SUSTAINABILITY OF FOOD SECTOR DEVELOPMENT

IN TROPICAL AREAS[1]

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ABSTRACT

Debates over the last few years concerning the future of the planet have seen the question of food sufficiency reappear. Developing countries in tropics and subtropics, usually primarily agricultural, are currently having to adapt to unprecedented socio-economic changes (urbanization, demographic growth, globalization of trade, widening disparities) and to cope with serious problems of food security, public health, and environmental damage. How can food sector contribute to meet new challenges? Can the food sector development model initiated by the countries of the North be durably applied on a global scale? Which are the new Research and Development priorities to face challenges? The objective of this paper is to try to bring elements to answer such questions. The first section of the paper focuses on the possible contribution of food sector development to meet new challenges. The second, third and fourth sections present respectively an outline history of food research over the past forty years, main achievements and limits of research past lines, and the concept of sustainability in food processing. This appraisal serves as a background against which to examine the new directions that need to be explored for a sustainable development of the food sector, which is the subject of the last section of the paper.

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INTRODUCTION

The developing countries in the tropics and subtropics, usually primarily agricultural, are currently having to adapt to extremely rapid socio-economic change (urbanization, demographic growth, globalization of trade) and to cope with serious problems of food security, public health, poverty and environmental damage. Debates over the last few years concerning the future of the planet have seen the question of food sufficiency reappear. With the world's population growing at an ever-increasing rate and an extra 1.7 million mouths to feed each week, the Malthusian fears of a widening gap between people's needs and food production are once more coming to the fore [1, 2]. The threat of medium or long term hardship is directing public attention to the need for a new international effort to increase food availability.

Faced with such issues, the development of these countries is generally handicapped not only by economic and political obstacles but also by the inadequacy of their scientific and technical resources in many fields [3,4]. This is particularly true for the food sector. In fact, for over half a century, most of the efforts directed to the agri-food sector have been focused on agriculture (perfecting and popularizing improved varieties and more intensive cropping and livestock systems), whereas only a very small part of the research resources has been targeted at the food sector (processing and trading of agricultural raw materials). It must be emphasized, however, that the situation varies considerably, from the rapidly developing countries of Asia or Latin America to the most impoverished ones.

In the North, the terms of the problem are different. The countries of the North, richly endowed with major scientific organizations and facilities, are faced not only with growing social disparities and the exclusion of some categories of their populations but also with the disruptive effects of uncontrolled industrial and technological development on the environment and on society [4].

As a whole, although the food sector has significantly contributed to ensuring food security over the past decades, questions are now being asked about its recent developments. The food sector is accused of being a tool used by the richer countries to establish economic and cultural domination. These countries are said to impose their own products and pattern of consumption on lesser economies, thus discouraging local production. The food industry is also alleged to expose consumers to major health risks, and the crisis associated with the danger of bovine spongiform encephalopathy (or "mad cow disease") being transmitted to man is but a further episode in a series of crises which include for instance, baby milk, hormones in veal, food colorings and ionized foodstuffs in Europe, but also mercury in fish in Asia, and food aid cereals, flavor cubes and mangoes treated with acetylene in Africa.

Why have developments in the food sector given rise to such concern? No doubt because food is different from other consumer products in that it passes through the body. Man is transformed by it to a greater extent than by any other product and his well-being more directly affected. It contributes to growth and good health - but can also cause illness or even death. It gives both sensory and social pleasure and also has a considerable effect on his sense of individual and collective identity. What is at stake in the development of the food sector therefore cannot be considered purely in economic terms. It must also include, the question of changing patterns of consumption; examining not only their economic but also their social and cultural implications [2].

Hence, after a century of major technical advance, essentially achieved by and for the countries of the North, it must be recognized that economic development can no longer be thought of in terms of "headlong pursuit", producing major local and global imbalances and uncontrolled effects.

This recognition has over recent years led the scientific and non-scientific community to ask (or re-ask) itself a certain number of questions [3]. We can no longer simply argue for "more and more" science (the experience of Eastern Europe has shown how scientific voluntarism can lead to enormous ecological and social problems). We must also ensure that science has a "social involvement", we must correct threatening imbalances and conciliate at times contradictory demands.

The World Conference on Science was recently held in Budapest (Hungary) in June 1999, under the aegis of the United Nations Educational, Scientific and Cultural organization (UNESCO), and of the International Council for science (ICSU). The extended title of this conference was “Science for the twenty-first century: a new commitment”. Deliverables of this conference included a “World Declaration on Science and the Use of Scientific Knowledge” and a “Science Agenda-Framework for Action”. Key points included i) science for knowledge, knowledge for progress, ii) science in society, science for society, iii) science for peace and development. They all go to show that the role of sciences and scientists in society have to deeply evolve, and that ethical issues are crucial for the new commitment of science to meet new challenges in the present changing context.

How can food sector contribute to meet new challenges triggered off by demographic growth and urbanization, globalization of trade, environmental damages, and widening disparities? Can the food sector development model initiated by the countries of the North be durably applied on a global scale? Which are the new Research and Development priorities to face challenges? How should scientists change or adapt their methods in the present context of unprecedented changes?

The objective of this paper is to try to bring elements to answer such questions. The first section of the paper focuses on the possible contribution of food sector development to meet new challenges. The second, third and fourth sections present respectively an outline history of food research over the past forty years, main achievements and limits of research past lines, and the concept of sustainability in food processing. This appraisal serves as a background against which to examine the new directions that need to be explored for a sustainable development of the food sector. This is the subject of the last section this paper.

THE CHALLENGES FACING THE FUTURE OF THE WORLD'S FOOD SUPPLY

Demographic Growth

The first challenge is demographic growth. The world's population should reach between 7.5 and 8.5 billion by the year 2020, almost four-fifths of whom will live in tropical countries. The total demand for cereals for human and animal consumption will need to have doubled by this date to about 1.7 billion tons. This challenge basically concerns agriculture. However, the food sector can help to increase the food supplies available by reducing post-harvest losses and improving the yields obtained from converting agricultural raw materials into finished foodstuffs. It is very difficult to evaluate these losses overall. They vary considerably from one country to another but are greater in hot, wet zones and are aggravated in developing countries by a lack of adequate storage and transport infrastructures. They also vary considerably according to the perishability of the commodities concerned. Post-harvest losses of 15 to 20% are often quoted for cereals in tropical areas. These may exceed 50% and even approach 100% for more perishable commodities like roots and tubers, fruit or fish. Appreciable reductions in such losses appear possible not only by improving storage, conservation and pest control techniques and processing yields but also by improving transport and marketing infrastructures and organization.

Urbanization

The second challenge is urbanization. The increase in urbanization rate is particularly rapid in tropical regions and exceeds that of demographic growth. It reinforces fears of a widening gap between people's needs and long-term food production. Urbanization alters dietary behavior. Town-dwellers eat more meat and more processed products that have a built-in service factor (convenience foods), in other words calories that cost more to obtain, and this is accentuated by their rising level of income. North Americans thus consume the equivalent of 800 kg of grain per annum, Italians 400 kg and Indians 200 kg [1]. The newly industrialized and urbanized countries

are moving towards an agro-nutritional model which it appears impossible to provide for on a sustainable basis for the entire world, from an energetic point of view.

Globalization of Trade

The third challenge is the globalization of trade. This raises the question of the competitiveness of tropical foodstuffs on the internal and international markets. We have seen certain foodstuffs invade the urban then rural markets of Africa, Latin America and Asia. The distribution of bread, rice, chicken, dry milk solids, beer, hamburgers and Coca-Cola has led some authors to fear that local produce will disappear and food become completely standardized. However, whereas analysis of the products consumed gives the impression of convergence towards a single or dominant pattern of consumption, analysis of dietary practices reveals a considerable capacity for appropriating and reinterpreting external references through cookery and styles of consumption. The celebrated "thièbou diène" of Dakar, a rice and fish recipe that has become Senegal's national dish, is prepared using Thai rice, local fish, mainly imported vegetable oil and vegetables introduced by the Portuguese and French. But it is far from being part of "international cuisine" and has become one of the symbols of African cuisine.

As a whole, as far as dietary change is concerned, the main overall trend appears to be diversification, in particular in urban environments. Consumers enjoy a more varied diet and obtain their supplies from a wider range of sources.

In the face of this overall movement, which is very noticeable in certain countries of the South, the tropical produce and culinary preparations specific to each culture will only be able to resist the globalization of trade if their diversity is exploited and they are put to varied uses. Benin is a particularly interesting case in point: maize is processed there into forty or so different products, and this in large part explains the limited penetration of imported rice and wheat. The identification of products with their country of origin is becoming an important consideration in food sector development.

The competitiveness of local produce in urban markets is nevertheless limited by three main factors: it is often not available widely enough or over a long enough period of the year, it is sometimes expensive compared with competing imported products and its quality does not always meet the new requirements of urban consumers.

As far as the international market is concerned, the competitiveness of tropical foodstuffs is not determined by price alone. Promotion of functional qualities is also an important factor. It is the distinctive qualities of such products as coffee, cocoa, tropical fruit flavors, herbs and spices, acacia gum, that have made them successful. Promotion of the distinctive nature of these properties is what enables such products to conquer new markets (e.g. specification of cocoa or coffee quality by geographical origin). And a loss of distinctiveness can lose them markets! Coconut oil sales initially dropped on the world market as a result of the problem of aflatoxins produced by inappropriate drying processes and the cost of the refining procedures needed to remove them. Vanilla and cane sugar are likewise faced with strong competition, the former from synthetic vanillin and the latter from artificial sweeteners.

Widening Disparities

The fourth challenge is widening disparities. Overall, the world currently produces enough food to meet its food requirements. Over 800 million people however, i.e. a seventh of the world's population, do not get enough food to lead a healthy active life. At the same time, almost 400 million people are suffering from illnesses caused by dietary excess (obesity, diseases of the cardiovascular system). The first situation is the result of political instability, war and poverty. Loss of identity and confusion of the social and cultural reference points which previously helped maintain behavioral equilibrium are suggested as reasons for the second. In neither case does malnutrition appear as a simple question of the quantities of food available. Food security should

include the notions of distribution and of sustainable access to foodstuffs for all, together with those of social and political stability, equilibrium and consistency. Overabundance of supply may be accompanied by a demand devoid of financial resources, as is the case in Latin America; if the gap between the two widens, food security becomes a major political problem in terms of a more equitable distribution of available resources. Witness the pillaging of supermarkets in the vicinity of the shanty-towns.

What has this to do with the food sector? Firstly, it can help improve the transportation and storage of the food resources available. Secondly, it offers opportunities for economic activity, employment and income in both rural and urban environments. Food sector activities today represent a major source of employment and income, particularly for women, in countries obtaining most of their resources from agriculture (most tropical countries, for instance). International comparisons show that an increasing percentage of the value added by the combined agricultural and food sectors in terms of GDP/person is attributable to the food sector. It is about 10% in the poorest countries and 50% in the richest. It is thus of quite strategic importance in tropical countries. And thirdly, it can play a part in reducing the cost of food production (lower losses, higher yields in terms of both materials and energy, more efficient marketing channels).

AN OUTLINE HISTORY OF FOOD RESEARCH IN TROPICAL AREAS

Writing an outline history of food research in tropical areas, the evolution can be schematically divided into four main periods, which are described below.

Processing of Exports Crops for the International Markets

The initial focus on industries producing export commodities for the international market (e.g. coffee, cocoa, palm oil, coconut, groundnut, sugar cane, tinned fish, etc.), was consistent with agricultural research in these areas [5]. The development of tropical agriculture was essentially regarded as a matter of increasing capacity for the production of cash crops in a context where trade was becoming international (product marketing was largely done locally, however, for instance in the vegetable oil and sugar industries).

Processing of Imported Products to Feed Local Populations

In the second period research aimed at developing the food sector to feed the local population by establishing local industries to process imported products (wheat-flour mills, breweries and soft-drink industries, powdered milk reconstitution plants, etc.), in order to meet a growing food demand triggered off by demographic growth.

Creating Tropical Versions of Imported Foodstuffs

It is only recently that food sector research has become interested in developing food crops for local markets, mainly aimed at feeding the urban population. It was first consisted of attempts to create tropical versions of imported products. They involved, for instance, the inclusion of millet, sorghum, or maize in traditionally wheat-based foodstuffs (bread, dough, etc.). Over 3/4 of food sector research into millet and sorghum processing has been devoted to such "compound flour" programs. Research into maize and sorghum processing has also been aimed at developing products shaped like rice grains, called "maize rice" and "sorghum rice".

Industrializing the Processing of Traditional Produce

The much more recent approach to develop food crops feeding the urban population has been to industrialize the manufacture of traditional products. This has involved mechanizing the processing procedures and marketing often ready-to-cook foods which are packaged more hygienically, like industrial products, and have a more standard quality; advantages supposedly sought after by the urban consumer. The strategy has been primarily pursued by private food-processing groups in Latin America and Asia, for example: farinha and bread-making quality cassava sour starch in Brazil, panela (brown sugar from sugarcane) and patacones (plantain crisps) in Colombia, corn meal (obtained after alkaline treatment) in Mexico, charqui (dried meat) in Brazil, tofu and tempeh (fermented soybean curd or cake) in Indonesia, nuoc mam (fish sauce) or cana noodles in Vietnam, etc. Similar experiments have been tried in Africa: cassava-based products like gari (grated and roasted cassava) in Togo, attiéké (a cassava product in granulated form) in the Ivory Coast, chikwangue (fermented paste) in the Congo, yam flakes in the Ivory Coast and Nigeria, millet-, sorghum- and maize-based flour, grits and granulated products in Senegal and Benin, baby food in Benin, Rwanda, Zaire and Burkina Faso, fruit juice, fruit nectar and locally-picked produce like mango, tamarind, guava and bissap in Senegal, Burkina Faso, Togo, Burundi, etc.

ACHIEVEMENTS AND LIMITS OF TROPICAL RESEARCH PAST LINES

Previous research priorities were certainly consistent with the development strategies adopted in tropical countries, and the objectives aimed at were often achieved thanks to the results of this research. In particular the coffee, cocoa, palm oil and coconut sub-sectors could not have been developed so well if procedures had not been established to maximize the value of such products.

Also, industrialization of local produce or substitutes to imported foodstuffs have certainly contributed to a certain extent to fill the gap between the growing food demand and the and food availability in tropical countries.

However, we have today a different appreciation of what is at stake in developing the food production system, or a clearer one, and this makes it possible to analyze main limits of research past lines with respect to new challenges facing food sector development.

First of all, the initial focus on local industrialization of imported raw materials, although it helped to fill the gap between urban demand and local agricultural supply in some countries, in particular Africa, also had the secondary detrimental effect to restrict outlets for local commodities.

Technology research initially focused on industrial-scale activities, either for cash crops for the international market or crops for local markets. Businesses on this scale appear more capable of rapidly supplying a suitable amount of produce of an appropriate quality to meet export market requirements or urban demand than small scale processing activities. In some cases, industrial technology and processing was able to learn from other sub-sectors where a processing industry had been developed (for instance, industrial wheat-milling processes were transferred or adapted to millet, maize and sorghum mills). However, this type of business could only operate at a profit over an extended period of time under particular conditions: they needed to have satisfactory control of the supply networks, which is frequently difficult to achieve because of inadequate regulation of production and marketing especially for food crops; and external technical assistance to bridge the gap between the technology employed and local technical resources.

As a whole, attempts at industrialization have, in the final analysis, had little effect on feeding the most impoverished members of society who make up most of the urban and rural population in Africa and remain a very important part of it in Latin America and Asia. In most cases these products have found a market, but a more limited one than expected. Only a small and largely well-to-do section of the population were prepared to pay extra for the quality advantages over domestically or traditionally produced products. Very few of ersatz products have met with commercial success in Africa or Latin America, for a variety of technical and economic reasons but primarily because the products had a weak market position. Consumers were generally unwilling to buy products that they considered to be of lower quality than the reference products, particularly when presented as direct substitutes.

Various observers have also criticized not only the lack of success but also the ethnocentric nature of research past lines. For instance, talking about research to develop tropical cereals, they stress that "the emphasis placed on compound flour has undeniably marginalized research into improving traditional procedures and the development of new products". Research has made only very few efforts to exploit a large number of local food crops: cereals (e.g. millet, sorghum, maize, fonio, quinoa, tef, amaranth), tropical roots and tubers (cassava, yam, taro, sweet potato, cana, aracacha, etc.), pulses (cowpea, pigeon pea, néré, etc.), vegetable oils (karite, balanites, etc.), fruit (cupuacu, acerole, mangostan, safou, etc.), all the more so as their role in the agricultural economy or as foodstuffs was geographically restricted.

And yet, commercial processing of such commodities has now developed with the opening up of the urban markets. As a result of past research priorities, scientists are not well equipped to meet the needs of new companies wanting to obtain information on processing procedures, improve product quality or diversify product use. Such knowledge is rarely committed to paper and its dissemination remains limited except in the case of a few major products. In addition, very little information on experiences and results is exchanged between Africa, Latin America and Asia even when they are dealing with the same subjects.

ABOUT SUSTAINABILITY OF FOOD PROCESSING

In the current renewal of the debate on global food security, there is a great danger of over-simplifying the problem by thinking that it is a question of quantity in the South and of quality in the North. Development of the industrial food sector appears essential in a context of rapid urbanization, of increased competitiveness between supply chains on a world-wide scale and of attempts to find new forms of added value in still essentially agricultural economies.

The faith in technological progress and industrialization that typified the 60's, 70's and 80's has distracted the attention of scientists from the questions of sustainability, i.e. social control, ethics, and long-term management of changes to the food production system.

This is true in southern countries as well as in northern countries. The effects of industrialization on Man's relationship to his food, on energy consumption, on the environment and on health risks were neglected. Such concerns were too remote from the short-term requirements of business and of policy-makers and often had ideological overtones. They have still not entered into fields of scientific research except to a marginal extent. Some of these concerns are given below.

Man's Relationship to his Food

As a whole the history of the world's food can be seen as a process of increasing remoteness in man's relationship to his food: remoteness in space because of the internationalization of trade in agricultural products and because of urbanization; remoteness in time due to a growing offer of stabilized and out-of-season products; and remoteness resulting from the growing length and complexity of the supply chains, with the development of an intermediation sector in the food industry (storage, transportation, marketing, processing, distribution). This sector is becoming more and more independent of agricultural production and consumption [2].

For the consumer, the increasing remoteness in his relationship to his food is reflected in a certain loss and confusion of his points of reference in terms of both identity and diet, contributing to certain nutritional imbalances and to loss of confidence in the industrial food sector and its lack of openness [2].

However a further analysis of the long history of these changes shows that man's relationship to food and to nature in general is in fact an ambivalent and simultaneous move towards greater remoteness and greater proximity.

The move towards greater proximity in the consumer's relationship to his food is shown by the development of farm produce, organically grown produce, local specialties, direct selling by the

producer and home-grown garden produce, and now suspicion about transgenic food. This is very noticeable in the countries of the South, but it is also apparent in industrialized countries, mainly in Europe.

Food Sector Development Models

The increased offer of ever more highly processed foodstuffs, particularly in the industrialized countries but now also in towns throughout the world, raises the question of the overall energy efficiency of the food processing system. To supply individuals with enough food, more and more energy needs to be injected into the transformation system, given the increased sophistication of the technology it uses and the services involved (packaging, portioning, pre-cooking, etc.).

An awareness of the two tendencies described above (move towards remoteness and proximity), in both the North and the South, opens up the way to the elaboration of new or complementary models for food sector development. Rural, small-scale, decentralized processing is no longer regarded as the survival of archaic, outmoded activities which ought logically to make way for more "rational" industrial processing. It is only recently that the strategic importance of the more decentralized enterprises, the rural agro-industries and the small-scale urban workshops in the food sector has come to be appreciated [8]. As the public authorities were often not officially notified of the existence of such activities, their contribution to the supply of processed food products was not usually taken into account. The view of a large number of policy-makers and scientists that the food sector was an archaic symbol of underdevelopment and technological backwardness did not help its importance to be recognized, either.

It is now recognized and developing as a fundamental means by which the consumer can maintain or re-establish reference points in his relationships with others, with himself and with nature. In addition, long-term respect for the environment is becoming a consumer preoccupation, particularly as regards food: interest in foodstuffs grown by less environmentally polluting agricultural methods and in biodegradable packaging; and mistrust or even refusal of irradiated or transgenic foodstuffs, etc. [2]. Over and above this, the individual as consumer is becoming a user with citizenship responsibilities

Management of Risks and Traceability

The process of increasing remoteness, already well under way in the industrialized countries, is now at work in the countries of the South as a result of their rapid urbanization and their growing involvement in international trade. This increasing remoteness means greater long-term risks for food security and environment. Management of these risks indeed raises the question of the sustainability of food sector development.

The greater length and complexity of the supply chains makes it more difficult to monitor the origin and the quality of foodstuffs or to react rapidly to large-scale outbreaks of food poisoning. These risks are all the greater with the growth of mass-production and distribution and have to be further controlled, which is all the more difficult in the context of developing countries.

DEFINING NEW RESEARCH PRIORITIES FOR A SUSTAINABLE DEVELOPMENT OF FOOD PROCESSING IN TROPICAL AREAS

The imbalance between the developed countries (richly endowed with scientific organizations and facilities) and the developing countries, manifests itself in cooperation-oriented scientific exchanges in the following way: funding and practices remain largely dominated by the idea of the transfer of knowledge, methods and technologies from the North to the South, and are at times solely concerned with exploiting local resources on the cheap. The scientific contributions of the South, potentially rich in representations of the world different from those of traditional science,

have not been integrated as real part of the cooperation model, unless they reveal themselves to be a possible object for economic exploitation [4].

The objective of this section is to illustrate how new fields of research can be opened up, taking into account ethical and long term issues in food sector development, to meet challenges facing the food sector development.

To Contribute to Employment and Reduction of Disparities

To meet the challenge of widening economic disparities, research must become involved in job creation in both rural and urban environments. Expanding food processing activities can help to increase income levels, particularly for women, and make food more readily available to the most impoverished members of society. Research and development work already carried out into urban agriculture [6], small-scale food production in Africa, rural agro-industries in Latin America [7], street food in Asia [8], shows the way for investigations of this type. In addition to its major contribution to the supply of local foodstuffs to the towns, it is worth recalling its importance in terms of job and income creation and its capacity for innovation [7].

Compared to what has so far been done in the agricultural sphere (smallholder organizations, training and advice for farmers, decentralized credit facilities), efforts to give the food sector a more professional approach have been neglected. This is a new field of research for economics, the social sciences and business studies, whose interest in this sector has up to now focused on the operation and policies of big business concerns. The diversity and complementarity of the different types of enterprise, the conditions under which they come into being, under which they operate, trade organizations, technical, financial and management training requirements, all these will need to become serious topics for research to back up their development.

To Make Local Products and Technologies Competitive on National and International Markets

The extremely limited interest that scientists have shown in this type of activity has led them to neglect the traditional processes used, the knowledge and skills they presuppose. A major field of research still in need of development involves identifying and characterizing the wide range of food technology know-how existing in the world. This wealth of expertise is put to good use in the North but is still relatively neglected in the South. Over and above the economic problem of providing outlets for local produce, the challenge is there to exploit the diversity of Man's heritage which such resources represent.

With a small number of exceptions, there are few countries in the South at present familiar with their own technical resources, i.e. their areas of expertise and own special products, while market operators are busy developing initiatives to exploit them.

Such initiatives concern both the local and the international sectors. The people of Colombia and Brazil, for instance, know how to make a product, so-called "sour" starch, using a combination of fermentation and sun-drying. The remarkable property of sour starch is that it can be used like wheat flour to produce leavened bread (i.e. with an alveolar structure) despite an absence of gluten [9].

This is not the case with other starches obtained from cereals, roots or tubers, which in the current state of technology can only be used to produce flat loaves. The development of this traditional know-how has resulted in cassava being more competitive on the local markets for starch products in these two countries. Bread rolls made with sour starch are now sold in fast food outlets in the big cities of Brazil, whereas until recently cassava had the image of being a poor man's food. It is still not known why this form of processing makes cassava starch suitable for bread-making. Scientists are currently trying to discover how to adapt the process for use with other starch products in other countries, with the twin objectives of giving added value to cereals, roots and tubers in the countries of the South and of manufacturing gluten-free foods essential to certain diets (baby food, people allergic to gluten).

Other examples are tropical roots and tubers (cassava, yam, sweet potato, cana, aracacha, etc.), which up to now have essentially been regarded simply as sources of starch. Better development of their distinctive properties would immediately open up new markets for these products. Some of them have properties that are in great demand on the international market, as a result of the recent regulations restricting the use of modified starch. Little research has so far been carried out into these properties: the resistance of starch to heat treatment, for use in frozen foods or baby foods; the precise rheological behavior required to produce analogues of fat; its rising quality in cookery; shear strength; etc.

To Design Environment Friendly Processes

Up to the present, when questions of technical aid were considered, little attention was paid to the energy yield of the food production system or to the environmental impact of its development. There is shortage not only of data but also of suitable methods for carrying out such assessments and providing answers to the various questions that arise: what proportion of the total energy injected into the agricultural or other sectors is used in processing, distributing and marketing the agricultural raw materials? What are the energy requirements of the different industries according to product stability (e.g. fresh, refrigerated, frozen, dried or sterilized products)? What is the environmental impact of these processing activities (e.g. water and wood requirements, pollutant effluents, by-products) in terms of the different processes used? Recent efforts in the industrialized countries to develop methods based on economic, ecological and energy balance sheets may well be a path worth exploring, even though they still have flaws.

To Re-Think Man's Relationship to his Food and Social Control of Food Technologies

Another field of research is the conditions required to give better social control of evolving food technologies: how can users, i.e. ordinary citizens, participate in the research and development process? Current research into the social control of technology represents an interesting approach.

It raises questions about long-term changes in technical systems, and man's relationship to his food and to nature in general. From this point of view, further attention should be laid on methods and tools to assess food risks and hazards as perceived by consumers.

It also raises questions about the role of research in the development process. Such an approach means that the issues examined and the objectives become inseparable from the way in which the research is carried out, and from ethical concerns. As far as Science in general is concerned, the new challenges and limits of past research results have revealed the reductive and compartmentalized representation of the world used in the traditional scientific approach [3,10]. Also, as far as scientific cooperation is concerned, former practices have been brought into question, in particular the linear view of development based on industrialization and the "transferability" and "transportability" of technology [4]. This is particular true for food sector research and cooperation, as recently analyzed in details in another paper [2]. Over the last few years new approaches have emerged, calling for a major reform of the practices employed by researchers, development officers, extension agents and politicians. This new wave of thinking has three main aims: to break down the barriers between the different disciplines, to focus research procedures on the users, to adopt more flexible and interactive methods of research project management, and to develop a new science-sharing approach (i.e. going well beyond simple knowledge transfer) [2,4].

CONCLUSION

After a century of major technological progress, one of the age-old questions facing mankind is still with us: will there be enough food for everyone tomorrow? Half a century of agronomic

research has shown that that the problem cannot be defined simply in terms of chasing after a constantly rising demographic curve and proposing more productive crop varieties. New priorities have emerged and key issues in today's debate are urbanization, globalization, disparity and poverty, health risks, long-term planning, social control of technology, sustainability and ethics.

As a consequence, the food sector development can no longer be thought in terms of "headlong pursuit", producing local and global imbalances and uncontrolled or disruptive effects. This is not just a wish. This is a profound and explicit social demand which has expressed itself, for instance throughout the rejection of scientific and technological advances such as irradiated or transgenic food in many countries, but more generally throughout the move towards proximity that has marked the recent changes in man's relationship to food and nature. This leads to the assertion that scientists are responsible not only to society in general in their own country but also to society in general throughout the world, as stated in the recent World Declaration on Science and the Use of Scientific Knowledge : *"Nowadays ethical implications of the use of scientific knowledge have become so profound and so much of concern to individuals and society at large, that any research or application of its results have to comply with ethical standards and principles. In this context, scientists themselves start to play an active role in defining and taking on their responsibilities"* [3]. This opens up the way to further thinking and re-thinking of scientific priorities, methods, and responsibilities in food research and development, both in Northern and southern countries.

REFERENCES

1. Brown, L. 1995. "Le siècle des limites", *Courrier de la Planète*, 29: 8-10.

2. Raoult-Wack, A.L. and N. Bricas. 1998. « Controllable development of the food sector in tropical areas: main challenges, fields of research and research procedures ». *Outlook on Agriculture*, 27 (4): 225-235.

3. Unesco.1999. "World Declaration on Science and the use of Scientific Knowledge". In *General Conference, 30 C/15, Appendix III*, ed. Unesco: 1-16.

4. Raoult-Wack, A.L., G. Toulouse, J.P. Kahane, and N. Bricas. 1999. « Sciences and Development », in *World Conference on Science, a new commitment, French Contribution*, ed. Commission Nationale Française pour l'Unesco: 34-42

5. Asiedu, J.J. 1991. La transformation des produits agricoles en zone tropicale. Paris, ed. Karthala, 335 p.

6. Smit, J., A. Ratta , J. Nasr. 1993. "Urban Agriculture : resource for food, jobs and sustainable cities". Washington, UNDP, Urban Agriculture Program.

7. Boucher, F. and J.Muchnik .1995. "Agroindustria rural : recursos tecnicos y alimentacion". San José, eds. CIRAD-CIID-IICA, 503 p.

8. Winarno, F.G.1986. "Street foods in Asia. A proceeding of the regional Workshop". Eds. Bogor, Food Technology Development Center and FAO, 255 p.

9. Westby A. and M.P. Cereda. 1994. "Production of fermented cassava starch (polvilho azedo) in Brasil", *Tropical science*, 34 (2) : 203-210.

10. Morin, E. 1995. "La méthode, tome 1:La nature de la nature". Paris, ed. Le Seuil, 398 p.