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Review article

**Consumer concerns about industrialized agriculture
and food safety:
importance, origin and possible solutions**

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Abstract — Modern agriculture and the food industry throughout western Europe, especially in France, have become the subject of consumer criticism. The concern is focussed mainly on product quality and safety, and on environmental impact. It has therefore appeared interesting to analyse the concern along with the answers offered by the various actors concerned. First, a global review of the good and bad points of the techno-economic development of agriculture over the past few decades is presented. Then, referring to survey results, an evaluation is made of the risks as perceived by consumers. The underlying explanatory factors motivating consumer concern and the lack of confidence in agriculture are studied in order to see if the answers proposed are appropriate to the problems. In fact, the answers often appear to be relatively technical (for example of a biochemical nature), whereas the points of concern are not limited to technical matters. Several wider range, more prospective ideas are discussed in conclusion, notably the world-wide situation and the overall question of biotechnology.

consumer / food safety / industrialized agriculture / risk / evolution of agriculture

Résumé — Le questionnement des consommateurs envers le productivisme agricole et les risques sanitaires alimentaires : importance, origine, et solutions recherchées. L'agriculture et l'industrie agro-alimentaire modernes font actuellement, en Europe occidentale et en particulier en France, l'objet de critiques de la part des consommateurs, notamment en matière de qualité des produits et d'impacts sur l'environnement. Ce texte vise à analyser ces questionnements et les réponses apportées par les différents acteurs concernés. En premier lieu un bilan d'ensemble de l'évolution technico-économique des dernières décennies en agriculture est tracé en vue de fournir une vision globale et synthétique de ses aspects positifs et négatifs. On donne ensuite une estimation des risques perçus par les consommateurs en s'appuyant notamment sur les résultats de divers sondages. Puis sont étudiés les facteurs explicatifs du questionnement et de la crise de confiance à l'égard de l'agriculture afin de disposer d'éléments pour examiner si les réponses apportées sont adaptées. Or ces dernières

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apparaissent souvent comme des réponses surtout techniques à une demande qui n'est pas seulement technique. Enfin diverses réflexions plus larges et plus prospectives sont esquissées, en considérant notamment la dimension mondiale et la question des biotechnologies.

consommateur / sûreté alimentaire / productivisme / risque / évolution de l'agriculture

INTRODUCTION

Throughout western Europe one confronts a phenomenon which many scientists, experts and farmers often find both paradoxical and difficult to accept:

– On the one hand, critical voices accuse modern agriculture of producing negative effects, especially concerning product quality and the environment. An apparently growing number of people, particularly in the media and associations, are decrying the negative impacts of industrialised agriculture.

– On the other hand, numerous experts have pointed out that the real impact of food risk on health, when measured, appears to be very limited [1, 34, 35]. Life expectancy continues to lengthen; death and serious illness attributable to food usually stem from behaviour and the choices of consumers (especially, high levels of tobacco and alcohol consumption) rather than from the intrinsic natures of products. As far as the state of the environment is concerned, the situation in France which is far from being in constant degradation has improved in some aspects over the past century: the bacteriological condition of water has improved; there is less urban smog; mountainous zones, previously eroded due to deforestation, have been reforested, etc.

The concerns about links between modern agriculture, the environment, food and health cannot however simply be swept away as if of minor importance. They reflect, in fact, a question of planetary scale relating to the sustainability of present-day agricultural production and food models, along with the concept of the “carrying capacity” of the earth.

In addition to the other scientific papers of these “Ruminant Nutrition, Human Health and Environment” proceedings, it seems interesting for the social sciences to shed light on the question. Such a different point of view can enrich understanding of the consumer points of view and serve as an initial analysis of the relevance of the solutions sought and proposed to solve this confidence crisis. In view of the diversity of the topics treated by these proceedings, here we have chosen a global approach, rather than a study targeted at a sole specific case. Indeed, many case studies have already been published on consumer perceptions and behaviours, relating to the mad-cow disease, bovine somatotropine (rBST) or genetically modified organisms (GMOs), or certain agricultural environmental issues. At present, a more comprehensive and overall analysis seems useful if one hopes to better understand the reasons for these present concerns. In fact consumer worries have become generalised and wide-spread, no longer linked to some very specific accidents. It is fundamental to better understand consumer concerns, since they are often the starting point for proposing new products, stimulating new lines of research and establishing new regulations.

First, a general outline of the techno-economic evolution of agriculture over the past few decades is given (Sect. 1), then consumer perception of risk factors in both food quality and the environment are discussed (Sect. 2). Explanatory factors and the origin of concern with regards to modern agriculture are then analysed (Sect. 3). On this basis, the appropriateness of proposed solutions to the denounced risks and lack of consumer confidence are evaluated (Sect. 4).

The conclusion deals with the world-wide situation and brings up the case of biotechnology, which seems to represent a specific source of consumer worry.

To start with, one must keep in mind that the techno-economic development of agriculture is influenced on the one hand by final demand and on the other hand by new applications growing out of scientific and technical progress. Analysis of the process of generating and spreading innovation shows that there is intense interaction and reaction between the various actors involved, rather than a linear process beginning with either science or demand. There is, in fact, a common image of the process running like a practically straight road from scientific discovery to development of a technical innovation followed by wide-scale diffusion. Or, in other cases, running in the opposite direction, from consumer demand to discovery in the research sector: the demand from consumers or clients is conveyed in terms of new products or techniques to develop, the latter are then expressed in terms of research effort to make, and finally the expected results can be reached (provided the means are given). Previously the first schema – a scientific or technological push – was the reference; today it is rather the second schema – a demand pull – which seems to predominate. In reality, both views are insufficient since they omit multiple interactions between all the actors concerned [9, 10]. Other elements must also be taken into account, such as the changes in the relationship between prices and the relative scarcity of the production factors used [22].

1. GENERAL ASSESSMENT OF THE TECHNO-ECONOMIC CHANGES IN AGRICULTURE OVER THE PAST FEW DECADES

For some time now, increasing suspicion, or at least a certain loss of confidence in product quality accompanied by a lot of

complaining about agriculture has become noticeable. The phenomenon is not restricted to a few specific cases in which serious mishandling of food safety resulted in accidents: quite harsh criticism is increasingly directed towards various negative effects of these transformations as well as towards the industrialised production model itself as a whole. What is the subject of these accusations? The agricultural production model developed in western Europe over the past few decades first sought to increase the production of food while reducing its cost. To do so, one seeks to increase both labour and land productivity. In breeding, this implies producing larger volumes of meat or milk per head of livestock in a given lapse of time: that is, increasing animal prolificity, their weekly weight gains and food consumption efficiency. These innovations have led to the industrialisation of agriculture with increased inputs or investments from industry, rather than self-produced inputs from the farming system itself. It has also resulted in the transformation of agricultural goods by the food industry and, finally, to their distribution through large groups which have replaced the old fashioned shorter circuits between producers, transformers and consumers. Moreover, the artificiality of production conditions has been strongly accentuated, and also the sizes of farms.

All of these transformations brought about by the three catchwords – productivity, efficiency, competitiveness – relied heavily upon advances in scientific and technical knowledge and their applications. This key aspect in the modernisation of agriculture means that scientists are deeply involved. A lot of results have been obtained, such as the relative decrease in the cost of food in the household budget, the general improvement in the standard of living, increased life expectancy, etc. (see boxes 1 and 2). But at the same time, negative impacts have also appeared and have led today to strong accusations. That is why

Box 1 – The cost of food and its progression: a few points of reference
(according to data from INSEE).

a) Part of the budget dedicated to food by households (%)

– Part of the food in % of total consumption spending in 1996

	food alone	food + drinks	Total: food + drinks + tobacco
France	13.8	16.6	17.8
U.K.	10.5	17.4	19.9
E.U. 15	–	–	17.5

– Development in France since 1949

Changes in the weight of food in the household budget

(including drinks, but not tobacco except in 1949)

Year	1949	1959	1979	1996
%	44.5	34.0	20.9	16.6

In 50 years, the value of food consumption at constant prices (i.e. adjusted for inflation) has greatly increased due to the modification of its composition (more meat and prepared dishes). Its part in the household budget has, however, dropped substantially.

b) Comparative development in prices for agricultural and food products (constant Francs).
(1970 = 100)

Agricultural prices at production:	Retail food prices:
1960: 108	1960: 100
1997: 49	1997: 109

a global assessment of these positive and negative aspects is given in Table I as a general overview of the situation.

**2. ASSESSMENT OF THE RISK
AS PERCEIVED BY CONSUMERS
IN RELATIONSHIP TO FOOD
PRODUCT QUALITY
AND THE ENVIRONMENT**

Criticism of the consequences of agricultural modernisation is not a recent phenomenon, although it was previously more limited and less vocal. The movement which gave birth to organic farming is several decades old [36], but for a long time its only echo was found in a limited number of associative groups. More wide-scale concern was voiced repeatedly during the 1970s and the 1980s following the energy crisis, prob-

Box 2 – Increased life expectancy at birth in France over the past 60 years (in years).

	Men	Women
1935	55	61
1981	70.4	78.5
1991	72.9	81.1
1997	74.6	82.3

lems of overproduction, CAP budgetary costs and the international conflicts stemming from subsidised exports. These concerns then spread to the population as a whole with increased worries about various pollutants (nitrates, liquid manure) and questions about food safety (especially since the BSE crisis), the use of GMOs, the use of hormones and antibiotics in animal breeding, etc.

Table I. Comparative view of the western industrialized agriculture model from the angle of sustainability on the basis of the French case.

Positive aspects of the productivist model	Negative impact
<p>1) at the socio-economic level</p> <ul style="list-style-type: none"> – abundant and diversified production of low prices foodstuffs (price support mainly due to their low level); – decrease in production costs of products; – reduction in the food part of the household budget (in spite of diversification and increased consumption of meat and prepared dishes); – food security assured, in general, at the levels of both quantity and quality; – switch from food export deficit to surplus; – improved standard of living for farmers and farm labourers; – improved productivity and comfort of work techniques; – rural depopulation gives farm children the possibility of finding work in other sectors of activity; – modernisation of farming results in revalorization of a profession before considered habitual and old fashioned, even backward; – regulations for previously abusive social practices (i.e. rent and share-cropping statutes). <p>2) at the level of the environment and health;</p> <ul style="list-style-type: none"> – increase in production through more rational techniques makes it possible to avoid too much human and animal pressure leading to over-grazing and erosion; – increased yield results in a reduction of cultivated surfaces, thus freeing lands for other uses, including forests and open nature; – improved production quality: less plant and animal illness (i.e. struggle against brucellosis and animal tuberculosis); – better knowledge of plant and animal nutritional requirements makes it possible to better adapt inputs and feed to their needs, thus avoiding limited production and losses due to deficiencies; – use of pesticides reduces loss, increases production and makes it possible to avoid certain dangerous natural toxins; tightened regulations have limited certain initial abuse of pesticides; – use of fossil energy (though limited) makes it possible to greatly enhance agricultural production and therefore the capture of solar energy through photosynthesis; – certain aspects of breeding conditions of livestock have been improved as new buildings have replaced the old dark, poorly ventilated and dirty buildings. 	<p>1) at the socio-economic level</p> <ul style="list-style-type: none"> – rapid increase in inputs of industrial origins and of necessary capital, often leading to excessive debt for producers; – productivity gains mainly benefit customers, farmers must constantly increase production to stay in business; – large-scale rural depopulation, resulting in near abandon of certain regions; – appearance of surpluses which are expensive to stock, treat or sell on the world market; – low priced selling of agricultural exports on world-wide markets discourages local production in several developing countries, thus increasing their dependency; – agriculture depends increasingly on multinationals in input supply upstream and on food industries and mass distribution downstream; – public subsidies to agriculture reach a high budget level; – disappearance of the peasant cultures and of traditional lifestyles and know-how. <p>2) at the level of the environment and health;</p> <ul style="list-style-type: none"> – spatial inequality with over-intensification in certain regions where pollution levels are high and agricultural depopulation in other regions where the territory is no longer maintained; – waste and pollution due to livestock dejection and the separation of plant culture and livestock breeding (previously mixed) along with their concentrations in different zones; – reduction in biodiversity even within a species (genetic diversity), in the number of species (species diversity) and in the ecosystem (ecological diversity); – presence at times of pesticide residues and of heavy metals in foodstuffs; – water pollution due to nitrates, phosphates and pesticides; – degradation of certain soils (erosion, reduction in humus levels, excess of heavy metals); – contribution to air pollution; – use of fossil resources and major increase in irrigation water; – impoverishment of the landscape (disappearance of hedges, less agro-system diversity); – too high animal density in some livestock buildings; systematic use of antibiotics for some livestock.

It is necessary to begin by developing a clear picture of the degree of consumer confidence in farm and food products or of their suspicion of them. Results from opinion polls taken by different organisations have been used for this purpose. Surveys, of course, have their limits and can produce an artificial impression of real opinions when people are polled about subjects on which in fact they have no clearly defined opinion. Moreover, the order of the questions, their forms and, especially, how they are related to one another and to the overall theme of the questionnaire can result in somewhat biased answers. They do, however, furnish useful indications and are quite often used, thus increasing the value of knowing the results.

The environment has now become a cause for worry in all sectors of activity. The legacy of the 20th century in terms of the environment is judged "quite negative" by two thirds of Europeans, particularly in Italy, Germany and Belgium; this situation is not the case in neither Finland nor Ireland [15]. However, the main present-day concern is not agriculture, but rather air quality.

As far as agriculture is concerned, over the past few years several surveys on quality, food safety and the environment have shown that public opinion remains somewhat divided, much more so in fact than articles or reports presented by public media would lead one to believe. In the United Kingdom, for example, in a recent MORI poll [26], concerns about the environment

and food safety were seldom mentioned spontaneously when those surveyed spoke of the main problems presently facing the country (Tab. II). In France, several surveys on food quality made during the same period showed fairly moderate and, above all, varied opinions (Tab. III). Differences in results for surveys taken at approximately the same date can be explained by the way the questions are composed and by the context, as well as by the use of the very polysemous term "quality": depending on the case, the people surveyed may refer to food safety, to the organoleptic characteristics of food-stuffs or to certain nutritional aspects. On the contrary, what are the food safety risks consumers fear the most? A survey taken in France at the beginning of 1999 shows the impact of recent food safety issues (Tab. IV).

These opinion polls bring out the fact that public opinion about food quality and safety is fairly moderate, with most consumers positioning themselves quite far from the apocalyptic or catastrophic visions denounced by others. In addition, farmers are quite often not held fully responsible for degradation of quality or the environment whereas financial constraints are usually considered to be the final deciding factors (Tab. V). Opinions also vary according to category or social group [11] and, especially, with reference to value systems and culture. Therefore, instead of saying "consumer(s) request...", one should clearly specify the views of their various categories.

Table II. Proportion of British citizens who spontaneously cite environmental concerns or food safety as an important problem (MORI poll, December, 1999; 1007 people) [26].

Themes (extract)	% referring to theme	
	most important problem	another important problem
Pollution – environment	1	6
BSE	2	5
GMOs	< 0.5	1
Animal welfare	0	< 0.5

Table III. Opinions on food product quality according to several recent polls in France (in % answers).**a/ Poll by the scientific magazine Eurêka /SOFRES** (December, 1996; 1 061 people).*Opinion on food products consumed nowadays*

better for health than 10 years ago	13
not as good	42
the same as 10 years ago, neither better nor worse	43
no opinion	1

b/ SOFRES/UIPP poll (Professional Union of the Crop Protection Industry, February 1997 & 1998; 1 003 people).*Opinion on the attention given nowadays by French farmers ...*

... to product quality	1997	1998	... to environmental protection	1997	1998
– not enough	64	52	– not enough	77	72
– enough	34	46	– enough	31	26
– no opinion	2	2	– no opinion	2	2

c/ CREDOC survey [11] (June, 1997; 2 002 people).*Opinions on food products:*

changes in quality over the past 10 years	%	present health risk nowadays	%
– improved	38	– yes, serious risk	20
– degraded	32	– yes, slight risk	35
– no change	30	– no, little risk	31
– no opinion	< 0.05	– no, no risk	11
		– no opinion	3

d/ SOFRES / SIGMA-UNCAA poll (December, 1998; 1 000 people).*Opinion on improvement or degradation of different environmental aspects over the past 10 years (% per line)*

	improved	degraded	no change	no opinion
air quality	2	84	13	1
water quality at the tap	11	59	28	2
landscape quality in France	15	57	26	2
food quality	27	54	17	2

e/ SOFRES / UIPP poll (February, 1999; 1 000 people).*Assessment of food product quality*

– nowadays		– in ten years	
very good	9	better than today	25
relatively good	71	not so good as today	36
relatively bad	17	the same as today	38
very bad	3	no opinion	1
no opinion	0		

Principal aspect defining food product quality for those surveyed (% , several answers possible)

– guarantee of no risk for health	50
– respect of hygiene norms during manufacture and transport	38
– taste	34
– nutritional quality	25
– low level of chemical products	25
– no opinion	0

Table IV. Classification by importance of various risks in food safety (SOFRES / SNIA-SYNCO-PAC poll) (February, 1999; 508 people).

	% considering the risk very high	Average note ^a
– Mad-cow disease	64	4.1*
– Assuring temperature control for frozen foods	55	4.1*
– Water quality	51	4.0*
– Genetically Modified Organisms (GMO)	49	3.9*
– Pesticide and insecticide use on crops	48	4.0*
– Livestock feed	47	3.9*
– Food additives, such as sweeteners, preservatives, colorings	24	3.2

^a The classification is from 5 (very strong noxious risk) to 1 (very low risk).

* Significant difference at the threshold of 99% compared to note 3.2.

Table V. Opinions on factors explaining the eventual degradation of food product quality according to two recent French polls (in % of answers).

1/ Poll by the scientific magazine Eurêka /SOFRES (December, 1996; 1 061 people).

<i>Opinions on the situation of farmer</i>	%
– use too much chemical fertiliser and synthetic products for livestock	29
– limit the use of chemical fertiliser and synthetic products for livestock	8
– simply follow the dictates imposed by the market	60
– no opinion	3

2/ Poll by SOFRES for SIGMA-UNCAA (December, 1998; 1 000 people).

<i>Perceived factors which could explain the degradation in food quality (% of answers)</i>	Date of SOFRES poll	
	12/1984	12/1998
– Economic conditions force farmers to sacrifice quality for yield	45	67
– Information on product composition and elaboration is lacking at the consumer level	–	41
– Consumers are more interested in product price than in quality	40	39
– Farmers are not interested in product quality, but rather only in making a profit	24	28
– No matter what is said, product quality is as good, if not better, today than it was 30 years ago	17	16
– No opinion	0	2

Opinion differences across the EU are evident due to cultural diversity, which can explain why taking a common position is sometimes difficult. This situation may be illustrated by the results of a Eurobarometer survey run at the request of the European Commission's DG XXIV (Consumer

Policy) in May-June, 1998, showing the different views on the question "Where are the safest food products obtained?" [14]. In some countries (Finland, Germany, France, Austria, Luxembourg, Sweden, Portugal) the most frequent answer was, "on farms and at small producers." On the contrary,

in other countries (Holland, The United Kingdom, Spain, Ireland, Denmark) supermarkets had the highest level of confidence, with the confidence in other distribution points, such as markets, varying according to country. The classification of sites where “the safest” foods are found was less influenced by age, sex and socio-professional category. The way people perceive biotechnology (supporters, risk-tolerant supporters and opponents) also differs between the European countries, as well as between the USA and Europe as a whole, as has often been pointed out [13, 19, 37]. This diversity can be largely explained by cultural diversity which has a direct bearing on the degree of confidence in administrative authorities, on the attitude towards making nature artificial and on faith in economic development.

3. UNDERLYING FACTORS AND ORIGIN OF CONSUMER CONCERN ABOUT PRESENT-DAY AGRICULTURE

Concern about agriculture and the decrease in confidence in certain products or procedures result from numerous factors and can be analysed from different angles. Particularly, one can either make an assessment of “objective” limits of the present type of agriculture, or proceed with an analysis of more “subjective” factors that contribute to the crisis. The existence of dangers or problems in a sector, an activity or a product are not adequate enough to provoke a general mobilisation resulting in the question being placed on the agenda and solutions actively sought! It is necessary that the risk motivate the actors, associations or organisations capable of making themselves heard and, thereby, that it stimulate increasing interest and commitment. It is this dynamic which nourishes the quest for finding solutions to problems [21] and it is a complex and subtle process. It can result in attention being focussed on concerns of low

risk as far as morbidity and mortality are concerned, while others, of much greater impact, attract little attention. On the contrary, even when a new risk is pointed out by experts, it is possible that the warning not be heard or that the problem be considered of only marginal importance (for example, minimising the seriousness of AIDS by some people during the early 1980s). For this reason it is necessary to take not only “objective” facts into account, but also the various social and socio-political factors which explain the concern about present-day agriculture and sensitivity towards certain risks.

3.1. Economic and structural aspects which brought productivist agriculture into question

The post-war productivist model of agricultural production was allowed to run freely too long. The fact that adaptations of the model were not introduced quickly enough to suit the changing situation have led to the appearance of several limits or resulting situations: agricultural surpluses, the burden of subsidisation, environmental impact, spatial inequalities due to the separation of regions into zones of heavy agricultural concentration resulting in pollution and other zones in which agriculture has tended to decline steeply. The demand, as addressed to agriculture, has also changed with urbanisation, changes in the structure of the population, socio-economic evolution and overall social transformation. This modification of the demand did not concern foodstuffs alone, but the functions of agriculture, the methods used, the landscape, etc. In addition, the development of global trade has sharply increased competition between exporting countries and has led to a modification of international trade agreements. Competition between different companies in the agro-food sector is also quite intense; competitors must react quickly and adapt efficiently to stay alive. This situation has

been made all the more dramatic by scientific and technological progress, resulting in the incessant appearance of innovations susceptible of modifying products or techniques in many fields [17].

The main goal for the food industry over the past few decades has been, and still is, the quest for ways of reducing production costs. This imperative is particularly strong for companies producing raw materials and intermediate goods used by the transformation sectors downstream. In fact, a quality label can help sell a product at a higher price at the level of the final consumer, but generally such is not the case upstream. This effort to reduce costs to a minimum seems to be one of the main causes susceptible of creating food safety problems. This point is well exemplified by the problem of BSE (lowering of the temperature and heating pressure of slaughterhouse products recycled into animal meals), the use of antibiotics and hormones, etc. Of course the problem of adulteration of foodstuffs has existed for many centuries. Still, the present context of agricultural overproduction in western Europe has made the problem unacceptable for the mass public and has fuelled a feeling of public indignation.

Food safety risks have decreased in numerous fields due to better hygiene at both the breeding and products level as well as through the eradication of various illnesses common to animals; however, other factors might well cause the risks to increase. For products the furthest downstream, changes in the chain of transformation have increased the impact of an eventual accident: additional links in the chain itself and its lengthening; the complexity of using a very large number of ingredients; the increase of prepared dishes; the use of refrigeration resulting in the multiplication of critical points where temperature control can be interrupted; and the increase in collective cooking (because of the high number of possible affected consumers).

These different aspects have all contributed to defining new goals in quality,

food safety, diversification, environmental soundness, etc. and clearly show the need for adaptation of the agricultural production model.

3.2. Origin and factors explaining the diminishing consumer confidence in modern agriculture and food

3.2.1. Industrialization of agriculture and food production largely ignored

For some sociologists, the food scare which is at the basis of consumer concern about food safety stems from the growing distance between producers and consumers. According to Fischler [18], high consumption foodstuffs are also highly manufactured products. That is, they no longer present the familiar features found in local production and consumption. They come from elsewhere; they have undergone transformations the natures of which are unknown; they have been handled by unknown hands and perhaps contain mysterious substances. They are, in fact, "Unidentified Edible Objects." Now, food is a particular type of product. By ingesting a foodstuff, one is, in fact, making it part of oneself, from which comes the idea "you are what you eat". However, since many people today believe that "nobody knows what they are eating" a problem is arising. Along with this situation, one can add advertising myth, even if the fact of being forewarned should limit its impact: advertising for foodstuffs tends to give agriculture a bucolic and traditional image quite different from the reality of what is actually happening in production. Hence there is a gap when consumers find out about what is going on backstage, for example the recycling of corpses of sick animals into animal meals fed to herbivores (even if it is a very small part of their feed)!

3.2.2. Risk perception

The perception of food safety risks varies considerably depending on the actor: many

experts in the sector consider the risks linked to modern production methods to be quite low whereas the public expresses a high level of concern and some associations or groups denounce them vehemently. How can such differences of perception be explained? One cannot simply say that it is a question of different levels of economic commitment and liability. Researchers, popularisers, and members of committees of expertise all defend the fruits of their labour (for example, results obtained in terms of efficiency) whereas the mass public, ignorant of the techno-economic constraints at play and the intense competition inside branches, is scandalised by their resulting implications. One can no longer, as it has often been the case, simply attribute it to a lack of layman education in this field, or even to an irrational public reaction. Sociological research has, in fact, made it possible to better understand risk perception. Experts assess risk according to two components: the probability of an undesirable event taking place and the seriousness of the consequences if it does transpire. In health safety one may, for example, refer to annual mortality rate. The public, however, takes a set of several other factors into account, as shown in numerous works [25, 30–32]:

- the possibility for those exposed to risk to control the risk: the feeling of mastery is the essential point;
- the knowledge of and familiarity with the specific risk: household accidents and automobile accidents generate less worry than the potential dangers of GMOs. The invisible or uncontrollable is especially prone to provoke anxiety;
- the delay before the appearance of bad consequences: some important risks (such as heavy smoking, or sun-tanning without precaution) are quite often taken deliberately with lack of concern for the consequences because they will appear only in the distant future;
- the semblance of catastrophe: an accident affecting several people at the same

time and place has more impact than individual accidents spread across time and space, even if the total number of people affected is much lower;

- the voluntary or involuntary nature of the event: one tolerates deliberate risk the best. A risk which one can hardly avoid arouses more indignation than one which one can easily avoid;

- risk related advantages for the person exposed to or taking the risk: a risk which brings profits to the person responsible for its creation but not to the person exposed to it induces a very high level of indignation. People are much more shocked by the impact of accidents to children because of the “innocence” of the victims;

- scientific incertitude: poorly understood risks make everyone nervous. In the case of controversy the public suspects those who minimise the risk of having vested interests in the affair (as for asbestos in France) or of being obliged to take their position by people who want to avoid a crisis (as for BSE in Great Britain at the end of the 1980s [24]).

Thus, some individual practices which represent a true danger, such as heavy smoking or driving a car, arouse less worry than nitrates or genetic engineering which are less well known, unobservable, difficult to control and can lead to risk exposure which is not a question of personal choice. So, acceptability depends on numerous factors in relation to risk perception. In addition, this acceptability is highly contingent on the consumer assessment of the expected benefits justifying risk taking and offsetting potential bad effects.

The role the media plays in publicising risks that operators wish to hide in order to protect their own reputations is extremely important. However, the world of the media is itself a competitive world where the quest to enlarge the audience and to be the first to give news can lead to a dramatisation, even an exaggeration, of facts, especially in article titles which have an important

impact. On the contrary, once all risk has been eliminated from a product or process, the echo given to this new level of security will be quite weak in general or even absent, thus maintaining an aura of suspicion. Such was the case for rapeseed oil. Accused of containing erucic acid in 1974 (thought to contribute to provoking heart trouble), the rehabilitation of its reputation never succeeded even after eliminating this fatty acid and in spite of its other nutritional qualities!

3.3. Doubts about institutions, progress and socio-economic evolution

The acceptability of risk is directly contingent upon confidence in institutions. "The perceived risk of biotechnology will be significantly influenced by trust in the system that produces it... Components of the relationship that builds trust, or distrust, is the extent to which an individual feels affiliated with the system, agrees with the distribution of decision-making power, and shares the values enabled by the system" [16]. This problem of confidence in institutions has become particularly acute in western Europe over the past few years. The contaminated blood and BSE affairs have led to the belief that the goal of safeguarding economic interests has been allowed to override health interests.

Criticism of the industrialized agriculture model or suspicions about food are often expressed on technical points dealing with taste, composition, etc. Such points, however, often reflect another dimension. For example, various recent innovations are perceived as being of negligible social utility. As Daniel Boy puts it [7] in speaking about GMOs, "there is a missing fundamental element in this progress which constitutes the king-pin between science and society: the utility function... One of the basic springboards towards acceptance of innovation is the risk/utility equation... If an invention arouses incomprehension as to its usefulness while presenting a potential

risk factor it is doomed to a motivated rejection." Such would be the case particularly for any innovation aiming at increasing productivity as long as surpluses remain a problem (at least for the moment). Moreover, refusing GMOs more often than not seems to stem from the crystallisation of concern over the overall socio-economic situation (concentration and increasing power of firms, globalisation of the economy, etc.). At times one even sees a certain loss of confidence in progress. Until a recent era, everyone in general expected the future to be better for their children, or, at least, that it could be. Today this faith in the future has been seriously eroded. Now, if one considers that the future will be worse than today, nostalgia for the past is susceptible of setting in. Finally, some innovations and scientific research seems totally "senseless" [29], which can produce a good bit of reservation as far as public acceptance of them is concerned.

Hence consumer suspicion is not rooted solely in a lack of knowledge of production and risk. The underlying issues are much more complex: "The argument that scientific literacy, or more knowledge about a technology, will increase support assumes that there is no reasonable basis for opposition. It assumes that technology is objectively a desirable thing and that opposition must stem from ignorance of its true benefits and costs. This approach not only fails to receive empirical support, but adhering to it, conceptually, severely jeopardizes policy development and communication strategies. (...) Proponents of technology often argue that public perceptions of risk are irrational. Yet, public risk calculations are rational, given the socioethical perspective from which they are derived. In fact, expert risk assessments also stem from a specific socioethical perspective. The difference between expert and public risk perceptions should be seen as the difference in the socioethical perspective which defines the calculation, not as the difference in rational ability" [16].

4. ARE THE PROPOSED ANSWERS APPROPRIATE?

4.1. Proposed solutions in the face of denounced risks and the crisis of confidence

Faced with the denouncement of risk or, more largely, with the criticism of productivist agriculture, the initial reaction of some scientists and many actors in the sector has often been to simply ignore them or to condemn them as being irrational and/or the fruits of ignorance. Generally the proposed answer is, hence, to better inform and “educate” the public. At the same time, one often emphasises the major risks of individual actions or those brought about by inattention (e.g. heavy smoking, allowing frozen foods to partially thaw, forgetting to wash ones hands before a meal, etc.).

A second attitude is to take into account these newly expressed demands at different degrees. This type of response is tending to become more frequent because in a market economy it is difficult to refuse to listen to the customer’s demands, a fortiori in a context of intense competition and with large ranges of goods from which to choose! Thus for example in 1999, faced with the rising opposition to GMOs, many large transformation or distribution companies announced that they were no longer using them [3]. For its part, the safety worry is imposing itself due to both penal risks relating to the matter and, above all, financial risks stemming from the degradation of trademark image in the case of a problem. In this way, along with the previous goals of cost reductions and the improvement of productivity, new imperatives have now been added for both production and transformation:

- **quality**, particularly in terms of composition, transformability, texture, taste, aroma, health value, etc.;

- **food safety**, all the more intended as detection methods are continually improved;

- **environmental protection and pollution reduction**;

- seeking **better social acceptability** of the techniques employed (e.g. animal well-being).

These new imperatives stand out in research axes developed by scientific organisations or those which push for calls for tender from the European Commission or different ministries. They also lead to the development of **numerous regulations and norms** in the fields of safety and environment and contribute to issues of traceability and labelling. Companies in the food industry sector, for their part, refine **product differentiation** and market segmentation so as to better adapt their offer to the different categories of customers and their specific desiderata.

4.2 Appropriate answers?

4.2.1. Difficulties and pitfalls in meeting the demand

Professionals working in the branch are, thus, increasingly active in attracting consumers, which involves “tracking” their changing tastes and buying behaviours. The reference to quality, in its various meanings, has become a leitmotiv. In agricultural research, consumer demand, or overall social demand, has become a central element in setting goals and priorities [17, 28]. Finally, representatives from consumer associations can now be found on the divers committees and commissions working in the field.

This answer, at first, appears quite adequate and pertinent. Still, the approach remains questionable, notably if concerns try to orientate public research around consumer demand. The latter can indeed mainly convey opinions of some certain categories or short-term views of needs. In addition, some social groups have more means of making themselves heard and being listened to than others, which could, of course, lead to biased decisions. Plus, with private

research playing an ever larger role, consumer demand is, in large part, satisfied. In this context, one might well ask if the role of public research should not be, at least in part, to explore other technological approaches or some different aspects, to develop a prospective vision, a long term view, a closer consideration of the needs of the less wealthy members of society (not so actively courted by private companies) and a more direct preoccupation with collective and public goods. While such is already the case, more seems needed.

A new route between two pitfalls must thus be found:

- One cannot simply refuse to listen to some consumer demands or complaints, considering them irrational and disregarding them, as previously done for organic products and GMO worries. These two examples show that such an attitude can result in later reinforcing ideas which initially one refused to listen to!

- At the same time, consumer demands should not be referred to literally in legitimising research, without first putting these demands into perspective and establishing priorities.

4.2.2. An essentially technical response to a question going well beyond this realm

A frequent solution for reducing health risk is to implement numerous hygiene norms or regulations. Such approaches, in fact, produce several perverse effects: for example, in the case of on-the-farm transformation and sale of dairy products or other such products, the level of investment required to meet the norms might restrict participation to only large exploitations. The final result promotes farm concentration instead of helping maintain smaller exploitations, especially in less-favoured zones. Implementing product traceability can also generate costly constraints. The problem of competing with countries imposing less rigorous norms must also be addressed. Bene-

fit-cost analysis is a valuable tool to be put in place before implementing any such regulations [2].

In order to enhance the organoleptic characteristics of food and its sensory perception by consumers, a lot of very sophisticated work is being carried out on the numerous biophysico-chemical characteristics which affect these organoleptic and sensorial traits. However, man's relationship with food is the complex result of a multitude of influences: historical, geographical, social, economic, psychological, etc. What is more, taste or savour as perceived by consumers does not depend solely on the physico-chemical composition of food but relies as well upon numerous other factors: the framework and social context of the meal, the symbol and image of the foodstuff, etc. [20, 23, 27]. That is, improving the image of modern agriculture and its products – particularly those which are often criticised as being “industrialized food” – would probably be useful if one wants to improve the perceived savour of food. While it is true that actions are underway to put agriculture in a better light and to rehabilitate its techniques, one might well ask if enough research has taken place and been taken into consideration on the same subjects in the human and social sciences.

Criticism from one part of the consumer population is not limited to an issue of biochemical nature. Over and above complaints about “tasteless food, too many additives, antibiotics, hormones, agriculture which pollutes, etc.” there are also questions of another sort. The question is raised, for example, on the constant quest for higher productivity or the justification of taking certain risks like the systematic use of antibiotics in poultry farming while in many sectors there is already a crisis of overproduction. Other questions center around the instrumentalist's approach to life and its exploitation in line with utilitarian production dogma. Jacques Testart [33] expressed this concern in speaking about transgenic

animals: “At the first level, the opposition is attacking the creation of tailor-fitted animals, modelled by human will and considered... to be ‘transformable material’. The tranquil assurance we show in taking control of all biological legacy, including both plants and animals, to structure it according to our own whims and fancies, the triumphant imperialism exercised on the living and the environment, the irremediable pollution of genes, of the air, of water, all have meaning: they mean, in fact, a presently immeasurable loss compared to proclaimed gains which might well prove derisory.”

In fact, the quest for high productivity affects all sectors of economy, due much more to the context of intense economic competition than to the agricultural techniques themselves (but consumer sensitivity is more acute in this sector where some aspects of globalisation seem less accepted than elsewhere). A frequent answer to the critics is the vertical differentiation of products on the basis of various labels or signs of quality: higher sales prices make it economically possible to use more traditional and more extensive techniques (with their precise specifications). However, many people are shocked by this dual system in which some consumers can afford “quality” food whereas others must content themselves with industrialised foodstuffs perceived more or less as adulterated. As far as GMOs are concerned, to get them accepted firms now place the emphasis on second generation products which will have “quality” features. In this case, however, since the notion of “quality” refers to composition or to contents of various elements enhanced by genetic engineering, will it always be in step with what consumers themselves understand when they use the term?

As to agricultural pollution, significant research has been carried out to reduce it. Not all of the results have been implemented, notably because doing so would sometimes lead to less easy practices or economically risky situations (as in the case of

integrated farming) whereas the economic incitement remains quite low in general. In fact, except for the specific case of organic farming, there has been no eco-label in agriculture up to now. However, at present several tries are underway. Whether or not such attempts will produce a strong enough echo remains to be seen. Even if one part of the consumer population requests “quality” products, one must not forget that price remains a central issue for many consumers.

Thus, nowadays consumer questions are taken more seriously into account and various types of answers are proposed: product differentiation makes it possible to choose between standard foodstuffs and various differentiated products (local, labelled or organic products); new safety norms and regulations are being drawn up; cleaner techniques are being developed and implemented; etc. Still, there is no guarantee that such approaches will be successful in calming consumer anxiety and doubt insofar as they might well help crystallise deeper worries, such as, in the case of GMOs, the evolution of the global economic system (globalisation, toughening of competition, consolidation of multinational firms into giant groups, etc.). The general public rejects GMOs particularly because they seem to offer advantages only to the companies which produce them, and not to the other stakeholders (especially not to the consumers). As far as agricultural products and practices are concerned, finding answers to the questions concerning productivism will probably mean moving towards a new type of agricultural model. This model should be diversified, pluralistic and multifunctional; agriculture should be capable of adapting more efficiently to the diversity of demands, constraints and contexts while setting itself the goal of greater sustainability [4].

5. CONCLUSION AND PERSPECTIVES

A central issue is at play behind all the concerns relating to agriculture modernisation

and food production industrialization: the sustainability of agricultural production and the food consumption model. What orientations should agriculture and the food industry follow, depending on the different contexts, in order to satisfactorily feed nearly 8 billion people in the year 2025 without degrading the environment? A lot of ink has already been spilled over this question and that of the earth's carrying capacity, so such questions will not be treated here except insofar as to say that the planet has a high production potential and that the persistence of present-day malnutrition stems mainly from the inequality of land and wealth distribution. It is therefore an initial question of either poverty or conflicts, which can seriously perturb agricultural production and the circulation of goods. However, an increase in food production would appear indispensable in the future.

Over the next few decades some specialists expect to see a high increase in the consumption of meat, particularly in developing countries, due to population expansion, urbanisation and the improved economic situation of some social categories [8, 12]. This situation will render the problem of land area and grain quantities all the more acute due to the ratio of conversion between the gross vegetal consumption of an animal and its net production of meat. On the basis of simulations drawn up using a model of the world-wide agricultural sector, the IFPRI has estimated that it will be possible to satisfy this growth in consumption without raising prices mainly by, on the one hand, increasing grain yields in large exporting countries, making it possible for them to increase their exportation and, on the other hand, enlarging the arable land in southern and eastern Asia [12]. However, not all experts are so optimistic! Moreover, many of them consider biotechnology exploitation a necessity since it increases production (first of all by reducing loss), improves the nutritional value of products, assures higher efficiency of various processes, etc. Still, it would be necessary that

biotechnology be made available to those who need it the most [5, 6].

What will the situation of western Europe be within this world-wide context? Will the orientation desired by part of the consumer population (quality products, protection of the environment, maintenance of various traditional production techniques, etc.) be compatible with the evolution in the rest of the world while heavy competition is at play on the market in all fields and the flow of information, products, capital and people is both amplified and accelerated? If production growth proves insufficient in some LDCs (due to institutional, agro-climatic or technical reasons) and demand on the external market comes to sharply increase, is there not a risk in leaving the role of filling the deficit gap essentially to exportation from the USA and two or three other major agro-exporters? Actually, the "quality and environment" option, preached for French and European agriculture by some organisations or movements, often goes hand in hand with the recommendation to limit exports to the world-wide market, which could, in fact, make it possible for some LDCs to stimulate their own production with less external competition. But this vision would have to be shared by all the major exporting countries. Can one, moreover, imagine that western Europe exist as a sort of garden of Eden turned towards quality or even luxury goods while other regions in the world are faced with crucial food and environmental problems?

To face such problems, some people entertain high hopes for the agricultural applications of biotechnology, while others, in line with the concerns treated throughout this article, are wary of them or refuse them. This is notably the case for genetic engineering, which is sometimes seen as too artificial and therefore a too risky manipulation of nature (with, for example, the insertion of genes from other species). It is also seen to further the industrialization of agriculture, resulting in tighter control by

large companies and multinationals. That is to say, for many people the advent of new technologies rhymes with the disappearance of farmers and nature, both of which play quasi-mythical roles in the imaginary.

In this field, deep public concern is not only technical (e.g. on biochemical aspects), but relates back to various other registers. Suspicion of GMOs is so deeply entrenched in part of the consumer population and, especially, amongst various leading associations that scientific documents attesting to their harmlessness would not be sufficient to alleviate mistrust. On the contrary, biotechnology is quite well accepted for medical applications [13]. To gain the same acceptance, or at least neutrality (particularly on the part of associations for which it is the war-horse) in agriculture, biotechnology will have to prove its usefulness and acquire a moral dimension, i.e. give credible proof of its usefulness not (only) to the large companies which have invested in it, but also to consumers, to European farmers and to farmers in the developing countries.

To do so might well require modifying the economic conditions of its implementation with, particularly, less privatisation of this sector, a more direct RD orientation towards the needs of the poor, and a better sharing of the benefits between all stakeholders. In addition, the biological nature of biotechnology should be allowed to reach its full potential rather than furthering the marketability of living matter and increasing the dependence of farmers on multinational firms. Reaching the full potential of biotechnology would notably mean leading agriculture to a new model based more on biological processes than on chemical applications. In addition, biotechnology would have to develop more soul, and a more ethical dimension. So it could be seen as a switch from a too highly industrialized agriculture rather than its ultimate reinforcement.

Will the opposition of some western consumers and world citizen associations lead to this direction and be sufficient to out-

weigh the economic forces at play to assure such a switch, or at least to give more moral direction to the biotechnological sector? Or will it simply form a strong block of opposition with no possible evolution – at least in the short run –, because the benefits for rich consumers do not appear sufficient? Or will the opposition abandon this subject for another campaign in a few years? Consumer concern could offer a means of eliminating, or mitigating, some of the harsher aspects of present-day economic developments, but it also runs the risk of enlarging the gap between the rich and poor if it results in stronger safety and environmental regulations in some rich countries, without allowing poor countries to improve their situation.

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Acronyms

BSE	: Bovine Spongiform Encephalopathy
CAP	: Common Agricultural Policy
CREDOC	: Research Centre for the study and the survey of living conditions (France)
DG	: EC's Directorate General
EC	: European Commission
EU	: European Union
GMO	: Genetically Modified Organism
IFPRI	: International Food Policy Research Institute (USA)
INRA	: National Institute of Agricultural Research (France)
INSEE	: France's National Institute of Statistics and Economic Studies
LDCs	: Less Developed Countries
MORI	: Market & Opinion Research International Ltd
RD	: Research & Development
SIGMA-UNCAA	: co-operative network of European grain co-operatives
SNIA	: National federation of animal feeding industries
SOFRES	: a French polling institute
SYNCOFAC	: National Federation of feed production co-operatives
UIPP	: Professionnal union of the crop protection industry