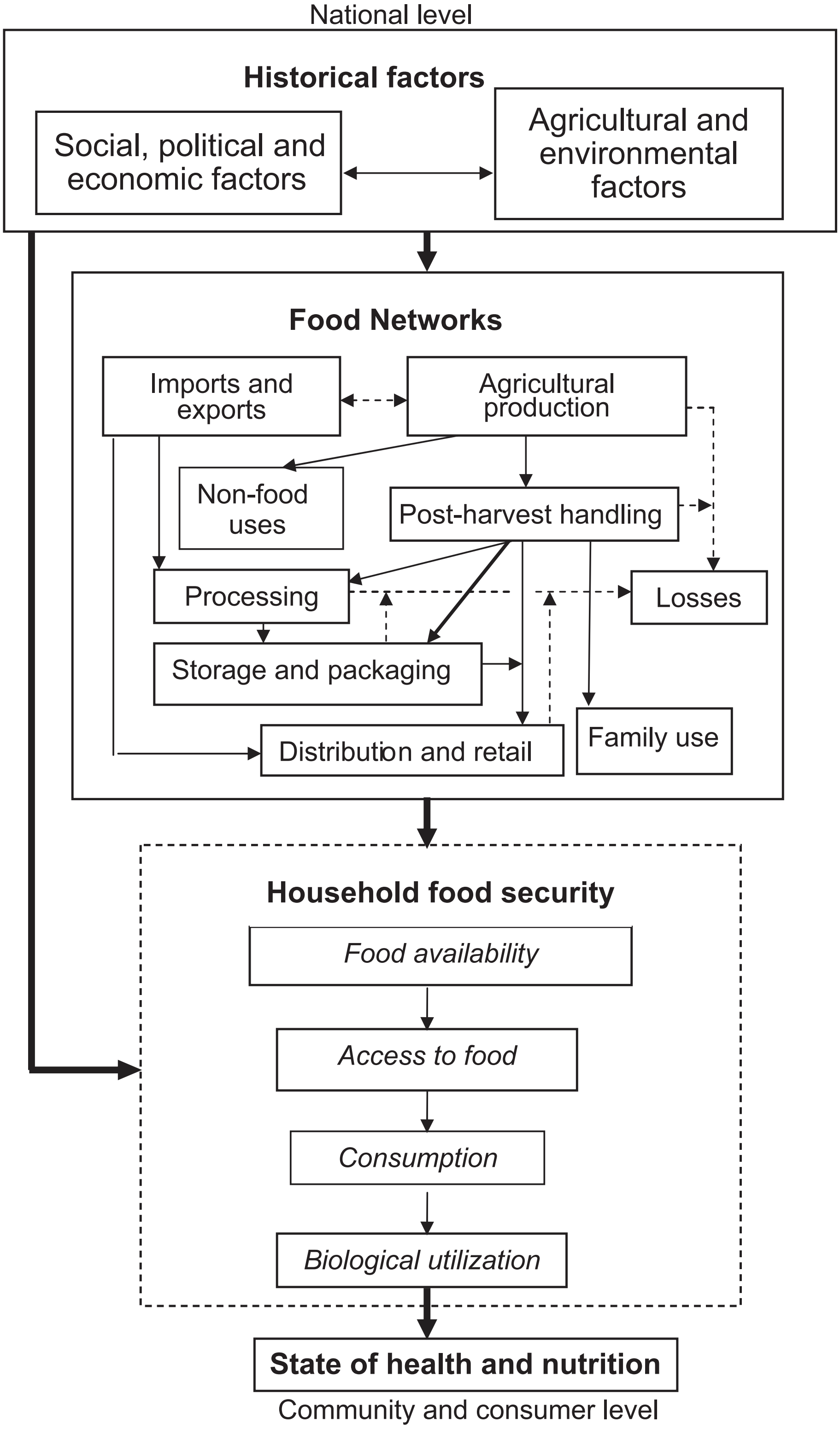
Looking at the above analytical concepts for the agrofood sector or system from the systems standpoint, we can see that the social purpose of the system is food security, whereas normally the global economic purpose is wealth creation and profit. We may look at the various participating actors and their technical, social and economic relationships and interdependencies in the various geographical areas within a given country or group of countries. Analysis may focus on a sector, a sub sector, or various interlinked sectors, at the micro or macro level, or combinations of both. We need to identify and characterize relationships and hierarchies. In this approach, the boundaries of the system are defined by a given set of food sectors or products and by groups of actors, including enterprises, as well as those enterprises supplying goods, services and capital inputs. We also need to consider how institutions, socio-economic, and political forces interact, in addition to the environmental characteristics that serve as a backdrop to the system. Its nucleus must include the pre- and post-production chains (and their ramifications) within which the agroindustries operate. Presented below are examples of the various analytical degrees and horizons of agricultural systems, from the national macroeconomic setting, to the microeconomic community environment, to the internal environment of a food processing enterprise. The emphasis is on the food chain and on processing,

Figure 3 shows one example of the effort to model a historical analysis of the global factors governing food security which produce a given state of food and nutrition. This is a simple, general model of sequential relations. Obviously, there are a great many possibilities and proposals for models representing factors, relationships and causalities with reference to food security. The example presented here is cited solely to illustrate the type of analysis which is possible, and the type of model which can be constructed.

The big box in the centre defines the boundaries of the food network subsystem which contains the food chain subsystem, represented using a model based on the consecutive-stage type of flow diagram. As systems, all food chains are subject to systems principles. It should be noted that in reality the food chain is immersed in a network, that is, is composed of,

FIGURE 3

Simplified analytical cause-effect model of food security and state of health and nutrition in a food system



Modified from Cuevas, 1991.

and related to other subsystems, and the conformation is not necessarily linear or simple. The need to approach food chains, in particular, from a holistic and systems-oriented standpoint has been identified on numerous occasions. Various approaches and methodologies have been used, and various orders of magnitude and environments (see Castro and Gutman, 2003; Bell *et al.*, 1999; Ranaweera *et al.*, 1998; McConell and Dillon, 1997; Bockel *et al.*, 1994; La Gra, 1993; FAO, 1990; Seepersad *et al.*, 1990). Hennessy *et al.* (2003) also postulated that many food safety problems are systemic, and they trace the nature of these systemic failures in the following four causes: system interconnectivity, communications, information and technology. This is why prescribed policy and analyses need to be systems-oriented, applying existing tools to model the main aspects of systems interactions. These various papers illustrate a range of detail and excellence in the application of the principles of systems analysis, from the simple use of the relevant terminology to genuine systems approaches to agriculture. Thecritical aspect of the system approach to the agrifood sector, compared to static and linear chain approaches, is that it embraces all subsystems from production to consumption, it internalizes and analyses the cross-linkages and relationships between chains, or better, between subsystems, and moves from description into identification of key components and relationships for which interventions might be needed (Dixon, personal communication, 2004).

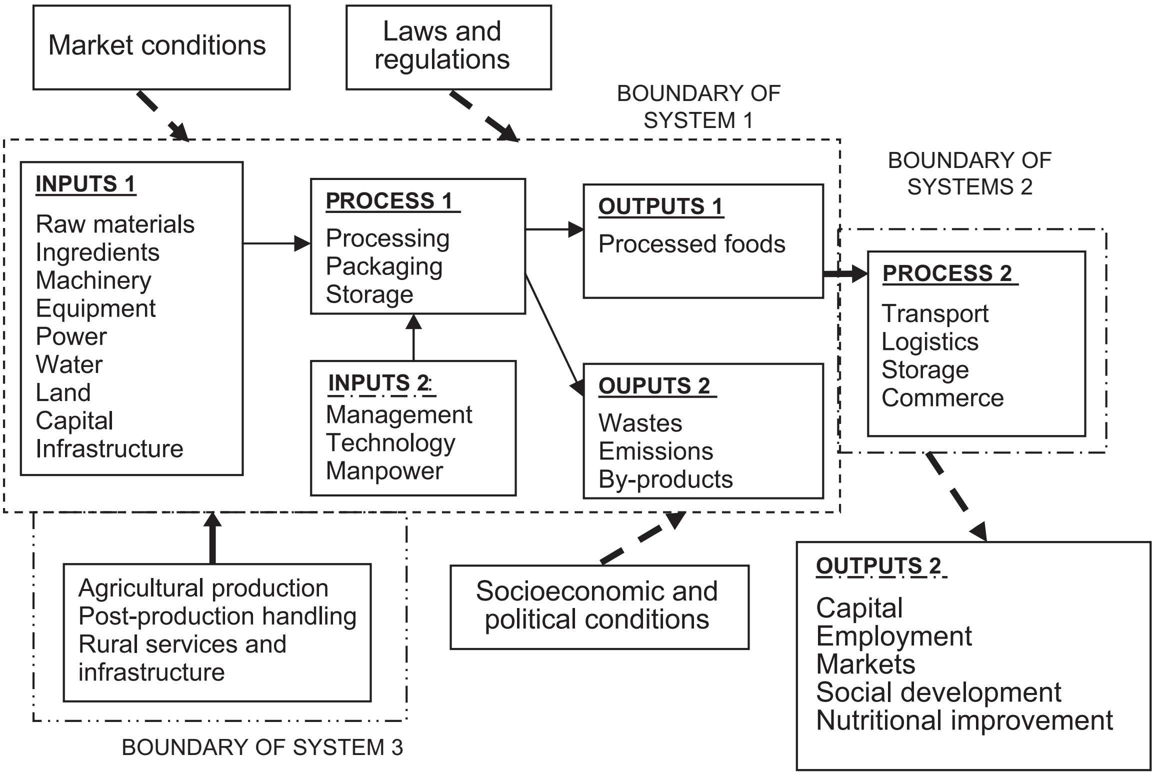
In addition to the systems approach to the food chain as a set of interrelated and sequential steps from field to consumers, there are other variants such as supply chains, link analyses (analyse de filière), commodity systems, productive chains, and value chains. In any case, it has been established that these chains have highly-evolved forms of coordination and integration, and rules of participation (Vorley, 2001), which are properties of systems, as can be seen. As an example, the value chain concept has been developed as related to Canada, where a supply chain is the entire vertical chain of activities from production on the farm through handling, processing distribution and retailing to the consumer, that is, the entire spectrum from gate to plate. However, little attention is given to how it is organized or how it functions. On the other hand, the value chain refers to a vertical alliance or strategic network between a number of independent business organizations within a supply chain.

The primary focus is value and quality, with demand-type of pull, and interdependent organizational structure. Through a systems approach it was established that vertical coordination, organization of industry stakeholders, feedback mechanisms, and quality and safety assurance tools as part of the 3-C (coordination, cooperation and communication) are key to the success of value chains (Hobbs *et al.*, 2000).

Figure 4, continuing the descent into lower levels of systems analysis, shows a more detailed model at a lower level than the system represented in Figure 3. This diagram is comparable to the "inputs-process-outputs" diagram, where inputs and outputs are both physical and socio-economic. This systems model purports to summarize the internal scenario of processing, with its major inputs and outputs. In essence, it shows that the general objective of the food industry as a subsystem is to receive materials, process them and deliver high quality and safe food products that satisfy consumers and provides revenues to the company and keeps healthy business. As can be seen in Figure 4, three possible boundaries have been drawn, which in turn define three distinct and interrelated subsystems. Subsystem 1 is basically the food industry. Subsystem 2 may be also part of 1, depending on the perspective and purpose of the analysis, and on the properties of the subsystems themselves. Process 1 is the processing plant itself. The box called "Inputs 1" can be very useful for determining the diverse factors that can affect the result of Process 1, from a broader position as compared to the most common and simple, but equally illustrative, model that processing is simply "raw materials → process → products", as there are usually many inputs for any given process. Notice that in that systems model we may already identify inputs that belong to the categories of methods, manpower, materials and machinery, also called the 4-M.

Figure 4 also invites the consideration that the outputs (or products) of a process can be the supply which feeds another process, and that these outputs can in turn be varied in nature, even with reference to broader settings than that of the economic environment. We need to remember that the food chain subsystem is not static, and that its products or total results are not just the simple sum of the contributions of its parts. Because it is a system, the food chain has properties such as self-stabilization, feedback, propagation, interconnectivity and evolution. For this reason, segmented

FIGURE 4
The food processing agroindustry as a system

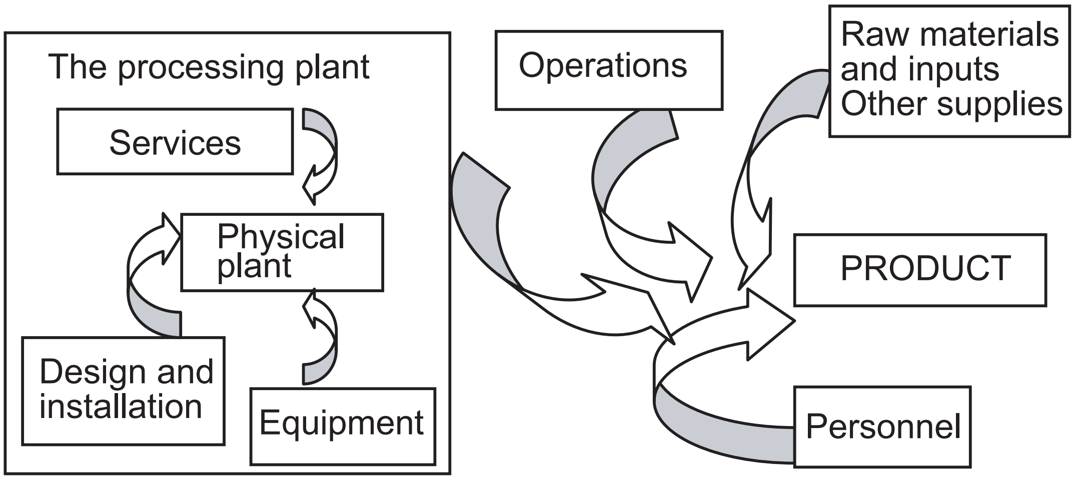


and isolated analyses and interventions are not always effective. Figure 4 therefore defines the domain of the agrofood industry as a system.

The processing stage as a component of the food chain is represented in graphic form in Figure 5. The big box contains the industrial plant and services, as an example of components of the "processing plant" subsystem. The other three components also make up part of the so-called 4-M of industrially oriented production. In this diagram, we can define or characterize either inputs (e.g., raw materials, personnel) or outputs (products) in terms of quality, quantity, suitability, uses, characteristics and costs.

Additionally, the scientific and technical literature contains numerous examples of analyses and models of processes belonging to the agrifood industry, at various orders of magnitude. As an example, Cuevas *et al.* (1985) present flowsheets specific to industrial maize processing of precooked flour for the preparation of Venezuelan "arepas". The process

FIGURE 5
The processing stage as a subsystem

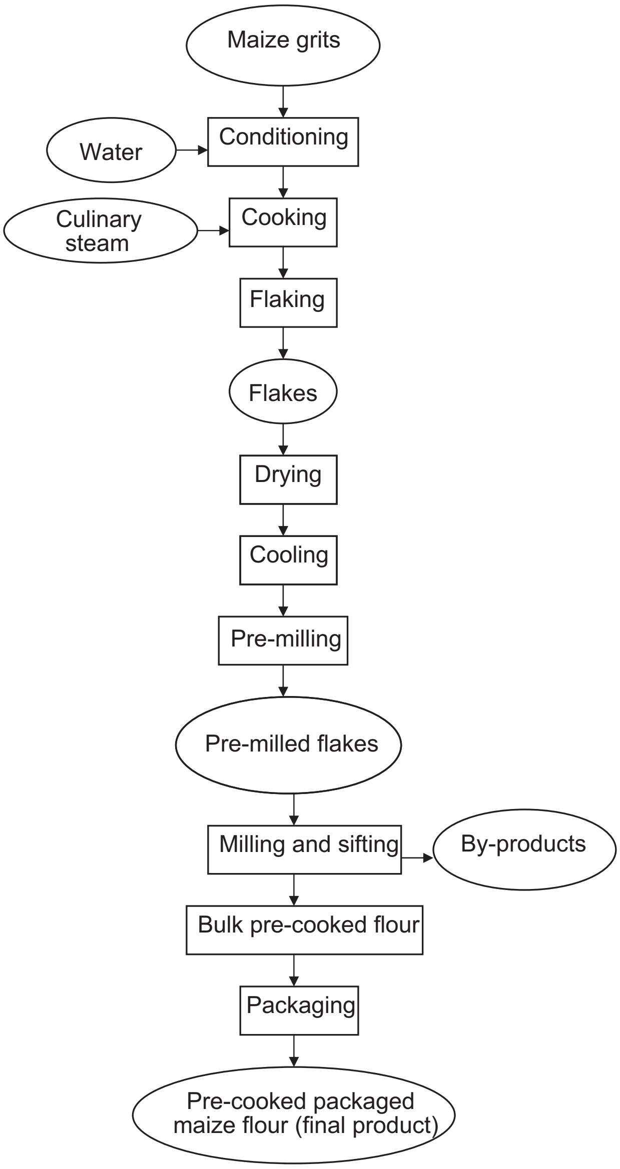


is broken down into its consecutive, interrelated operations, with the raw material as the first input and the product as the final output. This type of diagram, called a process flowsheet, is described and utilized in food engineering texts and, in general, in chemical and food engineering books and publications. Figure 6 shows part of the process for the production of precooked maize flour, as it was performed in Venezuela in the 1980s. There is first a process that takes maize and produces maize grits, maize germ and by products. From maize grits the precooked flour is produced, as shown in the process flowsheet in Figure 6. Industrial inputs such as steam, hot or cool air and electricity are not included for the sake of simplifying the figure.

Cuevas *et al.* (1985) also present an additional way of analyzing systems relationships in a subsystem like that of an industrial maize processing plant, using a materials balance diagram, as shown in Figure 7 (which does not explicitly show all losses). Similar diagrams can be prepared for energy balance and cost analyses, all based on primary specialized information obtained directly from the detailed study of manufacturing processes.

An equivalent approach can be utilized for the logistics, marketing and trade aspects, for instance in order to identify participants in the marketing chain and to define the cost/price percentages absorbed by the various actors in said chain, which becomes their economic interrelationship.

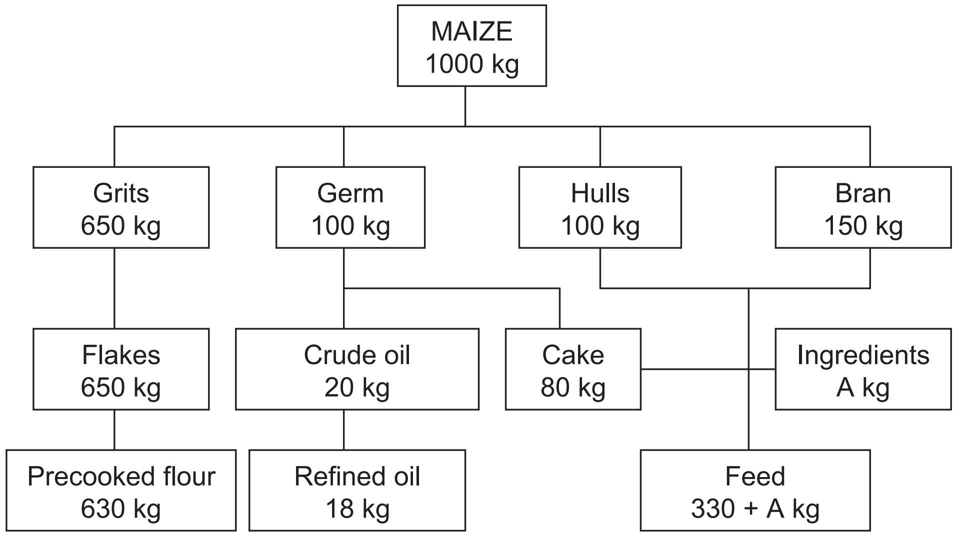
FIGURE 6
Industrial process for the production of precooked maize flour from maize grits



Adapted from Cuevas *et al.*, 1985.

In summary, it is important to depart from the linear static and descriptive approaches to describing the agroindustry and the agricultural sector, to a more comprehensive, realistic, integrated systemic view considering that food is produced and delivered to consumers in complex and interrelated networks (or subsystems) which in turn are part of larger and more complex systems, with components, behavior, and interrelations governed by the principles of systems. In modern marketing terms, it would be said that the food industry and in general food systems have as an essential objective to deliver high quality and safe food products to consumers. The term "consumer" is used here in the broad sense, not only as "clients" buying goods from a seller, but as "users" of the products coming out from a given system. In a food system, consumers buy or acquire food products. It is well known that a food product is not really "food" until it provides nutrients to a person (see Figure 3). To do this, the food product has to be eaten, that is, consumed, the nutrients absorbed and utilized biologically by the person. Hence, in this paper "consumer" is a comprehensive term not only implying the a person who buys something, but also and mainly a person who eats –consumes a food product, with

FIGURE 7
Materials balance for a precooked maize flour plant



Adapted from Cuevas *et al.*, 1985.

the hope to get nutrients, components good for health, satisfaction, better body condition, and good value for the money. Therefore, for any food industry and hence for a given food network to be successful, the needs and expectations of consumers have to be understood and fully satisfied, so that they get foods that are of value to them. This seems to be all that food industries, small and large, should be trying to do.

THE SYSTEMIC NATURE OF COMPETITIVENESS

We have seen in these different models how the systems approach can be applied from the macroeconomic to the microeconomic, or enterprise, level. Systems analysis is normally applied to economic or informational aspects. But it is also used in engineering aspects, especially industrial engineering, and traditionally in agriculture, but primarily in terms of economic relations. For the small food industry sector, the next step would be to understand how the components interact. This might be a technological and/or some other type of systemic interaction (not only economic), with a negative or positive impact on competitiveness.

For Porter (2003), productivity is the true measure of a nation's competitiveness in the long run, and depends on the value of goods and services, measured as prices obtainable in open markets, and how efficiently the former can be produced. In other words, efficiency and performance are the criteria (Castro and Gutman, 2003). On the other hand, competitiveness can be seen as the condition whereby the structure and strategic conduct of a productive entity such as a small food processing industry can have a positive impact on performance, ensuring the enterprise achieves the market position and participation needed to make it profitable and sustainable. Competitiveness in this sense depends on critical or “steering” factors which may or may not be subject to control (Da Silva and Batalha, 1999).

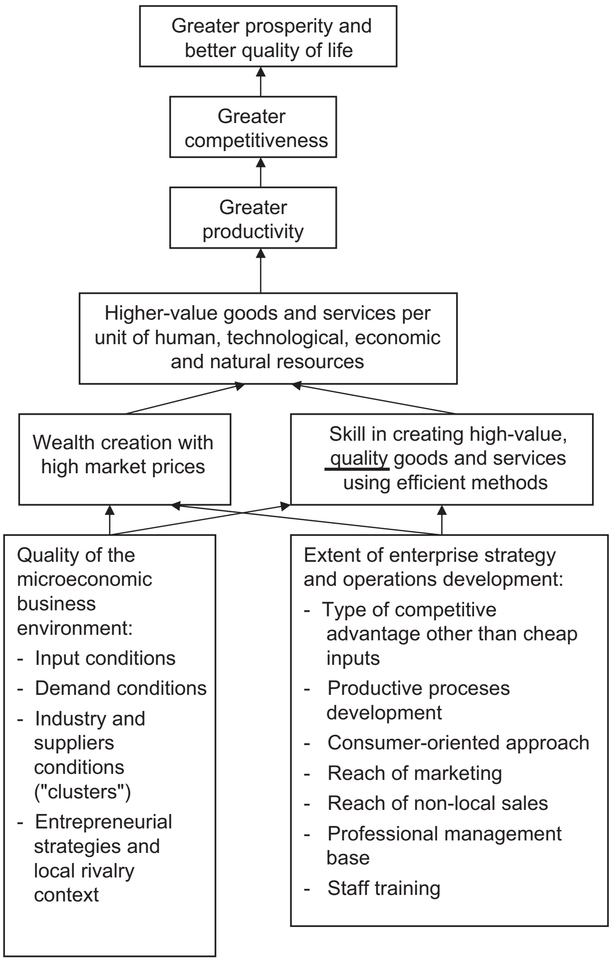
The potential for agroindustrial development in developing countries has been associated with the relative abundance of agricultural raw materials and a low-cost workforce. The traditional consideration is that the right industries for such settings are those making intensive use of raw materials and human resources, using by comparison relatively fewer of the less common resources, such as capital and skilled labour (Porter, 2003). Many industries that make abundant use of agricultural raw materials have features that make them particularly apt for prevailing developing country circumstances. Provided these materials can be obtained at reasonable cost, the advantage can partially offset the lack of infrastructure and skilled labour (FAO, 1997).

Some recent studies have shown, however, that this view of things may well set self-limiting conditions. This is because over reliance on "abundant natural resources", as opposed to their efficient and effective use, has quite possibly complicated the development of a successful agroindustrial sector and national economies in general. Economic development is difficult to achieve where policy and technical assistance are based on the extraction of natural resources, abundant, cheap labour, and raw materials and primary assembly-based trade (or, at most, simple, artisan processing). The control of value chains consists in control of the means of coordination, not the means of production. It is also based on strategic alliances and organizations, the value-added chain approach, and competition-oriented policies (Vorley, 2001). To put it another way, the traditional vision tends to be excessively localized, limited and even non-competitive, focusing on primary production and based on promoting the export of raw materials from a country which will then have to import processed goods, losing value addition. An alternative approach is to support initiatives that favor microeconomic development, where, according to Porter (2003), is where wealth is created. One example would be processing food at a slightly larger scale than that of the usual family kitchen. Home cooking-based efforts have the merit of solving immediate problems at the household and local level, but such initiatives can hardly be expected to promote sustainable community processes unless they involve the necessary social, technical, entrepreneurial, commercial and environmental considerations, and are seen as part of the wider web of agrofood systems.

What we should be doing, instead, is seeking solutions to problems of scant capital, poor or inadequate infrastructure and scarce trained human resources, so as to promote the formation of efficient enterprises and build on the strengths of the agrifood industries (even at the small-scale level) based on entrepreneurial concepts and the proper application of *ad hoc* technologies. Strategies based on the argument that there are no (or not enough) markets in today's globalized context or that promoting sustainable conditions for subsistence is a sufficient goal, are perhaps not very helpful. We also need to remember that educational development at the country level could be made a top priority of development plans and a condition of sector progress. We need to identify the factors which can promote growth and diversification for markets, the necessary investments, improvements in local and provincial conditions for business, and the variables which will allow enterprises to improve, flourish and triumph in that business environment. By tackling these problems from a holistic, systems-oriented stance the agroindustrial sector can help rural communities and societies move forward in their development.

Porter (2003) holds that wealth and prosperity are created at the microeconomic level by economic actors, particularly the enterprises and other productive bodies. Moreover, the same author postulates that the determinants of enhanced productivity can be grouped under two major factors: the quality of the microeconomic trade environment, and the degree of development of enterprise operations and strategies. Low-income countries, which usually have economies based on comparative advantages such as cheap labour and abundant local natural resources, need to improve their competitiveness determinants. They need to stop

FIGURE 8
Factors in competitiveness and prosperity



Adapted from Porter, 2003.

relying on their comparative advantages only and develop their competitive advantages in terms of their own unique products and processes (Porter, 2003). That is, the private sector actors should improve or change the way they compete to achieve economic development. For this they need better-qualified personnel, better information, better infrastructure, better suppliers and better relationships (Porter, 2003). Dirven (2001), for example, shows that small and medium enterprises are subject to and sidelined by factors such as economies of scale, access to international capital markets, perhaps limited local technical capacity, growing pressure from supermarkets, and the new developments in trade conditions. Figure 8 is an attempt to summarize Porter's postulates (2003). The sub factors determining the business environment have been conceived by Porter as four interrelated areas, represented by what he calls "the diamond of competitiveness", listed in the lower left-hand box of Figure 8.

One way of improving the trade environment is by the formation of productive groups or complexes ("clusters" according to Porter, 2003) in a specific economic field, which intervene in the production of a given set of goods. These conglomerates may be geographically close (or not), interconnected, companies, suppliers, service providers, trade associations, and associated public and private institutions of all types, linked by common and complementary elements (ECLAC, 2001). These conglomerates and their relations and processes enable the increased productivity of the principal enterprises, boost innovative capacity, and stimulate the formation of new businesses which in turn sustain innovation and expansion in the conglomerate.

Studies of competitiveness have utilized competitiveness indicators to determine the national potential for competition and growth. One indicator is the Global Competitiveness Index, based on quantitative and qualitative information, which breaks down competitiveness into eight factors or sub-indexes, including technology and management. Generally speaking, the technology factor measures the general level and quality of technology, including the ability of economic actors to absorb new technologies and engage in research and development. The management factor measures the quality of both managerial resources and competitive strategies, as well as the development of goods and control systems, including quality, human resources and marketing (Castro and Gavarrete, 2000).

Porter in turn has proposed a Microeconomic Competitiveness Index, based on a survey of almost 5 000 enterprises in 80 countries. It covers sub factors determining the quality of the microeconomic trade environment, and the degree of development of enterprise operations and strategies. This index shows that microeconomic factors have a major impact on variations in *per capita* gross domestic product. Table 3 shows selected data on the Global Competitiveness Index (GCI), and the Microeconomic Competitiveness Index (MCI) by country, for selected countries.

TABLE 3
Competitiveness Indexes

Country	MCI Rank (2002)	MCI Rank (2001)	GCI position (1999)
Chile	31	29	18
Mexico	55	52	31
Costa Rica	39	48	34
El Salvador	63	64	44
Guatemala	73	69	50
Honduras	78	74	55
Nicaragua	75	71	56

Source: Porter (2003), and Castro and Gavarrete (2000)

THE SYSTEMIC NATURE OF QUALITY

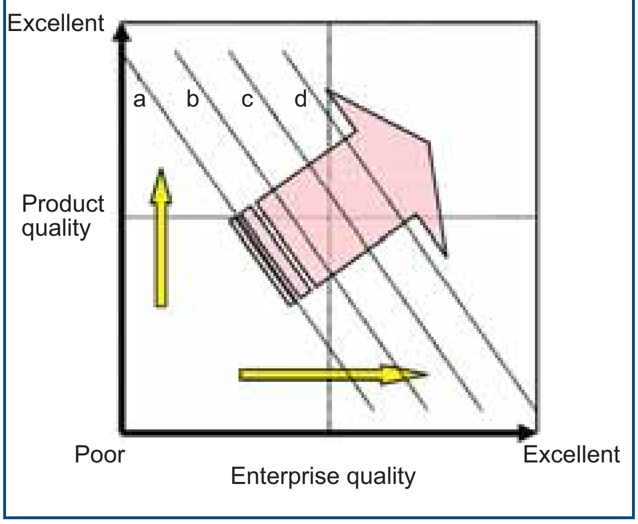
The definition of quality is usually open for discussion. Kramer and Twigg (1970) defined quality as product excellence measured in terms of a set of specifications to be met within set tolerance levels. These specifications, one might add, are framed in terms of what the market requires, at reasonable (ideally, minimal) cost to those involved. In a broader context, Juran (1988) defines quality as two interlinked components: product performance leading to consumer satisfaction, and the property of being free of defects and thus avoiding customer dissatisfaction. Potter and Hotchkiss (1995) in the classic book on food science suggested defining food quality as the measure of product excellence, including such aspects as taste, appearance and nutritional content, and comprising those characteristics relevant to determining consumer acceptance.

According to Satin (undated), quality refers to the combination of characteristics critical to establishing consumer product acceptance. For the food industry this is a mix of purity, taste, texture, color, appearance and manufacture. This author indicates that quality is associated with consumer perception of the value of a product in terms of what he/she is prepared to pay for it, which may well be subjective. In any case, once a standard is defined, product quality consists of meeting this standard. Fellows *et al.* (1995) see quality as meeting the specifications, expectations and criteria for a given product as agreed with or established by the consumer. The quality principle is seen as quality products satisfying the needs, solving the problems and meeting the expectations of users.

Other authors (e.g. Okazaki, 2002) view the term ‘quality’ as implying more than just one concept where some food products are concerned, and perhaps implying some ambiguity. Food quality can be divided into two concepts. One has to do with hygiene quality and the other with the non-hygiene aspects. The first, safety-linked concept, according to Okazaki can in turn be divided into three categories: absence of biohazards, chemical hazards and physical hazards. The second concept can be divided into four categories: sensory quality, nutritional quality, physiological quality (how the food acts to promote human health) and the quality requirements for processing (or use). This author believes that the safety aspects tend to be overemphasized, and that the others are also very important in considering the value of a product as food. From the public health standpoint, including the issues of marketing and export, safety is a front-ranking component of food quality in any case. In the context of national sanitary control regulations, for example, quality has been defined as the inherent set of product properties and characteristics which allow it to be assessed as like, better or worse than the other units and the reference unit of its kind. In this context, a food's property of being safe (neither endangering nor constituting a risk to health) is inherent in quality (Secretariat of Health, Mexico). All this may lead to recurrent discussions on whether or not "quality and safety" of food is redundant and that one may need only talk of quality as safety is implicit, or that safety has such implications that deserves to be mentioned explicitly.

In commercial areas, the term "quality" is considered in its broader sense, including all those attributes which make a consumer prefer one food product over another. In addition to the safety issues, this covers whether a product is healthful, nourishing and fresh, plus such characteristics as taste, integrity, authenticity and origin, besides any cultural or ethical value (OECD, 1999). Recent studies addressed quality management in leading companies in the industrialized countries (as an example, Gomiero *et al.,* 2003). These companies were found to view the so-called physical attributes of products as key measures of quality, and included the sensory or organoleptic parameters such as color, aroma, consistency and texture, plus appearance (size, weight, packaging condition, conditions of use, and hygiene). Enterprise quality may be seen as including all factors not attributable to the product, but which contribute to consumer satisfaction and customer perceptions with respect to the enterprise and its products, and future decisions to buy. These factors in turn serve to identify enterprise strengths and weaknesses (Gomiero *et al*, 2003). Therefore, several aspects may be included in a definition of quality, such as "satisfying changing consumer demand", "ability to meet the highest nutritional and public health standards", "optimum safety", "guarantee on the origin and nature", and other economic, cultural, economic, social and scientific dimensions (Inter-ministerial Food and Agriculture Committee, 2004). On the other hand, Formal definitions are given by standardization and regulatory bodies, such as ISO 9000:2000 Quality management systems – Fundamentals and vocabulary. Recently, a joint FAO/WHO publication established that "The terms food safety and

FIGURE 9
What quality should mean in the food industry



food quality can sometimes be confusing. Food safety refers to all those hazards, whether chronic or acute, that may make food injurious to the health of the consumer. It is not negotiable. Quality includes all other attributes that influence a product's value to the consumer. This includes negative attributes such as spoilage, contamination with filth, discoloration, off-odors and positive attributes such as the origin, color, flavor, texture and processing method of the food. This distinction between safety and quality has implications for public policy and influences the nature and content of the food control system most suited to meet predetermined national objectives" (FAO/WHO, 2003a).

Figure 9 suggests that quality, for products as for the enterprise and its resources, is an essential element in enterprise development and strategy. Quality can therefore be seen as a multifaceted concept with various components and aspects, and at least three dimensions that need to be analysed. These are product quality, enterprise quality (all factors excluding those to do with the product), and the relevant economic component. Meeting commercial standards and regulations on product quality, product safety, and product nature or identity, for example, imposes restrictions on the agroindustries which affect decisions as to compliance or non-compliance and the possible implications of each. To compete efficiently in domestic and export markets, companies need to identify the critical factors that compliance with these standards will require, in terms of making the necessary changes, and their costs. As for the three quality dimensions, product quality can be enhanced, but without enhancing enterprise quality, or vice versa, and the final outcome will be a situation of poor competitiveness. Boosting competitiveness will depend on enhancing the first two dimensions while lowering the relevant economic component. Alternatively, an enterprise may decide to produce at a pre-determined cost due to internal or external factors, and thus achieve minimum quality standards which will nonetheless allow some sort of return (OECD, 1999). The challenge is to identify the set of enterprise circumstances and trade environments (i.e. systems factors and properties) leading to maximum enterprise quality at minimum cost (or cost and quality level ensuring sustainable and enhanced competitiveness). There is no question that quality, including safety aspects, affects processing costs and cost-benefit ratios (Antle, 2000).

In the above figure, the four boxes in the graph show four different possible situations with respect to quality. Enterprises with excellent product and enterprise quality appear in the upper right-hand box. Poor product and enterprise quality are shown in the lower left-hand box. Good enterprise quality but poor product quality is shown in the lower right-hand box and good product quality but poor enterprise quality in the upper left-hand box. The lines **a, b, c** and **d** correspond to hypothetical (linear) functions of the cost parameter, in which the relationship cost **a** < cost **b** < cost **c** < cost **d** applies, for the sake of illustrating the possible effect of this dimension. These lines suggest that enhancing product quality for a fixed enterprise quality (vertical arrow) will increase cost. Likewise, enhancing enterprise quality for a fixed product quality (horizontal arrow) will also increase cost. The big diagonal arrow shows the direction in which both product and enterprise qualities rise (as do costs). The linear functions are hypothetical, of course, in that each specific case will have its corresponding cost function for different conditions of quality. In any case, the enterprise will have to move in the direction of the conditions found in the excellence box, but at the same time keep costs to a minimum, all in accordance with the prevailing business climate. Some small food industries in Latin America and the Caribbean seem to be facing problems when trying to optimize their performance in this domain, or simply are not able to identify and devise possible and feasible solutions to their priority problems.

When a more in-depth systems analysis of the interior of an enterprise is done, one may realize that the technological aspects cited in the discussion regarding Figure 8 are in turn based on other specific components which can be grouped into systems-linked subgroups. These

TABLE 4
Selected technological and management factors affecting industrial competitiveness and quality

Infrastructure: • Sanitary construction and design • Specifications • Building materials • Lighting • Ventilation • Power • Drainage and emissions • Worker safety	**Equipment:** • Sanitary design and construction • Specifications • Building materials • Assembly, installation and layout • Worker safety • Hazards and contamination • Maintenance and replacement parts • Consistency and operational continuity
Process technology: • Type of process • Unitary operations • Process flow • Materials properties • Materials balance • Energy balance • Process control • Raw and in-process materials handling and requirement • Storage • Packaging • Manpower • Energy and services requirement • Waste and emissions handling • Worker health and safety	**Location:** • Market access • Means of transportation • Raw materials availability • Manpower availability • Water • Power • Land • Waste disposal • Public services • Taxation and legal restrictions • Environmental conditions, climate, natural hazards • Socio-economic and community conditions • Legal and political conditions and relations
Markets: • Product uses and types • Product quality • Product quantity • Availability of supplies • Imports and exports • Market conditions	**Costs:** • Fixed • Variable • Capital • Property • Technology • Time and opportunity
Services: • Steam • Electric power • Fuels • Compressed air • Refrigeration, freezing • Inert gases • Cooling water • Processing water • Cleaning water • Transport • Quality analysis • Financial means • Training • Research and development • Market information	**Management and economics:** • Processes • Quality incentives and costs opportunity • Marketing and market share • Research and development • Administration • Innovation • Owner or stakeholder satisfaction • Position and public service to society • Public relations • Financial health and company sustainability • Human resources • Information • Enterprise strategies • Overall competitiveness

Adapted from Peters and Timmerhaus (1980) and with contributions from the author.

families of components, affecting competitiveness and quality from the very conception of a given industry, are summarized in Table 4.

The determinants of location, for example, are highly complex, as can be deduced from this table. For agro industries in rural and other areas in developing countries, transport is a major factor. Transport results in both physical and economic losses in most cases. This is exactly why many agro industries are established in the first place. Removing moisture from raw materials is usually a major objective. Food transport, therefore, is a key element of supply chains, food marketing and national development. Recent studies carried by FAO in the Latin America and the Caribbean region have demonstrated that in order to improve rural living conditions, increase income, and get communities and countries updated with social development, cost-effective actions through integrated, coordinated and multisector interventions are needed, directed to optimize this key element related both upstream and downstream to the food industry (De León *et al.*, 2004).

The other factors listed interact and affect the decision on where to locate. Energy and manpower availability are also vital, as are public services and, of course, proximity to the raw material production area. At the other end of the chain, however, market proximity is also a prime factor, entailing lower distribution costs for the finished product. In competitive terms, a country faces the challenge of enhancing the quality of the business microenvironment (Figure 8), through efforts to improve infrastructure, heighten the educational and other capacities of the workforce, and generally foster a favorable climate for the agroindustrial activity (Porter, 2003).

Another important element in process engineering and technology is energy requirements. As seen in Table 4, the energy factor affects the productivity of and return from processing activities. Energy is a key factor in successful operations, and arguably a direct processing input or requirement for ensuring the availability of a given service. Industrial services, after all, also require energy to pump water, for instance, or to operate hydraulic machinery. Every process, in line with its degree of development, normally requires more and more diverse services, with the corresponding impact on costs and returns. The percentage of energy required by type also varies from one industry to the next, depending

TABLE 5
Approximate comparative use of processing inputs

Type of industry	Input		
	Water litre/kg product	Steam kg/kg product	Electrical power kW-hr/kg product
Maize starch production	2.5	1.7	0.121
Oil hydrogenation	5.0	0.5	-
Oil extraction	21.7	2.0	0.022
Sugar refining	50.0	1.8	0.035
Lactose production	833.7	70.0	0.396

Adapted from Shreve (1967)

on whether the source is natural gas, electricity, petroleum products, coal (Singh and Heldman, 1993) or biofuels. Table 5 illustrates the requirements of selected services in the food industry.

Better access to and use of energy services, especially the agricultural and agroindustrial support services, can help reduce poverty. All post-production operations in the food chain require the efficient provision of energy inputs, efficiency here being a *sine qua non* for sector development. Indeed, energy in the food industry is a variable affecting product quality and safety, productivity, market share, and, lastly, economic and enterprise success. It is widely known, for example, that the correct choice of fuel can affect the processing costs profile and also the characteristics of processing operations and their output, merely by the varying calorific content (and, of course, the price) of each fuel, as Table 6 shows.

TABLE 6
Calorific value of selected fuels used in the agroindustries

Fuel	Calorific content, MJ/kg
Liquid propane	50.00
Fuel oil	46.05
Charcoal	30.80
Coal	30.18
Ethanol	27.67
Methanol	20.90
Maize cobs	19.30
Coconut and coffee husks	16.70
Fuelwood	13.80
Sugar cane bagasse	8.40

Source: Data from FAO (2000a) and Perry (1984)

One other factor, so vital and important for enterprise performance that it alone demonstrates the suitability of the systems approach, is raw material quality (Cuevas, 1992). Agricultural raw material quality is affected by production aspects, including such factors as seed selection, fertilizer application, weed control, pest and disease control, cleaning and selection (FAO, 1997). The same can be said of raw materials of animal origin. The efficient, cost effective and appropriate application of Good Agricultural Practices as intended to improve quality and safety of agricultural products will have an enormous effect on the quality of the final processed product, since no food industry can transform in a high quality and safe food product a lousy and bad quality raw material without deceiving the consumer. Issues such as crop production and protection, animal production, health and welfare, harvesting and on-farm processing and storage, energy management, and human health, welfare and safety, are among the recommendations for GAP implementation. As part of any effort to assure quality and safety of food, the formulation and implementation of good agricultural practices of a holistic and multidisciplinary nature for crop and livestock production through to the horizontal and vertical integration of markets has been recommended (FAO, 2003).

From the food industry point of view, one type of processing often requires a specific type of raw material, and, in turn, a specific type of raw material will be particularly apt for a specific type of processing. Many quality factors depend on aspects belonging to other systems, e.g., varieties, crop rotation, use of agrochemicals, in the farming system determine the type of material that becomes an input to the food processing plant. For fruits and vegetables, for example, a set of physiological pre-harvest factors demonstrably affects the post-harvest stages. Environmental factors such as temperature, luminosity, irrigation practices, soil type and winds are important, for example. Farm practices such as mineral nutrition and growth regulators have an impact on the following citrus quality factors (adapted from Duarte, 1992):

- Taste
- Weight
- Ripeness
- Rind thickness and texture
- Soluble and total solids
- Acidity
- Ascorbic acid
- Volume of juice
- Color

- Shape
- Size
- Pulp texture

With respect to processing technology, listed below are some of the more important physicochemical properties of processing materials and products in terms of food engineering activities regarding the design and control of processing lines. There have a bearing on quality and therefore on competitiveness:

- Melting point
- Boiling point
- Vapor pressure
- Density
- Composition
- Enthalpy and specific heat
- Thermal conductivity
- Viscosity
- pH

Getting even deeper into the engineering and technology aspects in a food industry, it has to be borne in mind that processing variables are those central factors of the processing subsystem that determine product characteristics. They are in turn dependent on equipment design, technology, manufacturing practices, human resource capacity, and the managerial approach of enterprise strategy. Processing variables can therefore be directly linked to the items listed in the bottom part of Figure 8. For entrepreneurs, and especially for engineers and technicians, these variables afford the opportunity for upgrading enterprise operations and strategies. Processing equipment and its performance is and unquestionably will be decisive in the quality of the end product. This is illustrated by the selected performance variables of processing equipment listed in Table 7.

Familiarity with the engineering aspects of operating equipment is obviously important for successful control of the key variables. This requires much more than a simple definition of the desired limits of these variables. The following steps in processing control are given for industrial processing, for example.

- Identify and list processing variables

TABLE 7
Characterizing performance variables of selected processing equipment

Equipment	Variable for operational design	Capacity variable
Centrifugal pump	Discharge head	Flow rate Power input Impeller diameter
Cyclone	Particle size	Flow rate Greatest diameter
Evaporator	Latent heat of vaporization Temperatures	Flow rate Heat-transfer area
Plate-and-frame filter	Cake resistance	Flow rate Filtration area
Tube-and-shell heat exchangers	Temperatures Viscosities Thermal conductivities	Flow rate Heat-transfer area
Mixers	Mechanism of operating system Geometry	Flow rate Power input
Hammer mills	Size reduction	Flow rate Power input
Continuous reactor	Reaction rate Equilibrium state	Rate of flow Residence time
Batch reactor	Reaction rate Equilibrium state	Volume Residence time
Screw conveyor	Bulk density	Flow rate Diameter Drive horsepower

Adapted from Peters and Timmerhaus (1980)

- Define the magnitude, source, timeframe and nature of changes in these variables
- Select the key processing variables
- Establish which key variables are subject to control
- Select the primary variables for control and set acceptable limits
- Establish the control protocol
- Repeat the same analysis for the secondary variables

This procedure contains the basis of control theory and of the most classic elements in industrial processing control. These are in turn based on a systems approach, as Figure 10 (a classical) illustrates.

The human factor, moreover, has always been a major determinant of competitiveness and industry success (including the food industries), and always will. Table 8 shows the complexity of the human contribution and relationships as an essential systems component for efficiency and effectiveness, with a direct impact on quality and thus competitiveness.

TABLE 8
Personnel characteristics affecting efficiency and effectiveness

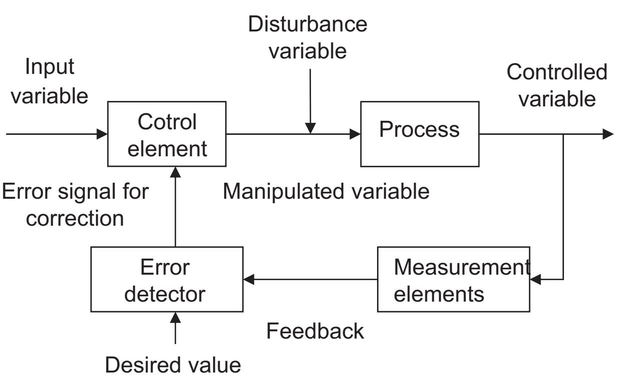
Skills	Know-how	Type of work	Attitude
• Mechanical skills	• Sufficient	• Monotonous	• Initiative
• Dexterity	• Necessary	• Situation and surroundings	• Enthusiasm
• Application	• Appropriate	• Hazardous	• Devotion
• Resistance	• Updated	• Simple or complex	• Responsibility
• Continuity	• Applied	• With equipment	• Interest
• Uniformity	• Solid	• With materials	• Participation
		• With services	• Cooperation
		• With personnel	• Ethics

TABLE 9
Human resource characteristics essential for competitiveness

Technical	Personal
• Managerial skills	• Creativity
• Entrepreneurial orientation	• Awareness of the need for quality, safety and efficiency
• Principle-, criteria- and excellence-based technological capacity	• Commitment to supplying society with better food products
• Adaptability to enterprise and enterprise environment	• Commitment to helping solve the social problems of food availability and malnutrition (Figure 3)
• Market-oriented, and hence customer-oriented approach	

Adapted from Cuevas (1998)

FIGURE 10
Block diagram of a control system



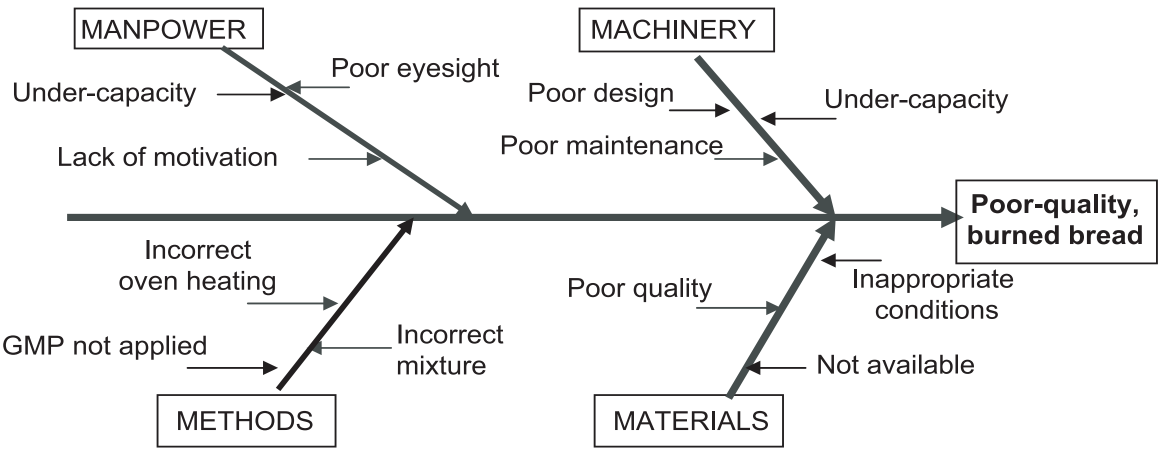
Adapted from Perry *et al.*, 1984.

The microeconomic competitiveness factors listed in Figure 8 suggest the kinds of professional management and highly skilled, trained personnel which global markets and economic conditions in the twenty-first century demand. This leads us to a definition of the human resource characteristics which will have to be sought and promoted, as shown in Table 9.

Further, systems analysis of the processing plant within the food chain subsystem can reveal factors bearing on product quality, and their interaction. One common way of showing this is by using cause-and-effect diagrams such as the fishtail diagram (Whiteley, 1994). Figure 11 gives an example of this for a bread bakery. In this diagram the 4-M (manpower, machinery, methods and materials) are represented along with their principal component sub factors as causes of the outcome expressed here ("poor-quality, burned bread"). In other cases "means" is substituted for machinery, a distinction is made between raw materials and in-process materials and management may be added (the latter as a fifth "M"), including marketing.

Primary sub factors such as "poor design" and "poor maintenance" affect the "machinery" subsystem, factor or system component. This then interacts with other factors such as "manpower", composed by various primary sub factors such as "lack of motivation" to determine the quality of a specific batch of bread. In this diagram, we may imagine that the small horizontal arrows represent the contribution (effect) of each sub factor, whereas the diagonal arrows represent the relationships and interactions of the sub factors, which result in the contribution of each factor. The central horizontal arrow represents the relationships and interactions of all these factors, and produces the result in the box on the right. We have thus shown the primary elements determining product

FIGURE 11
Fishtail diagram of a bakery



quality. They are not necessarily and solely attributable to the bread-making process as such. Poor quality of materials, for example, may stretch as far back as poor wheat seed management and inappropriate farm practices. As for processing, some studies suggest that there perhaps ought to be a global factor, or "sixth M", which would be "management". With this analysis we have established the fact that quality can be looked at as having a systemic nature, and taken advantage of this to learn which factors determine quality. It is now obvious that the bread-making plant (or simply the small bakery) is a subsystem within another system, made up of suppliers, buyers, regulatory bodies, transport providers and other systems entities, as shown in Figures 3, 4 and 5, which may easily be applied here as to comprise the bread food chain. In turn, the bread food chain is a subsystem of the wheat chain, within the great agrifood system. As an example, a high positive correlation has been found between raw material quality and final product quality for different fishery species in Argentina, including favorable effects on labor productivity, productivity and operating costs (Zugarramurdi *et al.*, 2004). Similar analyses can be constructed for the issue of food safety.

To summarize, we can see that quality and competitiveness can only be achieved and improved if the key elements affecting them and determining their outcome are identified and effective action taken to effect positive change. This must be done at the lowest levels of the agrifood hierarchy, i.e., the individual actors in the agrifood chain, through systems analysis of each productive entity in the enterprise and in the corresponding cluster, within the national agro alimentary context.

To analyse quality factors and design quality-enhancement strategies, we need to look at the concept of cost-effectiveness, which is the effect or impact produced per unit of cost. In the systems approach, effectiveness is the relationship between the system and its environment, or the impact of the system on this environment. Efficiency, on the other hand, refers to the relationship between the inputs and outputs of the system, such as achieving the greatest possible output for a given input (the maximization principle). Effectiveness usually indicates performance levels achieved with respect to the proposed objectives (Heylighen, 1998, 2003). Food product quality objectives are defined on the basis of market studies, norms and standards (such as the Codex Alimentarius, international trade standards and national regulations), of the express requirements of consumers and the mission and plans of the enterprise. It is important to establish the necessary cost control mechanisms, including the respective sensitivity and scenario analyses, in order to determine the cost-effectiveness of quality as illustrated in Figure 9.

The important thing where effectiveness is concerned is to realize that knowing the quality objectives, while essential, is not enough. In other words, having a standard or norm in hand or knowing what the market demands is not enough to produce a product of given quality that meets a given set of specifications. Proper technological as well as managerial capacity is essential in order to determine which factors interact at the various stages or parts of the subsystems and how. They can then be suitably and correctly modified to gain control of the system, and ensure that the desired outcome is produced at a cost level permitting a competitive position. In the "zero defects" concept, the goal is to do everything well from the outset, applying a preventive approach. This implies that it is better to design quality as inherent in the product and operations, instead of measuring the extent of compliance with respect to goals (specifications, methods, standards) via complicated and costly follow-up systems (Juran, 1988). In the past (and even in many companies today), "quality control" departments have traditionally understood "control" as "verification", "inspection", "survey", or "observation", rather than seizing on the term "control" in the sense of "mastery", "power", "command", "domination", "steering", for application within a more integrated and at the same time more reasonable and effective context.

Application of the "zero defects" concept as well as the concept of control in the sense of mastering and directing operations and processes, using a preventive approach, gave rise to use of the systems approach *par excellence.* The goal was to ensure one of the major components of food quality: food safety. This concerned the concept of hazard analysis and the control of critical points (*Hazard Analysis Critical Control Point System,* HACCP). It was designed and widely applied by the food industry in the United States, which was working with the space programmes of the 1960s on reducing health risks from food hazards. The concept has been exhaustively described for the last three decades in the technical and scientific literature (Bauman, 1974; Ito, 1974; Troller, 1983; Cuevas *et al.*, 1989; Cuevas *et al.*, 1990; IAMFES, 1991; Bryan, 1992; Cuevas, 1993; FAO, 1998; Mejía *et al.*, 1998). The broad HACCP concept is based on understanding all factors contributing to the rise of food-borne diseases, including the agricultural, ecological and biological characteristics, the processing and food management aspects, and the cultural aspects. In this particular systems approach, hazards are evaluated at all stages of the production, harvesting and management of raw materials and ingredients, processing, distribution, marketing, and food preparation and consumption, i.e., at every stage in the food chain. The principles that lay the foundations for ensuring food safety and the recommended HACCP approach are thoroughly described in a specialized CODEX document (FAO/WHO, 2003b).

The analysis of the manufacturing process is broken down into its operational components, which can be managed, analysed and controlled independently and individually, but which are also of such a nature as to make a definitive contribution to the final characteristics of the product and the overall outcome of the process. An analysis designed to identify potential hazards considers raw materials and ingredients, product handling and use. The critical points are simply the practices, procedures, operations or locations within a food system where loss of control can result in an unacceptable health risk. To put it another way, these are points where a preventive measure (or control measure) can be implemented to prevent a hazard to food product safety and hence to consumer health. As in any systems approach, the part of the analysis corresponding to the process is represented by a flow diagram showing the systems interrelatedness of operations, materials and flows. Presented below is an example of the application of this method in a hypothetical processing case.

It is obvious, in any case, that successful application of this method rests on the exact, efficient and cost-effective application of control methods at the critical control points, besides the scrupulous adherence to good manufacturing practices and standard operating procedures, as is required as a pre-requisite to HACCP implementation. However, one possible shortcoming in the application of this method concerns the assumption that control of the critical control points (once it has been

TABLE 10
Simplified example of HACCP for processing pulses

Operation	Hazard	Risk	Control	Follow-up	Action	Verification
Reception Washing Sorting	Spores	High	GAP*	Observe GAP		
Cold storage	Microbial growth	Med.	Temperature GMP*	Take measurements		Observation
Cooking	Spores not inactivated	High	Time-temperature GMP	Measurements Assess operating equipment Collect samples		Observation Measurements
Cooling	Spore germination	High	Time-temperature GMP	Measurements		Observation Measurements
More....	...	...	...	...	...	...

* GAP = Good Agricultural Practices; GMP = Good Manufacturing Practices. The General Principles of Food Hygiene Practices are recommended by Codex (FAO/WHO, 2003).
Adapted from IAMFES (1991) and Bryan (1992).

established that control is necessary) is actually feasible. Without real control of the critical points, not even the best intentioned and designed HACCP with the best follow-up will function effectively. Control measures must be feasible and practical in technical and economic terms (Bryan, 1992). Control actions are in turn much more complex than the simple definition of critical limits (prescribed tolerances which must be met to ensure hazard control) or measurements required for follow-up, and much more than a simple practice, or mere handling of some part of the equipment such as a thermostat. Often, once an HACCP analysis has been prepared, the critical control point is simply identified as "scalding", "freezing", "pasteurization", "heat treatment", "toasting", "drying", or "fermentation", for example, as illustrated in the many publications and books on the subject. These critical "points", however, are actually operations, parts of a process comprising a subsystem within the processing plant subsystem. Each of these operations, which in food and chemical engineering are called "unit operations", is in turn made up of a complex combination of and interactions with plant equipment, methods, manpower and materials (Figures 4, 5, 10 and 11). In these interactions, many dependent and independent variables, governed by physicochemical laws and acting in a physical and managerial environment, determine the result within a given timeframe under certain specific conditions.

As intimated in Tables 4, 7 and 8, and Figures 4, 5, 6, 7, 9, 10 and 11, because we are dealing here with systems, both control and corrective action may require complex analyses, calculations and specialized decisions from processing engineers, all with definite cost repercussions. Control therefore has an economic as well as a technological connotation. Using the correct time/temperature combination may well be more expensive, for example, that using a sub-optimal combination. This is why a correct, effective and viable HACCP application requires an in-depth systems analysis, or rather an analysis of the food chain as a system based on multidisciplinary criteria, as opposed to a simple microbiological approach to processing. Achieving other product quality features can be conceived in similar terms. In technical terms, Good Agricultural Practices, Good Manufacturing Practices, Standard Operating Procedures, and General Principles of Hygiene are all interrelated quality and safety assurance tools, and not objectives themselves.

Lastly, there are acknowledged problems with how small or less developed businesses handle the implementation of HACCP with respect to the food safety issue, so special guides are needed for such businesses. Some barriers to implementation have been identified. They include lack of state commitment, the characteristics of demand in the trade environment, the lack of legal requirements, financial and personnel problems, lack of technical support, poor infrastructure and installations and poor communications. This being the case, it has been recommended that strategies be developed to facilitate the implementation of HACCP in such industries (WHO, 1999). Efforts have also been made to evaluate HACCP cost–benefit ratios by diverse means, as an example by surveys through federal inspection systems in Mexico (Maldonado *et al.*, 2004), or using elaborate methods such as the application of the Bayesian theory of decision-making (Schimmelpfennig and Norton, 2003). We may add that one problem with the application of HACCP, in more developed as in less developed businesses, concerns the failure to consider that the steady, sustainable and effective design, implementation and utilization of HACCP depends on food handling and processing engineering technologies. These are part of a subsystem where technology, economics and management interface each other in the microeconomic business environment, requiring a multidisciplinary systems approach.

Chapter 3
Moving from needs to strategies and actions

ARE NEW PARADIGMS NEEDED?

A paradigm is a theoretical model which explains a type of phenomenon, or some social or economic behavior. It comprises the whole context and schema within which a thing or phenomenon is perceived, conceptualized, realized, validated and evaluated, with reference to an image or perception of reality, at any given moment or time, in any given social, economic or technical domain (Heylighen, 2003). Under the current circumstances of the world economy and those of Latin America and the Caribbean, new and innovative approaches may need to be developed for small agroindustries in developing country agrifood chains, perhaps even new paradigms. This paper proposes the possibility of revising the older paradigm on strategies for efficient, effective action to meet priority needs, enhance quality and competitiveness in the small food industries in Latin America and the Caribbean, and promote agricultural development. The strategy and action thus generated will in turn promote food security, and may be helpful as a guide or reference for other regions as well.

Our present state of knowledge indicates that progress in any given country, whether developed or developing, is directly linked, among other factors, to progress in the production sector. Sector development, success and sustainability are in turn directly linked to competitiveness. As mentioned, quite apart from the specific characteristics of the organizations, institutions, individuals or products involved, competitiveness is demonstrably dependent on both microeconomic and macroeconomic factors (Porter, 2003). Improving some aspects while ignoring others will not necessarily lead to substantially and sustainably increase competitiveness, and may indeed even lessen the capacity to compete. This is especially critical for developing country agricultural sectors. Isolated efforts such as increased investment, new political and institutional frameworks, renewed access to diversified markets and enhanced national infrastructure, are, though essential, simply not enough. They need to be backstopped by action targeted at productive agents in the food chain. Efforts need to be directed at pinpointing the principal systems components and how they interact in terms of competitiveness.

Defining the appropriate strategies, lines of action and operational practices for a positive, sustainable, environmentally friendly and human development oriented impact on competitiveness should be tailored to economic and social development and specific needs within the different countries. For a given country, our reasoning is based on the following premises:

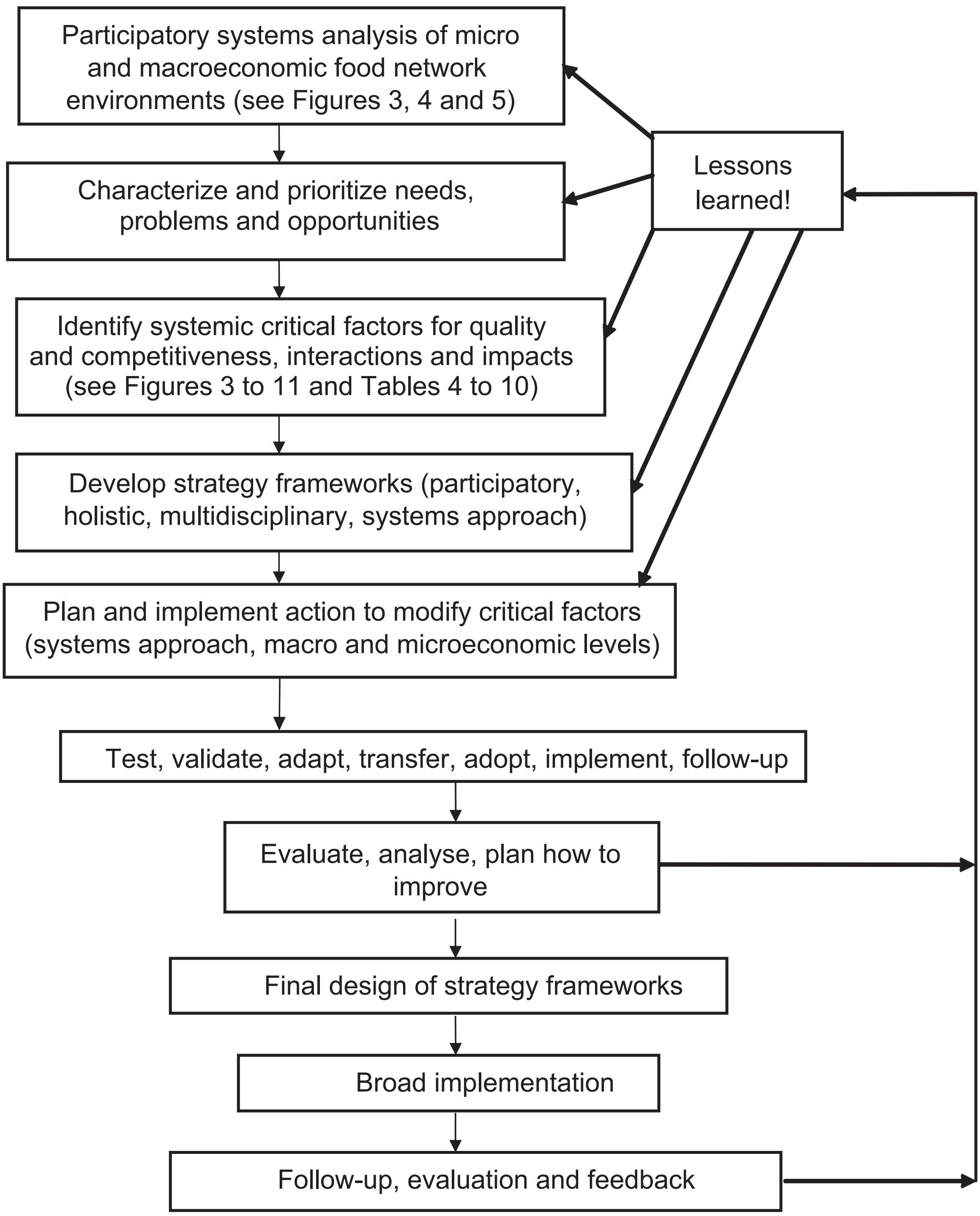
- Agricultural development contributes to a country's social and economic development.
- Greater prosperity and higher living standards are essential for agricultural development.
- Heightened competitiveness in the agrifood chains can boost prosperity for all actors in these chains.
- Factors affecting chain productivity, seen as systems components, must be improved to increase competitiveness.
- Factors affecting productivity are multiple in nature at macro and microeconomic levels, interacting and interrelating in dynamic ways in agrifood chains as parts of complex and dynamic subsystems.
- According to Porter (2003), effective action depends equally on improving the quality of the macroeconomic business environment and on developing (enhancing the capacity and effectiveness of) enterprise strategies and operations, mindful of the multidisciplinary nature of enterprise components.
- Food quality and safety, cost-effectiveness and commercial success are all indicators of productivity. They can be enhanced by improving enterprise development and the economic climate. These indicators may represent the aggregate effects of the system in making a given output or performance more competitive.

Some countries have postulated various lines of thought and action to promote and develop agroindustry, including state policy and mechanisms, expanding available resources, and improving available technology and training (Tratado de Cooperación Amazónica, 1995). We may hope to see individual enterprises boost capacity by themselves, benefiting participants, but such isolated acts cannot reasonably be expected to have a significant and sustainable bearing on competitiveness in the food chain even at the local level, much less at the country level. A frequent item on the agenda for discussion in many developing countries is the impact of international food safety regulations and their impact on the ability of these countries to meet these standards and still be economically efficient. In any way, the promotion of food quality policy and actions schemes that take into account the widest possible context, with participation and consultation between economic actors, government, technology and information providers, and the social community (Interministerial Food and Agriculture Committee, 2004).

A systems analysis aimed at reaching an acceptable level of competitiveness needs to focus on boosting the key determinants of technical, scientific, commercial, economic and institutional capacity. The overall approach should be founded on an analysis of food quality systems within a systems analysis of competitiveness. This means using the systems analysis to identify the specific context, components, relationships, priorities and key factors which can efficiently and truly bring about a sustainable increase in food quality and competitiveness.

Figure 12 presents one way of visualizing the implementation of more effective strategies and action for a country, both at the macroeconomic and microeconomic levels. This systems model is based on identifying and attending to needs, understanding that they are complex and systemic in nature, then seeking opportunities, and next defining systems objectives and critical systemic factors for enhanced food quality and safety. This leads to the definition of integrated, feasible, effective strategies and actions to boost competitiveness. In the concept illustrated in this model there is no room for the traditional *a priori* decision approach stating that isolated, one-off, action at the microeconomic (or even the macroeconomic) level, or the application of "one size fits all" solutions, can be appropriate or adequate ways of boosting competitiveness. On the other hand, catalyzing approaches are advisable, such as fostering local participation, adaptation of approaches to local conditions, consideration to cultural ways and priority needs, empowering of leaders at significant

FIGURE 12
Strategy and action to boost quality and competitiveness in small food industries within agrifood systems at the country level



cluster and chain levels, and providing required support with view to provide a flexible and enabling business environment.

COMPREHENSIVE STRATEGY DEVELOPMENT AND ACTION PLANNING

The different approaches to the analysis of agrifood systems have been extensively reviewed recently (Castro and Gutman, 2003). One example of a specific methodology for evaluating competitiveness in food chains is found in the work of Da Silva and Batalha (1999). These authors propose selecting the leading factors in competitiveness and their links, and then evaluating their impacts and the extent and kinds of control which can be exerted over these factors. One case concerned the livestock chain. It identified the sub factors involved in breeding, rebreeding and fattening technologies, inputs, enterprise management, market links, market structure and the institutional setting. Here the factors broken down into two separate categories in Figure 6 are presented as one. Another good example is the agrifood sector analysis methodological review done for the beef sector in Brazil, where the advantages and disadvantages of various methodologies were addressed (Henry *et al.*, 1999). A methodological review and proposal for chain analysis methodologies was also performed recently, focused on European food chains (Attaie and Fourcadet, 2003).

We need the systems approach to explain new developments arising out of the new global context and the value it places on quality. We need to consider this from the standpoint of economic, commercial and institutional interaction within the enterprise environment, and managerial, financial and technical factors within the enterprises. We need to analyse the origin of the forces behind the demand for quality, and understand whether the various requirements and trends truly represent consumer demand, or whether the driving force behind them is the national and international industrial firms (including the big supermarket chains), and how their new supply, sales and advertising practices and massively bankrolled and aggressive sales strategies can influence the market.

Lastly, it is also important to know how food chain subsystems are evolving under the drive for better quality. We should not forget that dynamism is a systems property of the food chain. We see this in the way its components interact in tandem and sequentially, creating a vast web of simultaneous interactions among components and subsystems. This may well increase the complexity of the system and how it operates, producing constant change and new properties. In this context, safety regulations and quality specifications governing trade and sales exert pressure from one side while production, processing, management and marketing costs for a given level of quality press from the other. This can produce a sort of cyclical domino effect whereby no subsystem is prepared to absorb the potential cost increases due to higher quality standards or parameters. And that may give rise to a paradox wherein many people may desire or even demand quality products and advocate the value of quality, but are not necessarily prepared to pay for them. On the enterprise side, it is a known fact that production costs and hence competitiveness have been affected by the new international regulations (OECD, 1999), which force entrepreneurs to make choices between complying with standards and getting profits.

These considerations suggest that quality implies much more than just a standard or some verification methodology traditionally referred to as "control". It suggests that looking at quality as a systems objective means grasping the inherent magnitude and nature of the system and its subsystems, interrelationships or concatenations, as well as the technical, managerial, economic and social implications. It is natural to view quality as a systems product and essential component of competitiveness, and as an objective aimed at heightened competitiveness. This is why the systems analysis needs to be made in terms of the systems objective, and why isolated action that disregards the eventual repercussions, the linkages among and nature of systems factors, and the systems trends and adjustments operating within the food chain is doomed to irrelevance.

By implementing the proposal summarized in Figure 12, using approaches such as those illustrated in this work to identify probable areas of action, and mindful of the complex nature of quality as illustrated in Figures 9 and 11, we should arrive at a definition of concrete lines of strategy to tackle the issues of quality and competitiveness. The procedure will use various tools ranging from basic surveys based on observation, inspection or interviews, to groups of experts and analytical and discussion workshops, to descriptive historical analysis, to cost and value chain analysis. It may employ more elaborate methods such as, perhaps, sampling and control via statistical designs and methods, dynamic observation of processes for the construction of empirical or mechanistic models, response surfaces based on factorial models, time series as part of statistical control and variation studies of quality, multivariable analysis, and evolutionary operations studies (Box *et al.*, 1978). It may even encompass highly advanced quantitative operations research techniques, econometric analysis and decision models (Schimmelpfenning and Norton, 2003). Private sector actors may decide that they need to use a host of management, marketing and quality-safety surveillance and control tools to reach their business objectives. One of those may be traceability systems, oftentimes considered as one essential element for a safe, high quality and efficient food supply. These systems are in general aimed at improving supply management, facilitating traceback for food safety and quality, and differentiating quality attributes of foods for different markets, all within a cost-benefit framework for the enterprises involved (Golan *et al*., 2004). All these tools have been widely covered in numerous specialized studies, publications and documents, which can be consulted directly for greater detail which is not relevant to our discussion here. The approaches may be adopted for use in networks of small-scale food industries, but of course the concepts are applicable to one or more enterprises of any scale.

As a check list of items for multi-disciplinary, multi-sector, multi-institutional participatory analysis teams, presented below are selected examples of possible areas of action designed to modify the critical factors as a typical result of a systems analysis for constructing strategic frameworks applying the reasoning expressed in Figure 12.

Consideration of the following with reference to quality in the macroeconomic environment (food industry systems) is recommended:

- Strengthen the technical, managerial and commercial capacities of food chain actors in all major food system aspects concerning enhanced quality and competitiveness, including the development of decisional information support systems for management.
- Increase productivity through the correct use of available technology and develop effective and beneficial links among

producers, processors and traders, and with other actors in food subsystems.

- Strengthen institutional, economic and policy capacity as needed, including:
  - ➢ policy formulation and the establishment of institutional capacity and services for rural agroindustry;
  - ➢ develop basic social services including the financial aspects, communications and transport, and most of all education, as components of rural development programmes;
  - ➢ develop technological infrastructure, including research and development capacity aimed at technology transfer and efficient extension services. This includes improving institutions that can contribute to economic development, such as universities, technical schools, regulatory and standard-setting bodies and the extension services. Relations with the private sector also need improvement.
  - ➢ develop market infrastructure, including market information;
  - ➢ develop macroeconomic and trade, investment and trade, and agroindustrial production and export policies, together with the corresponding financial programmes and management and information systems designed to favor competitiveness;
  - ➢ develop conglomerates to promote productive initiatives by groups of food chain agents and motivate innovation and integrated development. This will call for policy support for the growth of highly qualified economic actors with better strategies through the promotion of incentives, rivalry and trade interdependency.
- Protect the environment through sustainable interventions and promote the use of renewable energy sources and the reduction of greenhouse gas emissions.

In the microeconomic environment (food industry and related network or cluster), with reference to improving the management aspects:

- Carry out systems studies on the economic and policy aspects of food safety and quality.
- Develop managerial tools for success in modern markets which demand high quality.
- Conduct feasibility studies for reengineering agroindustrial production to ensure quality and boost competitiveness.

- Develop and implement total quality control systems.
- Develop business tools for cost-effective compliance with regulations and standards.
- Conduct training in quality and food safety culture, including the technical, economic and commercial aspects.
- Carry out market and consumer studies on food quality and safety demand trends.
- Generate and disseminate food safety and quality information, and contribute to awareness-building.

Also in the microeconomic environment (the small food industry itself), with reference to development of the technological aspects:

- Promote improved and hygienic practices and technologies in classification, processing, packaging, transport and storage.
- Conduct design, construction and sanitary utilization of equipment and installations
- Conduct development, maximization, validation, analysis and control of processes with prevention-oriented quality assurance approaches.
- Improve and guarantee raw materials quality including the application of Good Agricultural Production Practices.
- Apply combined preservation techniques.
- Improve and guarantee in-process and finished-product materials quality and safety through the application of Good Manufacturing and Handling Practices.
- Develop and apply effective, low-cost, environmentally-friendly preservation technologies and packaging materials.
- Improve non-microbiological quality factors.

GETTING INTO ACTION

The heart of this document is to propose ways on how to be able to evolve from a process directed to devise sound strategies, using the systems approach, to the hands-on process of implementing cost-effective actions, that will assist small food industries and their networks to improve their performance, deliver high quality and safe foods to markets, increase their competitiveness, and contribute effectively to national productivity and development. Therefore, it is convenient to present some experiences related to different implementation modalities that would illustrate how to put forward the approach presented through these lines. The information that follows, coming from different contexts and periods and all except one from real life cases, is intended to give a rapid overview and examples of interventions from the global, macroeconomic international and national levels (in which agroindustrial systems are immersed) to the microeconomic level of specific food industries or in general post-production stakeholders and their networks at local levels. Therefore, cases demanding comprehensive frameworks may be contrasted with very concrete and practical situations and the successful ways in which, through the application of the concepts explained herein, effective actions have been or may be put forward.

How to develop global strategic frameworks?

Given the identified need of many developing countries to compete in markets, and their limitations due to limited trained human resources, inefficiency within the sector, a competitive global environment and lack of appropriate governmental support, a strategic framework was developed recently. The Food and Agriculture Organization of the United Nations (FAO) has led an important strategy development effort regarding the post-harvest sector, collaborating with key partners and country stakeholders to develop a global strategic framework (FAO, 2004b). This is “A Global Post-Harvest Initiative. Linking Farmers to Markets – A Strategic Framework”. The purpose of this initiative is to improve the livelihoods of poor people by enhancing agrifood systems through sustainable and equitable post-harvest interventions. The FAO, the Global Forum on Agricultural Research (GFAR) and the Global Post-harvest Forum (PhAction) were the partners in this effort, with participation o a number of stakeholders. This framework originated on three supporting initiatives developed over the years 2000-2003: the Global Initiative on Post-Harvest (by FAO and GFAR), the Linking Farmers to Markets Initiative (by PhAction), and the Agro-based Small and Medium Enterprises and Markets in Developing Countries programme (by GFAR). The framework has a strong regional and sub-regional basis, obtained through a series of workshops and consultations in all regions, which culminated with the endorsement in October 2003 at an International Workshop at FAO Headquarters. These activities were led by an FAO team composed mainly of post-harvest systems specialists.

As a result, the framework has four strategies, namely, developing appropriate policies, strengthening institutions, developing competitive and equitable agrifood systems, and fostering networks. Each strategy is divided into collaborative action areas, expressed in terms of concept notes. While food crops are the primary focus, it may also cover non-food crops, livestock, non-timber forest products and marine resources relevant to the regions. Examples of the concept notes that will serve as a basis for the development of collaborative action-orientated projects are: development of a tool kit for market-oriented decision-making; enhancing rural agro-enterprises through integration of supply chains and effective business support; improving the quality, nutritional value and safety of food from smallholder producers and small and medium-scale agro enterprises; and enhancing performance, equity and environmental sustainability of commodity chains. The Strategic Framework will facilitate resource mobilization, and monitoring, evaluation and impact assessment of projects implemented under the framework. The Framework is to be implemented by supply-side agencies in collaboration with beneficiaries.

How to work with multi-stakeholder, multi-institutional strategy formulation processes to improve on-going national food and nutrition programmes?

Relationships between and within great systems, such as the agriculture, education or health systems of a given country, or managerial problems of national programmes, have also been analysed and improved using the systems-based method known as qualitative operations research (Mata *et al.*, 1989; Montealegre *et al.*, 1989; Montealegre *et al.*, 1990). This term can be understood as synonymous with or equivalent to systems analysis, and basically consists in the analysis of big and complex systems and of the problems, risks and decisions inherent in running and managing such systems, utilizing various quantitative and/or qualitative methodologies (Heylighen, 2003).

This approach was applied in Central America and Panama by a multidisciplinary team of the Institute of Nutrition of Central America and Panama (INCAP/PAHO/WHO), at the end of the decade of 1980 (Mata *et al*., 1988; Quintana *et al*., 1988). Group feeding programmes, with nutritional, health, social development or post-emergency-relief objectives were the subject of improvement processes. Many of theses programmes have as a basic operative design the participation of small local food industries and networks, to supply food products to the programme. Medium and large food industries participate as well in some countries, and several programmes also operate based on donated food products, where a food chain from the port inwards is established.

The methodology consisted first in forming a core project team. This team, however, was flexible in terms of its members, according to the system under analysis and according to the phase of the study. In general, the core team was composed by a systems and information engineer (leader), a public health management specialist (leader when dealing with health- and nutrition-related feeding programmes), a public education management specialist (leader when dealing with school feeding programmes), a public sector management specialist, a private sector management specialist, a food systems specialist (leader for the analysis of food chains), a community organization specialist, a informatics and computing systems specialist and a facilitated operations research events specialist. This core team was supported by the required technical, administrative and logistics personnel, usually provided both by the project and by the government institutions involved. Furthermore, since in some instances confidential, financial or politically sensitive information would be handled, an explicit agreement between the technical assistance institution (INCAP) and the concerned Ministry was signed, and pertinent institutional collaboration and participation was promoted and even secured (in some cases in the form of a Minister's decree, as needed).

Then, key programme-based teams with representatives of different types and levels of stakeholders were integrated. Those included top policy makers (even at the Minister, Vice-Minister or General Director level in a given Ministry), top managers in the programme, administrative and technical executing officers at central level, their counterparts at regional and local levels, and service point level (food warehouse, food service, school, health center, extension center, public works center, etc.) director and personnel, family representatives, suppliers of goods and services, supporting NGOs and international institutions representatives, donors, and the participants, men and women, themselves. Agricultural producers, transporters, handlers, warehouse managers, food preparation personnel, quality control technicians, accountants, primary health workers, teachers, and household heads are typical examples of participants.

Those teams worked through facilitated workshops, first to define the processes through which the different tasks and programme functions were executed, *from each stakeholder's point of view*. The chains corresponding to the flow of food products either from the field or from the ports, and the supply of other products and services were studied and thoroughly characterized. Core team members participated in the workshops. Processes were then modeled and the whole system was represented through different modeling aids, including operations, inputs, outputs, components and relationships. The objectives, resources, procedures, results, efficiency and cost-effectiveness were estimated, leading to characterizing priority problems and possible feasible solutions. The required actions at different programme levels were then identified. The actions were grouped according to place, time and level of application in the programme, and an implementation plan was prepared, agreed upon and presented to authorities.

Political support was obtained through parallel promotion and awareness raising activities, and budget and resources were dully allocated. The solution packages, as they were called, were then applied, and after a consolidation phase and continuous operation, a series of cross-sectional evaluations were done. The whole implementation process was done following a quasi-experimental type of statistical design, for evaluation purposes. Another series of workshops with the original participants whenever possible was carried out in order to evaluate the whole qualitative operations research process and make adjustments to the solution implementation. The higher authorities in the Government considered this as a worthwhile process, which overall lasted between six to twenty four months, depending on the system under analysis. No doubt that management quality, support and commitment, both on the technical assistance institution and on the government highest levels, as well as effective and positive participation of all stakeholders, were essential factors for the success of those system analysis and improvement projects.

How to apply the systems analysis to evaluate and improve the capacity of food networks, to implement segregated chains and traceability systems at the national level?

Given the need to comply with Article 18.2.a of the Cartagena Protocol on Biosafety, the Government of Argentina requested from FAO a project to assess the existing situation of production, harvesting, in-farm post-harvest handling, storage, logistics, transport and export of grains, mainly maize and soybeans. The capacity to establish segregated chains with traceability for non-GMO (genetically modified live organisms) grains would also be appraised. Responding to the official request, FAO designed the technical cooperation project TCP/ARG/2901 (A), approved in 2003 and to operate for 13 months, in which several technical services of FAO Headquarters would participate as part of a core multidisciplinary team strengthened by international consultants and a very strong national project team. The Seed and Plant Genetic Resources Service acted as the Lead Technical Unit with the close support of the Agricultural and Food Engineering Technologies Service, and the administrative support was provided by FAO Regional Office for Latin America and the Caribbean, located in Santiago, Chile.

Among the specific objectives of the Project were the evaluation of operations, infrastructure, capacity and logistics for handling, storage, transport, loading/unloading, and export of maize and soybean grains, including those arising from varieties produced through modern biotechnology, in each of the regions and provinces where they are cultivated. The project was also designed for the identification of needs for adaptation, improvement and modernization of post-production chains in order to be able to implement the identification, segregation, traceability and handling of those grains according to national and international norms especially what is established in the Cartagena Protocol on Biosafety. The strategies, costs, investments and policy and legal framework to achieve that objective would also be delineated (SAGPyA and FAO, 2004).

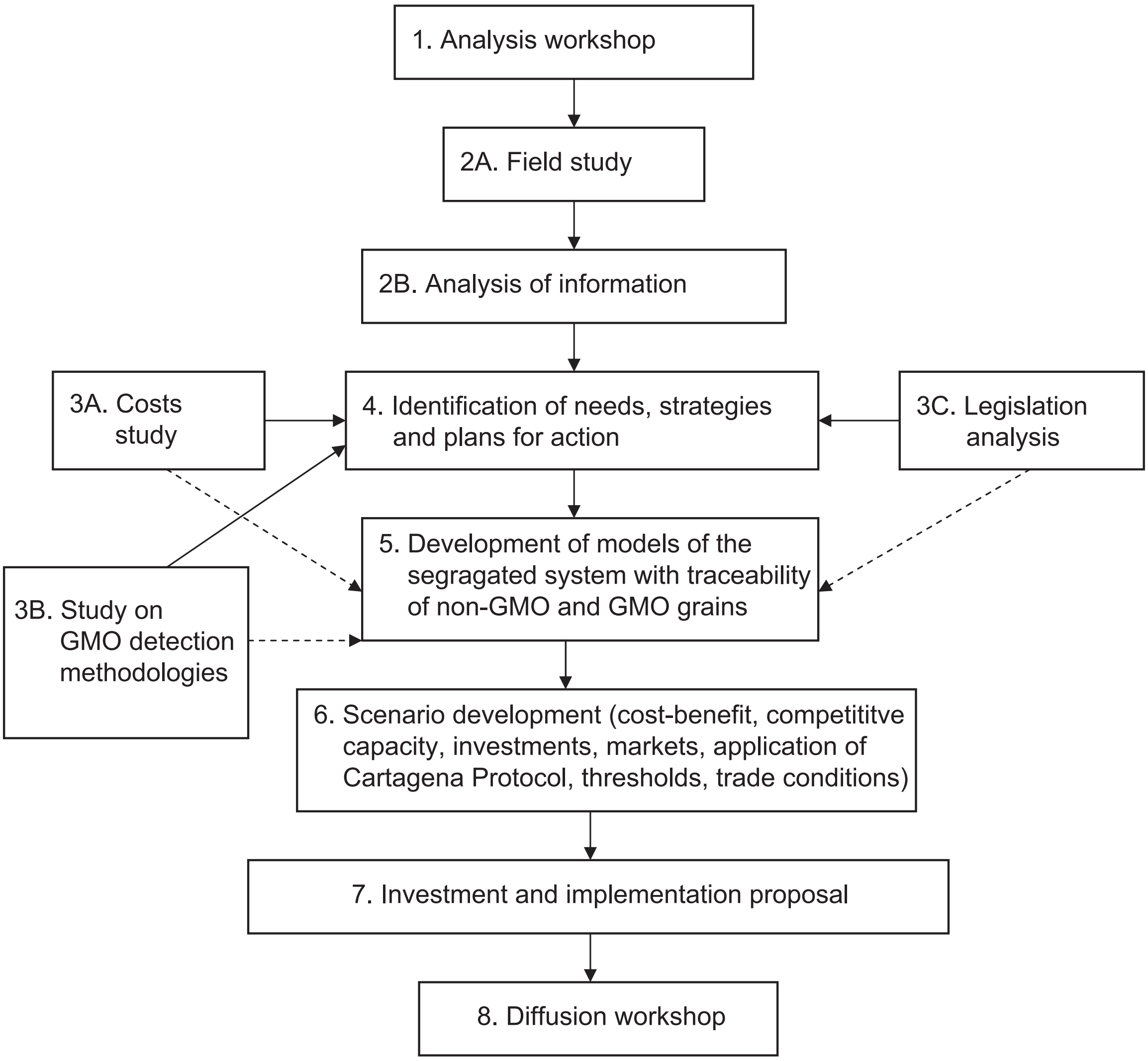
The project was executed in a country where grain production went from 20 million tons in the decade of 1960, to 70 million tons at the beginning of the new Millennium, and grains and derivatives account for near to 40 percent of total exports, contributing significantly to national income, employment and tax revenues. The international context determined the need for the country to be prepared to comply with international normative frameworks, especially Article 18.2.a of the Cartagena Protocol, and to compete under dynamic trade conditions from exporting and importing countries including different separation thresholds and labeling requirements. Besides, the country counts with a solid policy and legal framework regarding GMOs, and enough technical capacity and experience regarding grain chains of all dimensions and also segregated chains according to different quality factors and market-related standards.

In this context, the project was divided into two main phases: one of analysis and one of estimating and postulating the actions and resources required for implementing segregated chains. Figure 13 shows an interpretation by the author of the project's approach.

For the analysis phase the first step was conceived as a consultation, carried out in terms of a multidisciplinary, multi-sector Analysis Workshop, in which the situation and recommendations for improvement were discussed by stakeholders who are expert in grains chains in Argentina. With approximately 50 specialists in the distinct components of maize and soybean chains and networks, form both the public and the private sectors, the basic characteristics of the chains were discussed, the main issues that would have to be faced for implementing segregated chains were identified and discussed, and recommendations were proposed in relation to the best way to execute the field study. The workshop had the objective of doing an integrated analysis of segregated grain chains in Argentina, in order to identify the required modifications/additions, to identify the required information for segregated chains with traceability, and to establish general guidelines for the field study. The systems approach was proposed as the basis for the Workshop, and in general for the whole project, and it is summarized as follows (Cuevas, 2003):

- Identification of the essential components of the system
- Characterization of the relationships among the components

FIGURE 13
Analysis of grain chains for segregation and traceability



- Knowledge of the properties of the system, considering that it is dynamic, evolving, complex, and with a general common objective.

The integrated analysis of food chains would therefore be also a multidisciplinary, multi-sector, consultative effort, aimed at organization of priority information to be used for decision making. A methodological innovation proposed in this project by the author as part of the systems analysis approach, was to utilize the Hazard Analysis Critical Control Point (HACCP) method, a widely accepted food safety management system to assure the safety of food (FAO, 1998) and also based on food chain approaches (FAO/WHO, 2003), as a framework to analyse segregation and traceability for GMO and non-GMO maize and soybean chains in Argentina. This could also be applied to any other country wishing to perform such an analysis. Basically, the methodological proposal consisted on the following general HACCP-based principles, as applied to maize and soybean chains:

- Assemble the systems-analysis project team.
- Describe target grain products and identify intended use and trade requirements according to Cartagena Protocol, trade standards and current thresholds.
- Construct flow diagrams of the chains (Analysis Workshops) and on-site confirmation of flow diagrams and of current and potential capacity and operational procedures.
- List and analyse all potential hazards associated with each part of the grain chains, conduct a hazard analysis for contamination of non-GMO grains with GMO grains, and consider any measures to control identified hazards.
- Determine critical control points, that is, where loss of segregated property may occur.
- Establish critical limits for each critical control point, based on current or potential market conditions and trade requirements or regulations, that is, define or adopt a set of thresholds.
- Establish a monitoring system for each critical control point and for the whole chain, where traceability would be a key element.
- Establish corrective actions, that is, what to do to secure segregated chains and compliance with thresholds.
- Establish verification procedures, based on current up-to-date GMO detection technologies.
- Establish documentation and record keeping, again, based on a traceability system.

The last seven bullets above constitute the principles of the HACPP system. It was very important to find that in the country some international certifying institutions have been applying similar approaches for commercial segregated chains by private companies, mainly for maize.

Based on the specific suggestions form the workshop participants a field assessment was done, in which the different grain chains from production to export were visited and appreciated, complemented with interviews, visits and searches in national institutions related to those chains, in order to gather primary and secondary information, and then propose feasible actions for improvement of those chains and/or adjustment in order to be able to meet regulatory and market requirements. In other words, the project would propose the best possible options for producing, handling, trading and exporting segregated non-GMO and GMO maize and soybeans. Practical aspects of the type of information to be gathered during the field study would be the identification of:

- good practices of segregation and traceability;
- bottle-necks in the different stages of grain chains;
- critical control points (point in the chain where control measures should be established and standard parameters of action and performance followed to secure the efficiency of segregation procedures)
- strengths and weaknesses of current systems; and
- opportunities and needs for improving, complementing, adjusting, innovating or increasing the current capacity of grain chains.

As a result of the workshop and the field study, the project team prepared an agro-economic zone division of national grain agriculture, according to type of grains cultivated, density per grain, production and chain characteristics. Working hypothesis regarding quantities, thresholds and zones for segregated chains both for maize as for soybeans were postulated. It was established that the main logistic options for segregated maize and soybean chains are:

- Production → Harvesting → In-farm storage → Long transport → Port
- Production → Harvesting → Short transport → Grain elevator in zone → Long transport → Port
- Production → Harvesting → In-farm storage → Short transport → Grain elevator in zone → Long transport → Port

Each chain was analysed according to the advantages, disadvantages, requirements and characteristics. Additional capacity needed for storage and handling, costs of segregation and national capacity for traceability actions were likewise estimated. As an example, for segregation certification at a threshold of 0.9 percent, the strategic points for control of segregation and traceability would be:

- Traceability at the seed producers, once audited by a certifying body. Sampling and analysis is required for seed batches to be utilized.
- Inspection of areas planted with certified seeds. Identification of critical points. Eventual sampling in neighboring fields.
- Sampling of each truck on unloading. Sampling by field, batch and silo, with controls for each truck.
- Analysis on loading of first complete storage lot of segregated grain, based on samples taken on trucks unloading.
- Sampling and analysis of each transport unit from storage to pre-boarding at export port.
- Sampling and analysis on filling of each silo at pre-boarding site.
- Sampling and analysis on filling of each warehouse of the ship.

The required investment to segregate non-GMO maize and soybean were estimated, mainly related to the storage capacity, automatic sampling systems, stakeholders training, and institution development. Annual costs for segregated handling were also estimated, both overall as well as per each subsystem in the whole chain. Different scenarios based on various potential situations in international trade and application of Cartagena Protocol on Biosafety were analysed in the project, and a set of recommendations were given to the Government, regarding investments, costs, and export requirements and conditions for segregated maize and soybean chains (SAGPyA and FAO, 2004).

How to apply a competitiveness analysis to decision-making processes, as a tool to identify key interventions in specific food chains?

Any analysis of the component factors of these indexes easily leads to the conclusion that application of the systems approach to the analysis of competitiveness is highly appropriate. Taking the food system as represented in Figure 3, for example, we can establish the criteria for evaluating competitiveness at each link in the chains in accordance with the various aspects listed in the earlier table, and, of course, through the utilization of appropriate tools and methodologies for each evaluation objective. Table 11 shows a hypothetical case in the fruit chain of a given country, put together by the author for the purpose of illustrating the use

TABLE 11
Analysis of global competitiveness factors in the fruit chain

Factors of competitiveness	Production and harvesting	Handling fresh product	Storage	Transport	Processing	Distribution and retail
Technological development	L	L	H	L	L	M
Absorption of technology	L	L	M	L	M	M
Technology transfer	L	L	M	L	M	M
Innovation	L	M	M	L	L	M
Production process	L	M	M	L	M	L
Market and consumer-oriented plans	L	M	L	M	M	H
Total quality control	L	L	L	L	L	M
Financial management	L	M	L	L	M	H
Managerial capacity	L	M	L	L	M	H

H = high; M = medium; L = low (with respect to the position percentile of other countries or other chains, for example)

of simple tools for identifying weak areas and improvement opportunities in agrifood chains.

Irrespective of the purpose of any systems analysis, the factors and their corresponding sub-factors as required will appear in this way in the headings on the left. Qualitative and quantitative criteria can also be used to characterize the situation and performance of specific productive bodies of different subsystems, with reference to productivity, and hence competitiveness. The result in this hypothetical case would be that in general the production, harvesting, handling, storage and transport subsystems of this chain are the ones with the lowest competitiveness, production and harvesting being the worst. Is probable that this case describes a country where the processing and distribution/retail subsystems are accommodating themselves rapidly to changing conditions in the market. As an example, this example could refer to the situation where supermarkets and medium food industries are responding to urban and big-city consumer demands, and therefore have modernized themselves and improved the competitive capacity. They might be driving a process of change backwards in the chain, as recently described for the Central American countries (Berdegué et al, 2003).

The underlying idea of this table can be used as a guide for the formulation of technical support strategies, policies and even concrete action to boost specific capacities, as these have been shown to boost competitiveness in the macroeconomic environment. Obviously, priorities can be established, focusing on those boxes in the table which received an "L" for low. A similar analysis should be made at the microeconomic level of the enterprises involved and their business environment.

How to conduct an experts' analysis and identify critical factors for improving the use of energy and environmental protection by the small agroindustry?

Small food industries play a very important role in the economies of rural communities in Latin America and the Caribbean. Many of these industries use energy intensively, mainly in terms of fuelwood and other biofuels to manufacture traditional products of high cultural value and wide demand in national markets. Examples of these are *tortillas* (maize-based unleavened bread) in Central America and Mexico, *arepas* (maize-based unleavened bread) in Colombia and Venezuela, fruit preserves, cassava products, *panela* (raw sugar from sugarcane), smoked fish and meat, etc. Fuelwood, as a source of a potentially renewable source of bioenergy, could be a key factor for fostering sustainable management of natural resources in those agroindustries, if it is used in an efficient and clean way. Also, food quality and safety, profits and overall business competitiveness may be improved through better practices.

Based on this background, the Agricultural and Food Engineering Technologies Service of the Food and Agriculture Organization of the United Nations (FAO) organized an Experts Meeting gathering several Latin American professionals related to the small food industry and to the efficient use of bioenergy to analyse in an integrated way the main problems regarding the use of fuelwood as a source of thermal energy and the possible ways to promote the improvement and increased capacity in those enterprises through the efficient use of fuelwood. The design of strategy packages with integrated solutions, able to be adapted to different countries, and aiming to improving quality and competitiveness were part of the Meeting's objectives. FAO's partners were a Mexican university (Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México, UNAM) and an NGO dealing with appropriate rural technologies (Grupo Interdisciplinario de Tecnología Rural Apropiada, GIRA), with participation of experts from the Region, in areas such as food technology, food and nutrition programmes, agroindustrial and rural development, ecology and environment protection, fuelwood utilization, food engineering, post-harvest systems, rural sociology and agroindustrial networks (Cuevas *et al*., 2004).

The Meeting was developed in two stages: in the first, the experts presented, from their own professional and country perspective, the problems, challenges and opportunities of the micro and small food agroindustry in the Region (one day); and in the second (one and a half days), with an integrating vision and following the methodology of "Logic Frameworks", discussion workshop sessions were carried out to determine priority problems, solution alternatives and required actions to promote sector development. The "Logic Frameworks" methodology consisted in facilitated sessions going from brain-storming on sector problems, grouping of related problems in families, characterizing the nature and possible context of each family, cause-effect analysis, and finally conversion of problems into objectives for a strategy framework with directed actions, which in fact were the specific solutions to the priority problems. A one-day field visit allowed the experts to review and improve the problem analysis and to share views in a more relaxed atmosphere.

The central part of the analysis was the micro and small, traditional, Latin American and the Caribbean food agroindustry. According to the experts, these industries may be identified by a preference to use local resources, the use of fuelwood as an energy source, or the intensive use of any energy source, the small investment rate, the use of simple technology or artisan traditional procedures, the use of family labor including women, and the small size regarding number of workers and total capital invested. The experts considered that these industries are key players in local development, generating a considerable number of posts for non-agricultural employment, contributing to food availability, using agricultural materials, and offering an alternative to migration to the cities. However, the discussions also led to agree on the fact that the industries are affected by a complex series of problems, with general characteristics in common across the Region. Typical problems are that many of these industries still belong to the informal sector, are excluded from institutional programmes, face a very competitive business environment, sell their products at low prices, use manufacturing technologies and practices with low efficiency, cannot comply with quality requirements and use little or non of quality assurance methods, do not have incentives to improve production, have little capacity for investment and to obtain credits, and use bioenergy in highly inefficient ways, contributing to the degradation of forest resources.

It was determined that in order to improve the sustainability of the micro- and small-agroindustries sector in Latin America and the Caribbean, it is required to develop integrated, systemic and participative approaches, sensitive to local cultural differences, and including technical, economic, social, cultural and marketing aspects. A planning matrix was designed, with the objectives and actions organized logically and hierarchically in four theme areas: Institutional, Economical, Environmental and Technical (which includes energy issues). Typical strategy lines to improve competitiveness of the small food agroindustry would be the strengthening of technical and management capacity of human resources, the immersion into technological innovation processes, the improvement of management and negotiation capacity, the promotion of adequate institutional frameworks, and the promotion of environmental protection productive approaches. The application of this Matrix would lead to the improvement of the rural agroindustry in the Region, minimizing environmental impacts and improving the use of renewable resources. Comprehensive project proposals could be prepared as outcomes of this type of systems analysis.

How to evaluate the viability of improvement in quality and competitiveness of current food industry businesses and post-harvest and processing plants?

The social and economic problems in Georgia and the severe process of transition into the principles of market relations and economy had a negative impact on the fruits and vegetables post-harvest handling and processing industry. In the beginning of 90s approximately 64 processing factories were functioning in the country as a whole. 600-650 thousand tons of fruits and vegetables were processed annually. The value of the industrial production (960 million containers), in comparable prices, reached up to 785 million GEL (2.066 GEL – 1 USD, average rate of 2001). About 65 percent of the production was targeted for the former Soviet countries, and a definite part was exported abroad. In the decade from 1991 to 2000 a number of investments were incorporated in the field of processing industry, mainly with the intention to provide adequate technical capacity to processing factories. However, there was scarcity of raw materials and the supply of equipment/machinery was suspended, impeding thus the technical progress of the sector. Some of the typical problems in the sector were (Lapachi, 2002):

- modern and efficient technologies characteristic of competitive enterprises and global market economies were lacking;
- the chains do not operate in integrated ways and the links between fruit producers and post-harvest handlers, transporters and processing factories are nil;
- marketing and other information services were not developed;
- difficult economical and political situation in the country;
- the tax system was not regulated;
- there was a non-convenient investment environment.

These and other problems made the field fall in a deep crisis. Despite of the apparent surplus capacity of processing factories, the satisfaction of the market demand regarding processed products was reduced down to 50 - 40 percent and the rate of unused capacity grew to 90 percent in relation to installed capacity, production fell down to 5 - 6 million containers, and only 10 out of 64 processing factories were operating and with low production. The need for a prompt analysis of the sector was identified, and the Government requested FAO's assistance to assess the possibility for the improvement for existing fruits and vegetables post-harvest handling and processing chains. To find feasible solutions to these problems, the Ministry of Agriculture and Food of Georgia and the Food and Agriculture Organization of the United Nations agreed on executing the Fruit Sector Rehabilitation Project TCP/GEO/0065(A).

The general objective of the technology capacity assessment component of the project was the preparation of pre-investment baseline study of the fruits and vegetables post-harvest and processing sector aiming at the improvement of the chain including marketing. The specific objectives were to study the characteristics of supply and demand in the fruits and vegetables sector, constraints and main requirements for success including the economic, financial and legal aspects, to identify the alternatives for the sector rehabilitation towards meeting market conditions and requirements; and the identification of the main needs and opportunities for increasing competitiveness in the sector, including the improvement of fruits and vegetables quality and safety.

The methodology was based on the study of the aspects needing rehabilitation or modernization. Close cooperation with the authorities of the relevant sectors including representatives of the processing enterprises, scientists working in the sector, processing specialists, agro-entrepreneurs, and representatives from the retail markets. Aspects of the study related to requirements and constraints on fruits and vegetables supply chains; economic, financial and legal aspects; infrastructure of the sector; priority needs of producers, agro-entrepreneurs and retailers; ways to solve the seasonality in the chain especially as it affects the processing industry; and ways how to assist processors in finding the niche markets. In order to be able to meet project's requirements and budget constraints, key enterprises had to be selected to be included in the study. Specific enterprise selection factors were used such as the legal and operative status of the enterprise, production capacity, technical base, specialization, functioning state, management style, leadership and commitment to improvement and success. Table 12 shows the general organization of the study, which included both post-harvest handling as well as processing enterprises.

The study concluded, among other things, that the sector faces a number of economic and financial problems, due to the transition related to economic reforms in the country including the privatization processes. The sector has problems in meeting market requirements and being competitive, including financial problems such as those due to the cost of electrical energy. The plants in the fruits and vegetables chains face also a lot of technical problems, including those of obsolescence and lack of spare or substitute parts or pieces of equipment. The enterprises

TABLE 12
Pre-feasibility study of the fruits and vegetable sector

1. Main definition of the activity	• Description of the activity • Raw materials annual quantities handled • Other inputs • Style of marketing • Style of management • Production indicators • Plans for improvement • Approaches of the company to the business.
2. Market analysis	• Market capacity (including unsatisfied demands) • Current supply, market contribution, competition • Price, packing, distribution, product supply chains • Trade and retail activities • Market related problems; market information • Internal market characteristics
3. Technical aspects	• Infrastructure • Production process (type of the technology, yield and productivity, losses) • Raw material and composition (quantity, source, quality, opportunity and contracts) • Equipment (present condition, minimal requirements for their rehabilitation) • Industrial facilities and services • Human resources • Packaging and storage • Quality assurance • Cost elements.
4. Marketing aspects	• Co-ordination of financial, trading and industrial aspects • Distribution and promotion • Logo and image • Marketing strategies
5. Financial aspects	• Investments (land, building, equipment, materials and etc) • Operation costs • Total costs • Income • Balance, financial operations (cash flow) • Analysis of company's profits • Profit and loss • Financial needs, financial support (resources, planning) • Business plan • Economic analysis
6. Management aspects	• Organization • Decision making • Sub-contracts (on raw material, production, sale) • Management of production • Operations management • Management of industrial security • Financial management • Quality management • Information management.

1. Legal and trading aspects	• Food laws and regulations • Food labeling • Licenses • Government policy (subsidies, taxes) • Insurance • Quality standards.
2. Risk factors and profit	• Cost analysis • Risk factor analysis • Opportunities and constraints • Property of the company • Priority decisions.

also face marketing problems due to incipient actions in free-market economies, and need the development of marketing capacity and to count on efficient marketing services. The apparent lack of appropriate agricultural and market information also complicates further the situation. The legal aspects also create constraints to the optimal performance of the sector. The study proposed a number of courses of action as possible solutions to the problems. One of the study's recommendations was that the integration of value-added chains, with appropriate support services including financial aspects and technical assistance, would contribute efficiently to the development of the sector. The study proved that the reasons for the critical situation in the sector are of economic, financial, technical, technological and marketing nature. Their eradication and rehabilitation of the situation would be quite possible if technical and financial assistance could be provided.

How to apply HACPP to small food industries and their networks?

As it is well known, the HACCP system is recommended as a food safety assurance tool, as discussed earlier. When the system was beginning to be widely applied in developed countries, actions started also to develop in Latin America and the Caribbean. As an example, the Institute of Nutrition of Central America and Panama (INCAP/PAHO/WHO) provided technical assistance to the small and medium food processing enterprises that supplied national food and nutrition programmes with ready-to-eat, industrially processed, nutritionally improved food products. The execution of those programmes demanded a high degree of coordination, supervision, quality control, and technical assistance. One way to establish a quality and safety assurance programme at the national level was to develop a dual quality and safety assurance system: on the one side, a supply chain from raw materials to consumers, with inspection, supervision, sampling and training. On the other, a generic HACCP system for food bakeries, which later would be adapted to each bakery's conditions, requirements and interests, on the basis of training and supervision activities (Cuevas *et al.* 1989, 1990). Once trained, and a basic (essential steps) HACCP-like system had been agreed upon and implemented, the processing plants would be inspected and supervised on a regular basis. Sampling and chemical analysis and sensory evaluation plans were carried out by a central laboratory. Since the HACCP systems were adapted to the technical, financial and management needs of the small food processing industries, their application was feasible, efficient and effective.

All participant food industries would receive a monthly report on their performance and the quality and safety of their product and consumer acceptance. The best performers would be given public recognition, and not a single health-related illness was recorded in several years of operation. Under performers would be visited, advised, and if recurrent, then an economic penalty would be given to them and eventually they would be removed from the list of suppliers.

Similar approaches have been successfully applied to school feeding programmes where the small, medium or large food industry were the suppliers of special products formulated on the base of specific nutritional objectives, including foods fortified with micronutrients (Cuevas, 1995, 1996).

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Small food industries operate within a web of macroeconomic, microeconomic, social and technical forces that determine competitiveness within the sector. This bulletin proposes to utilize the systems approach to establish the analytical context for all factors affecting food quality and safety, and hence food industry competitiveness, and identify the engineering variables intrinsic to the food industries and their environment and which, once improved, will make the sector more competitive. The document presents a conceptual methodological proposal whereby any strategy based on the above approach will make it possible to identify and address the priority needs of the small and medium food industries sector in Latin America and the Caribbean region and to respond efficiently and effectively to those needs through sound action.
The ideas proposed in this bulletin address, from the food engineering and technology perspective, the complex issues faced by small food industries in today's markets, where high quality and safe foods are demanded by consumers, and where all businesses, no matter how big or small, must be competitive to survive and succeed.

ISBN 92-5-105250-6 ISSN 1010-1365

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TC/M/Y5788E/1/12.04/1100