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Increasing Fruit Consumption to Improve Health

ISAFRUIT Forum

ISAFRUIT Project

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Increasing Fruit Consumption to Improve Health

ISAFRUIT Forum

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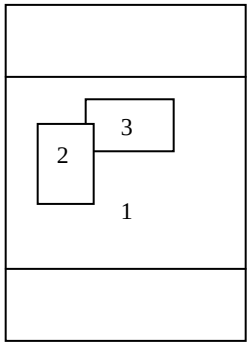
3. Apricot 'Hacıhaliloğlu' (by courtesy of Bayram Murat Asma, Apricot Research Centre, Inonu University, Malatya, Turkey).



EDITORIAL

In January 2006 the ISAFRUIT project began. 300 scientists from 60 research and development institutions and SMEs, in 16 countries across Europe, the USA and New Zealand, embarked upon a mission to encourage increased consumption of fruit, to improve the health and well-being of the European population.

Despite government initiatives to encourage people to eat more fresh fruit and the fact that fruit is synonymous with good health in the minds of consumers, quantities consumed are not increasing, and they vary widely across Europe, from 70-100 kg in Italy, the Netherlands, Greece and Spain to 40-60 kg per person each year in Poland, the UK and Germany. This suggests that many Europeans still do not consume the recommended daily minimum of five portions of fresh fruit and vegetables.

The EU Framework 6-funded ISAFRUIT Integrated Project in the area of food quality and safety is the only FP 6 Integrated Project entirely focused on fruit, and runs until 2010. The emphasis of the individual projects that are comprised in this integrated study is to address bottlenecks to fruit consumption such as: consumer perceptions, fruit availability, quality and convenience, and environmentally-friendly production. The project focuses on the idea that improving both the quality and availability of fruit and fruit products, along with raising customer awareness, will boost fruit consumption and improve the health and well-being of Europeans.

ISAFRUIT's goal of increasing fruit consumption has strong foundations in new knowledge created by a multidisciplinary team of natural and social scientists addressing many aspects of the multi-faceted fruit chain. Meeting consumer expectations in terms of quality, flavour and taste plays a key role in achieving increased fruit consumption and ISAFRUIT's supply chain approach has been addressing bottlenecks that may affect these characteristics.

Starting with consumer science, social scientists have been identifying and explaining patterns of variation in fruit consumption across Europe. The project's researchers have been investigating the reasons for consumer behaviours and their attitudes to new innovations; asking what are the drivers behind buying decisions for fruit and fruit-derived products; and analysing traits of fruit and fruit products supply chains to identify their capacity to act as a coordinated chain.

It is well known that a diet rich in fruit and vegetable content can reduce the risk of chronic disease, but the fruit traits responsible for the beneficial human health effects of fruit consumption are not well known, such as those related to cardio-vascular diseases and obesity, particularly in younger generations. These are also targets of investigation for the ISAFRUIT project, which studies the impact of regular consumption of fruit and innovative fruit-derived products on health. A significant percentage of European consumers suffers from fruit allergenicity. Close cooperation among ISAFRUIT scientists (human health experts, fruit geneticists, horticulturists) is addressing this problem from many angles, with the goal of providing consumers with fruit of reduced allergenic potential either thanks to innovative growing techniques, or because these genes have been silenced in novel transgenic products via biotechnology.

Processed fruit products can be more convenient for the consumer, therefore novel fruit products and processes have been developed and the health properties of these foods have been investigated. The keeping qualities of minimally processed products and fruit-based snacks can help to increase the availability and wider consumption of fruit especially by the young and ISAFRUIT is developing a knowledge base on the uptake of such products.

Consumers are now also much more aware of where their food comes from and they want questions about how their food has been produced to be answered. ISAFRUIT has directed efforts to attain the highest pre-harvest quality of fruit by developing sustainable

production methods that save energy and natural resources such as water, and reduce pesticide and fertilizer applications thanks to the adoption of precision agriculture methods, including innovative mechanical equipment, models and decision support systems. This work lays the foundation for studies on the post-harvest phase of the supply chain, which aim to provide the consumer with high quality fruit at every purchase, to increase the potential of meeting consumer expectations, while the use of “generally regarded as safe” methods to preserve quality during storage will also increase consumer confidence. Non-destructive tools for quality control along the supply chain will help the trade to guarantee the quality expected by consumers. This all contributes to producing fruit and fruit-products that are more inviting and acceptable to the consumer.

ISAFRUIT researchers have carried out the largest to date study of consumer acceptance of existing, innovative apple and peach varieties throughout Europe. The results from these studies and knowledge gained mapping genes responsible for important fruit quality traits in these species will facilitate bringing better varieties to market in future, including prospects for reduced chemical inputs and low- or allergen-free-products.

Finally, ISAFRUIT has developed strategies to identify, protect and exploit intellectual property and to disseminate new scientific information, skills training and knowledge, including plans to involve the key actors in the European fruit industry. This new knowledge can ultimately be disseminated to a variety of audiences including key decisions-makers, with whom the responsibility of policy-driven change lies.

In June 2007, the European Commission adopted a White Paper setting out a wide range of proposals to tackle nutrition- and obesity-related health issues. An advisory group, made up of representatives from each Member State, was appointed to monitor progress. Its final report is due in 2010. Among other measures proposed, new programmes to promote the consumption of fruit and vegetables are being developed. In line with these objectives a joint initiative of ISAFRUIT, the International Society for Horticultural Science (ISHS) and the European Economic and Social committee, has brought together ISAFRUIT researchers with their colleagues from the World Health Organisation, the Directorate General for Agriculture and Rural Development and ISHS to discuss issues related to fruit consumption from the perspectives of consumer behaviour, the health-giving benefits of fruit and initiatives to encourage increased consumption, in particular by school children. This volume provides reviews of the work done in these areas.

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Teresa Briz
Universidad Politécnica de Madrid
E.T.S. Ingenieros Agronomos
Madrid
Spain

Siet J. Sijtsema
LEI Wageningen UR
(Agricultural Economics Research Institute)
Wageningen
The Netherlands

Anna Jasiulewicz
Warsaw Agricultural University
Department of Agrarian Policy
and Marketing
Warsaw
Poland

Anastasia Kyriakidi
Agricultural University of Athens
Department of Agricultural Economics
and Rural Development
Athens
Greece

M. Dolors Guàrdia
Institut de Recerca i Tecnologia
Agroalimentàries
Tecnologia dels Aliments
Monells
Spain

Isabelle van den Berg
LEI Wageningen UR
(Agricultural Economics Research Institute)
The Hague
The Netherlands

Ivo A. van der Lans
Wageningen University and Research Centre
Marketing and Consumer Behaviour Group
Wageningen
The Netherlands
&
LEI Wageningen UR
(Agricultural Economics Research Institute)
Wageningen
The Netherlands

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Abstract

This study gives more insight in motives and barriers, i.e. positive and negative drivers, for European fruit consumption, as a basis to meet consumer requirements in developing new types of fruits and fruit products and to develop interventions. For that purpose, focus group discussions were held in Spain, Greece, Poland, and The Netherlands. Consistent with existing literature, healthiness, (sensory) pleasure, and (lack of) convenience emerged as major drivers of fruit consumption, with appearance, habit, and price as additional drivers. Talking about fruit, participants have fresh, unprocessed fruit in mind. Fresh fruit was more or less regarded as a synonym for health. The fresher, the less processed, and the more natural the fruit product, the healthier it is perceived to be. Especially, pleasure and convenience are conflicting with this. Implications of these conflicting drivers and solutions for product development and interventions are given. Still, quantitative research is needed to get insight into what extent certain motives and barriers play a role for different fruit types, different consumption moments, and different consumer segments.

INTRODUCTION

There is general consensus that the consumption of fruit is an essential part of a balanced diet, which in turn plays a primordial role for the prevention of chronic sickness and premature death (Brug et al., 1995). However, despite promotion efforts (a.o. national "five times a day fruit and vegetable" campaigns in Poland and Spain), average European fruit consumption remains well below the level recommended by the World Health Organisation (WHO) and nutrition experts (Groot et al., 2007; Pomerleau et al., 2004; Schreuder et al., 2007). In addition, large differences in average fruit consumption can be noticed across countries (with a relatively high average of fruit consumption in countries as Greece and Spain, but a rather low fruit consumption in for instance Poland), as well as within countries (a.o., see Kamphuis et al., 2006; Krebs-Smith et al., 1995; Pollard et al., 2001, 2002). Those studies consider consumption as well as the actual behaviour of consumers, but as far as we know there is minor attention to the background of this behaviour in terms of motives and barriers. To better understand this behaviour of consumers in our study there is especially attention for the reasons behind eating or not eating fruit.

As such, it is clear that more insight in European consumers' motives for and especially their barriers to fruit consumption is necessary to meet consumer requirements in developing new types of fruits and fruit products and to develop well-planned interventions targeting especially those consumers whose fruit consumption is well below recommended levels.

In this paper, we present the results of an exploratory, qualitative study using focus groups into different consumer motives and barriers (i.e. positive and negative drivers) behind the fruit consumption in Europe. These motives and barriers may reside in consumer wishes, perceptions, associations, knowledge, and so on, which may be contingent upon consumer and situational (consumption and purchase) characteristics (Sijtsema et al., 2007).

METHOD

Participants

Focus group discussions were organized February 2007 in Spain, Poland, Greece, and The Netherlands. In each country, three focus group discussions were carried out, each one with 6-10 participants. Aiming for a variety of motives and barriers from different consumer segments, different target groups were considered for the three focus group discussions in each country: full-time workers, people over 60 years old and couples with children living at home. Those segments were selected based on criteria like time available, stage of life, and presence of children. Each focus group consisted of one target group for homogeneity reasons, to make sure that within each focus group the participants had some common background and experiences against which they could exchange their wishes, perceptions, associations, in order to increase active participation of all participants. Across the four countries and the three target groups, there were 94 participants in total, with at least 30 participants per target group.

Focus Group Guide

All focus group discussions followed a guide that was carefully developed beforehand (see Table 1 for the aim of each task and some examples of questions). The moderators in all four countries used this focus group guide[1], which gave instructions on the procedure and a list of questions per part. During the focus group sessions, participants carried out a combination of individual (e.g. ranking different kinds of fruit on healthiness) and group tasks (e.g. discussion on the reasons for the ranking of different kinds of fruit on healthiness).

[1] Please contact the first author if you are interested in the focus group guide

Each focus group discussion took approximately three hours.

Analysis

All group discussions were recorded, transcribed and translated. The data was structured and coded based on a priori coding scheme. This input from the four countries was interpreted.

Table 1. Outline of focus group guide.

Part	Aim	Examples of questions
1. Introduction	Introduce moderator, participants, topic and agenda for the discussion	Please introduce yourself, name, age, family situation, job and hobbies
2. Top-of-mind associations with fruit	Get the minds of the participants focused on the topic from their own perspective	Write down what first comes to your mind when I say 'fruit' What color comes to mind when you think of fruit?
3. Reasons behind top-of-mind associations with fruit and fruit consumption	Gain insight into the reasons behind associations people have with fruit and people's definition of fruit consumption	What did you write down as the first thing that came to mind when I said fruit? Why? Could you explain that? When was the last time you had fruit? What was it?
4. Changes in consumption	Gain insight into motives for and barriers to fruit consumption	Have you changed the amount of fruit you ate over the last years? Do you eat different products? What is the reason for change? Could you explain that? Are there other reasons?
Break		
5. Perceived healthiness, convenience, and taste	Gain more insight into health-, convenience-, and taste-related motives and barriers	Why do you rank your fruit (apple, banana, grapes, orange, peach) or fruit product (glass of wine, fresh peach, dried fruit, canned orange juice, apple pie, freshly squeezed orange juice, canned fruit) like this?
6. Consumption moment	Gain insight into consumption- and purchase-situation dependent motives and barriers	Where do you eat fruit? At home or out of home or both? Why do you eat it there, why not? Are there any more reasons (not) to do so? Can you explain that? Is it a habit? Has it changed? Do you like to see things changed? What are they? Why/why not? And where do you buy fruit?
7. Image of fruit eaters and noneaters	Gain insight in additional motives and barriers (by indirect probing)	After short descriptions of a fictitious fruit eater (John) and a fictitious person (Peter) who does not eat fruit, participants were asked to further describe each of the persons by his looks, character, job and way of living. Give arguments for John to convince Peter to start to eat fruit, and arguments for Peter to stay convinced not to eat fruit.

RESULTS

Fresh versus Processed Fruit

Before describing the motives and barriers that emerged from the focus group discussions, the reader should be aware that when participants talked about fruit they consistently thought about fresh, unprocessed fruit, across countries and target groups and

throughout the discussion. They typically had in mind whole pieces of fruit. Processed fruit products, canned or bottled juices and canned fruit, were typically not considered to be equivalent to fresh fruit. This was illustrated by statements like: "*There are no fruit products to replace fresh fruits*", "*Fruit has to be raw, natural, straight from the bush or tree, juicy and healthy*", "*Processed fruit is substitute of fruit but it is not the real fruit*". Several participants affirmed that some of the most important properties of fruit are freshness and juiciness, and that whenever fruit loses these properties it is no longer considered fruit. This seems to be especially applicable to industrial processing and also to processing at home, i.e.: "*Fruit that has suffered any kind of elaboration, no matter if it has been at home (jams or roasted apple) or in an industrial way (canned juices, fruit in syrup, etc.) is no longer fruit*". There is one exception made for freshly squeezed juice (preferably by oneself, at home), it is generally considered to be equivalent to fresh fruit, which is illustrated by statements like "*Only if it has been squeezed by you*" or "*Only the juices prepared at home have the attributes of fruit*".

There are some differences between countries though. For instance, some Dutch participants declared "*Knorr Vie is fruit to me because of the commercials*" and "*I usually buy Knorr Vie so then I have half of my daily needs*". On the other hand, another Dutch participant stated "*I do not think Fruit2day is fruit, it is just a juice*". This is also expressed by Spanish participants "*It is better to consume Fruit2day than nothing, but it can hardly be considered fruit*". Greek participants considered products like Knorr Vie and Hero's Fruit2day not as fruit, but as vitamins' supplements, which cannot be compared with the vitamins that come from fresh fruit. Overall, it seemed that Polish participants were more likely to label (industrially) processed fruit products (like canned, dried and frozen fruit, and marmalade) as fruit than especially Spanish and Greek participants.

In addition, processed fruit products were not considered to have the same health effects as fresh fruit and there was an overall lack of confidence in their components: "*Juices from a shop have preservatives or even added sugar*", "*You buy a can of orange juice for only 1€, with how many oranges in it? How is that possible? It cannot be good*", "*To eat peaches in syrup is to eat unhealthy food, like French fries*". Again there are some differences in opinion between countries and participants. A Dutch participant for instance stated: "*canned fruit is also good, I always ate food from cans and I am still healthy*".

Motives for and Barriers to Fruit Consumption

Most focus-group participants expressed a positive attitude towards fruit consumption, mainly driven by the utilitarian benefit of health and the hedonic benefit of pleasure. When participants mention a more negative attitude towards fruit consumption especially (a lack of) convenience comes forward. During the focus group discussions it appeared that these and a number of additional aspects are important drivers of fruit consumption and function as motives and barriers, depending on the characteristics of specific fruit products and background of the consumer.

1. Health. For participants fruit is synonymous with health. Fruit was generally viewed as being part of a healthy life: "*It's good for you and don't you want to live long? You will have a better quality of life*". Some participants explicitly stated that the concern with their health and the health benefits of fruit is a reason for increasing their fruit intake. Among the health benefits mentioned by the participants, we may summarize the following: gives you a better look, gives you a better skin, helps to loose weight, prevents diseases and provides energy for sports.

The nutritional value is discussed in different ways. The content of carbohydrates and sugars comes forward as well as the caloric content of fruit. Some participants substituted other types of food with fruit "*I am on a diet and I have increased the fruit consumption and decreased other types of food*." Besides also some specific nutrients/ingredients were

mentioned like minerals, vitamins and antioxidants. A participant expressed it like: "*apples have fibre, vitamins and minerals*".

Despite promotion campaigns like '5 a day', several participants admitted not to have a clear idea about the recommended daily intake and whether they fulfil it or not. In addition, the participants only take fresh fruit in consideration and not other products such as fruit salad or fruit juice. Participants that knew about the recommended daily intake, stated that despite those recommendations, they just do not feel like eating fruit at all, see the recommendation as more relevant for their children than for themselves.

Fruit is perceived as less healthy than earlier days. "*The percentage of vitamins in apples nowadays is only 20% of the vitamins amount 20 years ago, so you need to eat 5 apples instead of 1 to get all the vitamins*". Besides that also the content of pesticides, hormones and chemicals is mentioned, which are also thought to affect the taste and/or the appearance of the fruit.

2. Pleasure. Overall, participants considered eating fruit as a pleasure and an enjoyment, because of its sensory characteristics (taste, smell, juiciness, texture, etc.) and associate it with bright colours, sun and nature. Many participants recalled eating certain fruits at home with their parents or on vacation somewhere and these thoughts bring back nice memories.

There is a clear seasonality in fruit consumption. Being associated with freshness and coolness, it is eaten more often in the summertime. Typical statements were "*There is nothing like the pleasure of a slice of watermelon in a hot summer day*" and "*An orange is nice when you are thirsty*". Participants agreed that in summertime there are more fruit varieties available, fruit is cheaper, has a better quality and is tastier.

Although consumers have different taste preferences, most of the participants agreed that local fruits are more natural and fresh, with perfect sensory characteristics. On the other hand, participants claimed that they are curious for tasting tempting new fruit varieties that are now available and did not use to be years ago (e.g., kiwifruit, pineapples, etc.).

From the focus group discussions it emerged that there is a clear threat to the pleasure that consumers derive from fruit consumption. Participants complained that the taste of fruits is not homogenous. Different levels of ripeness provide consumers with fruit with a wide range of taste, juiciness, and texture; even in the same variety and even if they are bought at the same time. This seems to be a strong barrier that restrains the consumption of fruit: consumers are reluctant to buy because they do not have any guarantee of what they will get: "*When you open the lid of yoghurt, you always know what you are getting, you know its taste. That does not happen when peeling a piece of fruit*". In this way, the quality of the fruit does not fulfil the expectations that consumers have when they buy the fruit.

In addition, a number of participants suggested that fruit that is currently on the market does not have the same taste, or the same smell, or the same nutritious ingredients, as in the old days or as fruit that has been recently harvested. Statements like "*I am very skeptic about fruit. Fruit does not taste anymore as it used to be*", "*The taste of fruits has changed a lot since my childhood. Nothing tastes the same*", and "*I miss the smell fruit used to have 20 years ago*" illustrate this idea.

There seems to be some nuance in the association between pleasure and enjoyment and fruit. When asked for their associations in a direct way in the beginning of the focus group discussion, participants associated eating fruit with pleasure and enjoyment. Nevertheless, when asked for the image of fruit eaters and noneaters later on, participants linked the eating of fruit more to a regular, dutiful lifestyle, and complete abstinence from fruit to a more hedonistic lifestyle. This seems to suggest that there are some barriers to fruit consumption, that diminish the pleasure derived from its taste, smell, juiciness, texture, and childhood memories.

3. Appearance. The appearance of fruit functions as a motive or barrier at the moment of fruit purchase and consumption: "*I buy fruit on impulse, depends on how it is showed or*

displayed" and "*Depending on how fruit looks, I will or I will not have dessert*". Participants consider that fruit has a huge variety of intense, rich, vivid, and attractive colours and they are attracted by the appearance of new fruit varieties.

In addition, the appearance of fruit is also used as an indicator for the taste, juiciness, and naturalness (and therefore healthiness and food safety): "*The fruit products must have a natural look*". In Poland, participants stated that fruit should not be "*too perfect*", which means for them that too perfect fruit is not as tasty and healthy, and they mention that "*It is probably sprayed with pesticides, etc.*". They claimed to prefer organic fruit over conventional fruit, in spite of the fact that it looks "*less pretty, with worms*". In Greece, participants expressed their opinion that fruits that look bigger than expected have too many hormones or had pesticides applied to them. Generally, participants expect fruits to have the dimension and weight that is specific for the variety, and deviations are suspicious.

The appearance is not always considered to be a good indicator of for instance taste. Participants complained that the taste of fruits is not as homogenous as their appearance, discouraging fruit consumption since you never know what you are going to get. Nor does appearance seem to be a good cue for ripeness/shelf life: "*You buy them and they are hard and green. You put them in the refrigerator, and 2 days later they are over ripe and you have to throw them away*".

4. Convenience. Consumers regard convenience as an important driving force for fruit consumption. Convenience can be considered from many points of view: purchase, transport/storage, convenience in preparation and consumption.

The availability of fruit is often seen as a constraint to its consumption. Participants mentioned that they frequently eat out of home (usually lunch and at workplaces) and that fruit is not always available. As mentioned earlier, participants also indicated a higher availability (more varieties, lower prices, and better quality) in summertime.

Aspects of the convenience in transport are the size and firmness of the fruit. Small pieces of fruits are preferred to bigger ones, as are non-juicy fruits. "*You can put small fruits in your school bag and take it everywhere: to the gym, to class, on the bus, etc.*". Fruits such as strawberries (and plums and peaches) cannot be carried with you out of home, "*They get smashed when you put them in a bag*". Other fruits, like apples or bananas, are preferred in this case.

With regard to storage convenience, participants expressed a preference for fruits that are easy to store: "*I like fruits that are easy to store*" and "*Fruit is not convenient if it is easily spoilt outside a fridge*". A short shelf life was considered to be rather inconvenient as it means that the fruit must be bought in small quantities and is therefore, due to limited time for shopping, not bought as often as wished. Larger fruits (pineapple, watermelon, etc.) are also considered to be inconvenient when it comes to storage, especially for one-person households.

In general, participants prefer fruits that are easy to prepare and consume: "*I like fruits which are easy to eat*", "*If there was a peach that could be peeled as a mandarin, I would eat more peaches*". They complained that some fruits need careful washing, difficult peeling, and cutting. Quite often participants that mentioned inconveniences in the preparation and consumption of fruit, referred to a lack of time: "*It is so much work, I do not have time*" and "*There is not enough time to buy and peel the fruit*". Participants also admitted that they are too lazy to prepare fruit and prefer fruit that you can "*Just wash and peel and put them in your mouth*". This was also mentioned as a reason for the growing demand of ready-to-eat or take-away fruit products. Still, not all participants like small fruits that can be readily put in your mouth: "*The proportion of pit versus fruit is not satisfactory enough to make me eat cherries*" and "*When fruits are too small you need a lot of them to be satisfied*".

It seems that everyone likes to eat fruit as long as it is already prepared. Some participants mentioned that if the fruit was previously prepared by somebody else (mother,

wife), they would eat it. (Too) hard fruit, smelly fruit, juicy fruit, presence of pips, seeds or stones (cherries, grapes) and presence of hair on some fruits (peach) were also considered to be inconvenient for consumers. With regard to juicy fruit participants complained that it may dirt your clothes or the table cover and you need to wash your hands afterwards.

5. Habit - Position of Fruit in Diet. Participants claimed that for those who have been eating fruit since childhood, fruit becomes a need. It is such a part of their diet that they would not consider giving it up. Even though they notice changes in the varieties, know that fruits are stored longer these days, distrust residues on fruit, or consider fruit to be expensive, they need to eat fruit. The participants over 60 years of Greece and Spain for instance cannot imagine having lunch or dinner without ending with fruit as dessert or a snack in between meals. Of the countries studied, particularly in Greece and Spain, and specially the elderly, fruit is considered as a dessert. Greek and Spanish participants even claimed not to know whether their driving force to eat fruit is health or pleasure: they simply state that it is a habit.

6. Price. In Poland and the Netherlands, price was mentioned as a barrier to fruit consumption. In Poland, participants for instance said that they were dissuaded from purchasing organic fruit due to its higher price. Price was not mentioned as a barrier in the Greek or Spanish focus groups.

DISCUSSION

Health, pleasure and lack of convenience are the most often mentioned drivers of fruit consumption. Besides this also issues like appearance (both at the purchase and the consumption moment), habit and price were raised during the discussion. Consumers have clear associations between (fresh) fruit and health. This is in accordance with increasing consumer awareness of the health benefits of fruit and vegetable consumption in the last decade (WHO, 2003; Lock et al., 2005). Pleasure and related aspects like taste are also mentioned as the most important determinant of dietary behaviour for food in general by for instance Shepherd (1989), and for fruit in particular by Krebs-Smith et al. (1995), Brug et al. (1995), and Ragaert et al. (2004). The importance of appearance, i.e. colour and size of a fruit, has also been determined more often (Ragaert et al., 2004; MAPA, 2005). The wide variety of issues related to convenience and lack of convenience that came forward in each session, is consistent with other studies in which young consumers admit themselves to be lazy such that having to peel fruit acts as a main barrier for them (70%), while only 10% dislikes fruit (Fruticultura Professional, 2004). In general, the "portability of fruit" and the "absence of a need for any preparation or cooking skills" should increase fruit consumption (Marshall et al., 1994; Fruticultura Professional, 2004), as also emerged from our study.

Our results show that consumers weigh several conflicting motives and barriers in their choice for fruit. That consumers experience conflicts between fruit characteristics is also described by Connors et al. (2001) and Sobal et al. (2006). Those authors present the personal food system in which five types of drivers (taste, convenience, cost, health and managing relationships) consistently emerge as salient for many consumers, with other additional drivers also salient to some individuals and groups. In our study especially sensory characteristics in terms of pleasure, taste, appearance, health, and convenience were discussed extensively. Besides that also habits related to fruit consumption seem to affect the way consumers perceive those conflicts. Below, we describe a number of these conflicts, which may hamper an increase in fruit consumption.

Health – Pleasure and Appearance

In consumer decision making there is a strong competition between fruit and other products considered as substitutes: for example milk derivatives, sweets and snacks (not to mention that consumers may for instance decide to read on and not eat anything for the moment). Before purchase and actual consumption, consumers typically attempt to infer

(sensory) pleasure from the external appearance of a (fresh) fruit product, even tough appearance often is a far from reliable indicator. As such, they have learned to look for fruit that has a nice appearance. However, a too nice or too homogeneous appearance may easily lead to doubts about the naturalness of the fruit, the amount of chemicals that have been applied and therefore its healthiness. On the other hand, the health motive may not be strong enough in cases in which appearance seems to indicate that the sensory quality does not reach consumer wishes or expectations, also due to heterogeneity in taste, texture, and juiciness of pieces of fruit bought at the same or at different times.

Although there are some conflicts related to health and pleasure, an eye catching characteristic of (fresh) fruit is that in the perception of consumers it is a type of food in which health as well as pleasure are both represented.

Health – Convenience

A healthy product as fruit is strongly associated with 'pure' and 'natural' and 'high nutritional value'. Those associations are conflicting with some convenient fruit products for which additional processing steps are needed. A processed, heated, packed fruit product might be more convenient but is typically perceived to be less healthy due to lost nutritional components and a less natural image. Thus for several types of fruit consumers experience a conflict between the healthiness of the fruit (product) and its convenience. For other types of fruit like apple this conflict is nearly not experienced.

Convenience – Pleasure

Lack of convenience is a major barrier in fruit consumption. Several issues of convenience were expressed during the discussion. A very clear conflict is that consumers prefer fruit for its juiciness but they do not like sticky hands.

Another issue of convenience is related to a lack of availability. For example, consumers expressed that not all restaurants offer fresh fruit on their menus. But if restaurants offer juices or fruit salads, consumers admit that they prefer tempting choices of desserts that are not usually available at home. So they prefer to those new things instead of fruit what they would have had at home.

Participants admitted that they associate eating fruit to eating at home, and usually, to dessert. In previous studies it was confirmed that ice creams and sweet desserts (35.8% and 45.7% respectively) are the substitutes for fruit in out-of-home situations (MAPA, 2005). Related to this the following challenge is formulated: "To eat more and more meals outside the home is probably the biggest challenge to those seeking to promote fruit and vegetable consumption, given the very small amounts of fruit and most vegetables consumed away from home." (Guthrie, 2004). Although some types of fruits are easy to take along with you, in general consumers experience problems related to this.

When participants talked about their own fruit consumption they associated it with pleasure. However, when asked for their image of people who eat fruit, they ascribe healthy lifestyle, but also a regular, dull, dutiful life to them. On the other hand, the image of people who do not consume fruit is that they enjoy life much more and experience much more pleasure. This inconsistency is possibly to be due to inconveniences that one has to overcome when consuming fruit and diminish the pleasure from fruit consumption as a whole, but are more easily overcome by dutiful people with a regular lifestyle.

Health/Pleasure – Habit

If consumers have eaten fruit since their childhood, it becomes a need. This fact appeared several times in the focus-group discussions. John and Ziebland (2004) stated that: "If you started when you were a baby eating an orange a day or something similar, you would continue to eat an orange a day." For those consumers it turned out that this habit of

eating fruit is just something they do and they are not consciously making a linkage with health or pleasure.

Besides that consumers also associate fruit eating with enjoyable times with family and friends and in their childhood. This shows that not only rational associations are related to fruit consumption but also emotional aspects.

There is a conflict between health/pleasure and habit in the sense that, especially older, people mentioned that the taste of fruit these days is not as good as the taste of the fruit from their childhood days. This may of course be due to decreased taste perception in elderly people, but from our study it seems that it is at least partially due to the fact that fruit nowadays is perceived to be less natural and therefore less healthy than fruit in the past.

Differences between Fruits and between Segments

The way in which the sketched are experienced, obviously depends on several aspects like types of fruit, consumption moments and situations, and person characteristics, cf. Sobal et al. (2006) who states that the priority of drivers of food choice varies according to individual traits, personal states and situational contexts.

First, the type of fruit is important to mention. Consumers have a different perception of apple and plum, due to a difference in nutritional value, their taste and texture.

Second, the consumption moment and situation influences perceptions and preferences. If the ingredients for a dinner on a special occasion are bought, consumers probably have different perceptions and preferences than when doing their weekly shopping. An apple and a plum are probably eaten in different situations and differently perceived.

Third, consumer segments of specific groups of consumers should be taken into consideration. Personal preferences should not be lost out of sight. For example, some consumers prefer sour apples above sweet apples, or peaches instead of oranges. Besides, culture may play a role. In literature the influence of culture or ethnicity on the fruit consumption is not always clear (Osler, 1993; Levine and Guthrie, 1997; Reynolds et al., 1999). However, the focus group discussions showed that there were some different expressions among the people from the different countries studied. Moreover also issues like health consciousness and convenience orientation might have an effect. Consumers who are more health conscious have more positive associations of fruit and childhood memories (Sijtsema et al., 2008).

RECOMMENDATIONS

To increase fruit consumption it is of value to overcome contradictions by means of interventions and promotion or product development. In this part problems as well as possible solutions are presented. Finally, some directions for further research are given.

Interventions/Promotion

As far as we know interventions to increase fruit consumption often make a linkage between fruit and health. But as we know still most consumers do not meet the recommended daily amount of fruit. It may be the case that the message about health might especially attract the attention of consumers who are more conscious about health and probably already eat enough fruit. Moreover those health conscious consumers have more positive feelings to fruit (Sijtsema et al., 2008) and have more positive childhood memories related to fruit. Therefore it might be of interest to develop interventions for other target groups like convenience-oriented consumers, who might be educated to see for instance an apple as a snack that can easily be taken along. This example shows that when searching for different target groups it is important that the advantages and disadvantages of different fruit types are recognized. This means that a general approach for all fruit types together in such an intervention is of less value. The characteristics that make apples a snack that can easily be

taken along need not be shared by other types of fruit, e.g. strawberries. It is important to take consumption moment into account here too, as a characteristic, e.g. juiciness, which is a barrier in one situation, needs not to be a barrier in another situation. In any case, it seems that any intervention with a message about health should be complemented with messages about pleasure and convenience, in which case more hedonic or more convenience-oriented consumers might be reached too. Overall, it is a challenge to position fruit products in such a way that barriers are played down without loosing the link to the positive image of fresh fruit in terms of healthiness and taste.

Our research showed that consumption of fruit included rational as well as emotional aspects. In communication with the consumer both aspects should be taken into consideration while now especially interventions are oriented on the rational aspects.

Our focus group participants immediately thought about fresh fruit when asked to give the associations they have with fruit. It may be the case that recommendations of public campaigns are probably interpreted only in relation to fresh fruit, and may therefore miss their impact when it comes down to the consumption of prepared and especially processed fruit. It may prove worthwhile to explicitly focus on (prepared and) processed fruit products, which may be as good as fresh fruit from a nutritionist point of view, but not correctly appreciated by consumers.

Product Development

Fruit is a food category that consists of different types of fruit, with different characteristics, i.e. taste and size, image for daily eating or for a party. Therefore each type of fruit may need its own approach in product development (and other elements of the marketing mix). Consumer research for product development should therefore be directed to specific types of fruit and not for fruit in general.

Based on the motives and barriers that emerged in the focus group discussions related to fruit consumption, it seems that novel fruit products should preferably:

- have a satisfying and homogenous sensory quality that lasts for a while
- have reliable (and easy) cues that can be used as indicators of sensory quality
- be natural/have a natural image, to exploit the almost automatic association with healthiness, taste, and (for at least some consumers) nice childhood memories, and to avoid any association with GM, chemicals, and pesticides
- have a nice appearance without losing its perceived naturalness, a.o. not too homogenous
- be convenient, again without losing its perceived naturalness
- be targeted to specific consumer segments and consumption moments

Thinking about novel fruit products should not be limited to the product itself, but also to other elements of the marketing mix. New ways to bring fruit products to the consumer, for example vending machines that offer fresh fruit and fruit juices instead of sodas and snacks (National Conference of State Legislatures, 2005) can make a major contribution to convenience.

Remarks about Approach and Future Research

For exploration of motives and barriers, focus group discussions were useful to get insight in a variety of motives and barriers. Additional quantitative research is needed to get a more detailed insight in the importance of the different motives and barriers across different purchase and consumption situations, across countries, and across consumer segments. More specific recommendations have to await the results of such a study. Also, research is needed to investigate the consumer adoption of novel fruit products. Which fruit product characteristics make the chances of adoption bigger for which consumer segments? How should one position novel fruit products and how should one communicate about them?

This exploration also gained insight in product characteristics on different levels

which seem to be of value when making the linkage between product characteristics in consumer terms and product characteristics in technological terms useful for product development. This suggests that this approach might be of value to start with filling in a matrix for the House of Quality of Quality Function Deployment (Hauser and Clausing, 1988).

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A Qualitative Analysis on Trends in Fruit Consumption in Four European Countries

Jos Bartels[1], Marianne Groot[2], Anastasia Kyriakidi[3] and Ivo van der Lans[1, 4]
[1]Wageningen University and Research Centre, Agricultural Economics Research Institute, The Hague, The Netherlands
[2]Wageningen UR, Applied Plant Research, Zetten, The Netherlands
[3]Agricultural University of Athens, Department of Rural Economics & Development, Athens, Greece
[4]Wageningen University and Research Centre, Marketing and Consumer Behaviour Group, Wageningen, The Netherlands

Keywords: fruit consumption, expert interviews, health, convenience, out-of-home consumption, qualitative analysis, scenario development, trend factors

Abstract

The aim of this paper is to present future fruit consumption trends in four European countries using expert interviews. Experts from both outside and within the food fruit sector in Greece, the Netherlands, Poland and Spain were asked to elaborate on the trend factors that have influenced fruit consumption in the past and on the trend factors that are expected to have an impact in the future. Furthermore, they were asked to draw possible future scenarios on fruit consumption. As expected, the most important past trend factor that emerged in all countries was the importance of people's health in relation to fruit consumption. Besides the health trend, which is expected to become even more important, convenience is also indicated as an important determinant of fruit consumption in the future. In addition, future scenarios drawn by the experts were concerned with health aspects, convenience and a decreasing impact of economic factors. Moreover, all experts predicted that future fruit consumption in Europe will increase significantly.

INTRODUCTION

Over the past decades, research has confirmed that consumption of fresh fruit and vegetables contributes positively to people's health (WHO, 2003). The World Health Organization recommends a daily intake of more than 400 g of fruits and vegetables per person. Consumption of sufficient amounts of fruits and vegetables can lead to a reduced risk of obesity, several types of cancer and coronary heart disease (Block et al., 1992; Dauchet et al., 2006; Gerster, 1991; Hertog et al., 1993; Key et al., 1996).

Moreover, a study by Joffe and Roberstson (2001) has shown that 26,000 deaths before the age of 65 years could be prevented annually in the EU if European citizens would consume fruits and vegetables according the recommended amount.

The aim of this study was to identify the major factors driving fruit consumption. This paper will present the qualitative results of interviews with experts inside and outside the fruit sector in four European countries: Greece, the Netherlands, Poland and Spain.

This study was part of a broader project, called the Isafruit Project. The mission of Isafruit is to improve human health through increased consumption of fruit that is produced in a sustainable way. The overall vision was that better fruit quality and availability, as well as a higher level of convenience and improved consciousness of consumers, would lead to higher fruit consumption. As an expected consequence, higher consumption could lead to increased health gain and well-being for European citizens. Isafruit has been in strong cooperation with economic and technical researchers in order to attain the goals of the project (Isafruit Annex I, 2006).

METHOD

Respondents and Sampling

In this study, expert interviews were held to gain a first insight on the trends of fruit consumption and consumer perception. In four selected countries, a number of experts inside and outside the fruit sector were asked to identify the trend factors that have determined fruit consumption in the past, and that are forecast to determine fruit consumption in the future. In particular, 10 experts were interviewed in Greece (5 outside and 5 inside the food fruit sector), 12 experts were interviewed in the Netherlands (6 outside and 6 inside the food fruit sector), 12 experts were interviewed in Poland (6 outside and 6 inside the food fruit sector), and 12 experts were interviewed in Spain (6 outside and 6 inside the food fruit sector). The selection of countries was based on the analysis of Schreuder et al. (2007) to present a representative view of the entirety of European countries. The criteria used were: geographical, more or less urbanized population, economic factors and trends in fruit consumption (see Schreuder et al., 2007).

Procedure

In the first part of the interview, the experts had to sum up five past trend factors that could have influenced fruit consumption in their own country. Furthermore, they had to elaborate on the reasons why these factors could have influenced fruit consumption. The same procedure was used for the future trend factors. Finally, the experts inside fruit sector were asked to elaborate on possible future scenarios concerning fruit consumption.

Besides qualitative answers, experts had to state the possible impact (in percentages) of the factors on fruit consumption. They also had to state for each specific factor when (in which year) the maximum impact on fruit consumption would be reached. This rating was used for a Trend-Impact-Analysis (TIA) (Gordon, 1994), in which statistical data and human judgement are combined to produce realistic future scenarios on fruit consumption in Europe. The results of the TIA will not be presented in this paper, as it is beyond the scope of this study. For further details on the results of the TIA, see Groot et al. (2008).

Based on the qualitative results of the first round of expert interviews, a second round of expert interviews was conducted employing several features of a Delphi-study. The Delphi-method is a systematic procedure for evoking expert opinions (Dalkey and Helmer, 1963). According to Dalkey and Helmer (1963), there are three features to Delphi: (1) anonymity; (2) controlled feedback; (3) statistical group response. In the Delphi of this study, only anonymity and controlled feedback were used.

The summaries of the results of the expert-interviews in the first round were sent back to the 46 experts via email for a second round. In all four countries, the Delphi technique was used for the experts outside the fruit sector and inside the fruit sector separately. The following four questions were asked to all experts: What do you think is the single most important aspect in the summary? Why is it the most important aspect? What do you think is the most important aspect that is not in the summary? Why do you think this aspect is missing? Finally, the results of the expert answers in the second round were used to finalize the summaries on past and future trends and to create possible future scenarios for European fruit consumption.

RESULTS

Trends in the Past

1. Experts Outside Fruit Sector. In Greece, health and well-being was considered to be the most important trend factor for the experts outside the fruit sector, followed by convenience, then demographic changes and then economic factors and marketing activities.

Sustainability, product variation and quality seem to influence fruit consumption at a lesser level than these factors.

In the Netherlands, the experts outside the fruit sector pointed out the trend factors of health, convenience, (product) innovation, availability and lack of identity. Fruit as a healthy product was associated with prevention of problems concerning obesity. Convenience appeared to be important in consuming more fruit, meaning that the healthy choice could be turned into an easy choice by better packaging, availability of fruit at a greater diversity of places and new fruit products such as juices, fresh cut salads and ready to eat fruit. An important negative trend that was mentioned was that fruit still does not have its own identity or consumption moment. According to the Dutch experts, many consumers do not seem to have a fixed fruit consumption moment during or in between meals. Furthermore, many people have also lost contact with the origin of fruit. Consumers are unable to identify where fruit was grown or how it was produced. However, the experts mentioned that this trend is already changing.

In Poland, experts pointed out that the trends influencing fruit consumption could be divided into positive and negative factors. The trends negatively influencing consumption are the slow development of real incomes of households, consumption traditions (habits), limited access to supply of fruits year round (seasonal availability) and change in supply factors (replacement of old distribution systems, which led to low marketing intensity and lower availability). The trends pro-health lifestyle and the increase in the supply of imported fruits (diversity and attractiveness of supply) positively influence consumption.

In Spain, experts suggested that both health and product variation were the most important past trends that had an impact on fruit consumption. Health and well-being has been mentioned to be the driving force, since people are more aware of the importance of good nutrition habits. The Spanish experts had different views on product variation. Product variation refers to the availability of new fruits, new varieties, convenience aspects, and even new ways of storing and packaging (e.g., smaller portions). Quality issues have also been mentioned several times related to income aspects and to food safety aspects. If people have higher income, they prefer to buy higher quality fruit with more food safety guarantees.

2. Experts Inside Fruit Sector. In Greece, based on the number of times an existing trend factor is mentioned by an expert, the following factors appeared most important: quality (i.e., quality assurance of products), marketing (i.e., modern logistics, promotion of fruit consumption in schools) and economic factors such as stabilization of fruit retail prices. Besides these factors, health and well-being was also mentioned. Convenience, sustainability, perception and demographic changes appeared to be trend factors with minor importance according to the Greek experts inside the fruit sector. Furthermore, out-of-home consumption was not stressed by the experts as an important determinant of fruit consumption.

In the Netherlands, health, product variation and food safety appeared to be the most important past trends influencing fruit consumption. Besides these factors, convenience was also mentioned. Product variation was not only regarded as the broadening of the fruit assortment with new categories and varieties but also as the modification of characteristics of the existing fruit categories (like improved health value or better possibilities for processing). Based on the expected impact of the trend factor, the experts consider product variation the most important consideration, followed by health and convenience. Other trend factors mentioned are: identity and experience, increased environmental awareness and changes in the supply chain.

In Poland, the expert interviews inside the fruit sector pointed out some additional factors affecting fruit consumption. The experts were basically consistent in identifying the main factors affecting the trend. According to them, the factors of utmost importance could be effectively divided into positive and negative factors. The factors negatively influencing consumption were: slow development of real incomes of households, consumption traditions,

limited access to supply of fruits year round and the proficiency of the distribution system (supply factors). The factors positively influencing consumption were: market infrastructure development (supermarkets), marketing activities, pro-health lifestyle and the increasing supply of imported fruits (diversity and attractiveness of supply).

According to Spanish experts inside the fruit sector, the trend factors health and well-being, product variation and quality were the most important. Campaigns such as "5 a day" help consumers to be aware of the importance of following a healthy diet. Furthermore, product variation seems to be a growing trend. The year-round availability of products, new fruits and new packaging have also been very important trends in the past years.

Trends in the Future

1. Experts Outside Fruit Sector. Greek experts outside of the fruit sector cite the trend factors of health, convenience, out-of-home consumption, product variation and economic factors as most important. Furthermore, marketing was mentioned as a factor influencing future fruit consumption. Trend factors such as sustainability, quality and demographic changes appeared to be of minor importance. Perception/authenticity was not stressed by the experts as a factor that could play a crucial role in fruit consumption. Generally speaking, experts expected an increase in the supply of fruit products, with special health and high quality characteristics, also due to an expected increasing demand for out-of-home fruit (food service). The supply of convenient fruit products could increase the overall fruit consumption. Most experts expect the maximum impact of the trend factor health and convenience to occur in the next 5 years.

In the Netherlands, experts expect that health concerns will continue to be a trend related to fruit consumption. There will be even more (media) campaigns regarding the positive effects of fruit on health, due to increased scientific evidence in support of the healthy aspects of fruit. The health and convenience aspects of fruit will be integrated and stressed in forthcoming products. Communication about health, convenience and identity will shift to out-of-home demand. Promotional campaigns, funded by government or producers, are expected to target children directly (rather than only through their parents). Another further trend factor that is mentioned is that consumers still want to be seduced in the future. Therefore, even more new varieties, both within existing varieties and from new tropical fruits, are also expected to enter the market. New, attractive and effective packaging could be further developed. Finally, the origin of fruit will become more and more important, as people want to experience the true and pure taste of fruit.

Experts in Poland expect that the consumption of fruits will grow in the future, especially in preserves (jams, juices and nectars) and in organic fruit. The Polish experts state that consumers will appreciate the nutritious value of fruits and relate consumption of fruits with health and physical fitness, changing their consumption habits to follow the example of other Europeans. Consumption of fruits and preserves will still be influenced by the economic factors (incomes and prices); however, some positive changes in these factors are also expected, leading one to expect lower fruit prices. The influence of economic factors is expected to be decreasing consistently until 2020 because the average income is increasing systematically with the availability of fruit products. Additional factors that were mentioned include: proliferation of a pro-health lifestyle (health and well-being) and changes in consumption patterns (out-of-home/demographic changes).

Health and well-being is considered to be the most important trend factor in Spain. Quality was mentioned second, followed by convenience and demographic/economic changes. The awareness of the relation between health and nutrition is growing, and consumers are exposed to a variety of information that encourages increasing their fruit consumption. The quality and convenience issues are strongly related to health. If people consume fruit, it should be adapted to their needs, which implies a demand for quality fruit in

a format that is easy to consume (e.g., washed, peeled, fresh-cut). Experts have also stressed the importance of demographic developments in Spanish society, for instance, an aging population, an increase in immigration, changing economic aspects and the general growth of well-being.

2. Experts Inside Fruit Sector. Experts of the Greek fruit sector reported health and well-being as the most important trend factor, followed by convenience and economic factors. In general, an increase in the supply of fruit products with special health and quality characteristics is expected. Fruit consumption is also expected to increase as availability of new products can suit the increased demand for out-of-home fruit products. Most experts expect the maximum impact of health and convenience within the next 15 years. Although the opinions about the extent of the impact differ among experts, the health trend is expected to have the biggest impact on demand in the coming years.

Experts inside the fruit sector in the Netherlands considered health to be the most important trend factor as well, followed by product variation and convenience. Experts generally expect an increase in the supply of fruit products with special health characteristics and a high guarantee for food safety and sustainability. Due to an increasing demand for out-of-home fruit (food service), the supply of convenient fruit products is expected to further increase. The supply of fruit should become more demand driven, and there will be more focus on the "fruit experience". All experts have mentioned that future trend factors are more or less obvious already. Most experts expect the maximum impact of the health and convenience trend factors over the next 10 years. Although opinions about the extent of the impact differ among experts, the impact of the health trend factor is generally indicated as the most important in the coming years.

According to the experts in Poland, future consumption will grow, mainly on preserves and fruits produced organically. They have reported that consumption should increase due to an increase in average income and changes in consumption patterns and in the Polish lifestyle and because of the increasing marketing and promotional activities within Poland.

Health is also considered to be the most important trend factor by Spanish experts, followed by convenience and quality. Health is regarded here not only as not being sick but also as looking physically attractive. Since fruit is considered to be important for a healthy diet, it will be a crucial issue in the future according to Spanish experts inside the fruit sector. Convenience is a consequence of general changes in habit. As consumers demand other kinds of products, packaging etc., people will also ask for higher quality products in the future.

Future Scenarios for the Fruit Sector

The three most important factors derived from the analysis in each country were used to develop future scenarios. Thus, three possible scenarios were developed for each country. In order to reach the goal of increased fruit consumption, recommendations were given by the experts from inside the fruit sector. The overall recommendations were:

- better cooperation and a more adequate exchange of information within the fruit chain (Greece, the Netherlands, Poland)
- all parties of the fruit chain should be more focused on consumer demands to develop products that better fulfil consumer's expectations (Greece, the Netherlands)
- stabilization of the market (Poland)
- development of more products suitable for preparing and processing (Greece, the Netherlands)
- increase of kind and variety of fruits and preserves (Poland)
- presentation and packaging should be taken into account in development of new products (Greece, the Netherlands)
- in order to avoid negative influences, economies of scale should be applied by growers as:

cost minimization (Greece, Poland) and the margin between grower price and consumer price should be diminished (Spain)
- more sustainable production to meet the health goals (the Netherlands, Spain)
- traceability systems (i.e., "tracking and tracing") are needed to guarantee quality (Spain)
- more communication about the health aspects of fruit (the Netherlands, Poland, Spain)

For more details see Groot et al. (2008).

DISCUSSION

A main conclusion of this study is that there seems to be quite some overlap between the different countries studied in both expected future trends and scenarios concerning fruit consumption. However, results also show that countries in different stages of (cultural and economic) development will see consequently different development in fruit consumption. Furthermore, it seems evident that the process through which fruit consumption will evolve in different countries will also be different.

Having said this, the experts in all countries have pointed out health as the driving force for past and future consumption. The typical consumer in the EU is expected to become even more health conscious, seeking new ways to turn toward a healthier standard of living. Media campaigns, government legislation and new research information can help trend in that direction. These future developments will also certainly influence the business decisions of all the sector's members: growers, retailers and traders.

At the same time, convenience and out-of-home consumption are expected to play a major role as people are expected to have less available time for the preparation of meals and cooking. This will lead to the development of new products/packaging that will be more convenient to carry and eat in an out-of-home situation.

Demographic changes (i.e., changes in average family structure) will also shift the demand for convenient products in the different countries concerned. Similar economic factors also help to determine fruit consumption; this is especially true in Greece and Poland. Product variation, such as preserved fruits and functional food, was mentioned as an upcoming trend in all countries. However, the perception of product variation itself seemed to garner various explanations from various experts in various countries.

Almost all experts in the countries studied here have reported that fruit consumption is expected to increase within the next few years. Again, the kind of fruit or fruit products that will cause this increase could differ tremendously between different countries in Europe.

Concerning the trends of the past, a distinction can be seen between experts from inside the fruit sector and experts from outside the fruit sector in both Greece and the Netherlands. In all four countries, the experts from outside the fruit sector recognize additional trend factors for future fruit consumption, which are essentially unrecognized by the experts from inside the fruit sector.

As mentioned in the introduction, the aim of this study was to identify the major driving factors in fruit consumption. The study gives an extensive and structured overview of European experts, both within and outside the fruit sector, sharing ideas on future development. The results of this study highlight the driving forces and the appropriate steps that should be taken by the industry or legislation in order for this increase in consumption to become reality. Since the current study only reports the qualitative results on possible European fruit trends, a quantitative analysis could measure more specifically the impact of each trend factor in future European fruit demand by effectively targeting the consumer.

RECOMMENDATIONS FOR POLICY

Based on the above results, a helpful policy for increasing fruit consumption would be:
- supporting promotion/information campaigns in order to make consumers aware of the

health aspects of fruit consumption
- supporting the development of and possibilities for effectively combining convenience aspects with health aspects of fruit and fruit products
- supporting the development of and possibilities for a sustainable way of fruit production
- supporting the cooperation between the various parties in the fruit supply chain

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A Theoretical Framework for Consumer Willingness to Adopt Novel Food Products

Magdalena Kraszewska (MSc)
Warsaw Agricultural University
Ul. Nowoursynowska 166
02-787 Warszawa
Poland

Jos Bartels (PhD)*
Wageningen University and Research Centre
Agricultural Economics Research Institute
P.O. Box 29703, 2502 LS The Hague
The Netherlands
*Corresponding author: email: jos.bartels@wur.nl

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Abstract

This paper presents a theoretical framework for the adoption of new fruits and new fruit products by consumers. Based on an extensive literature review, various elements of consumer adoption behaviour are presented and discussed. First, several consumer innovativeness approaches are examined, some of which are incorporated into the proposed new theoretical framework. Second, important correlates of the consumer acceptance of novel products are described and presented in the context of fruit. Finally, a conceptual model for new fruit and fruit product adoption by consumers is described. This model will be the basis for further qualitative and quantitative empirical research.

INTRODUCTION

Despite constant developments in product design and marketing, most new products in the food and drink industry ultimately fail (Martinez and Briz, 2000). Some authors estimate the success rate to be as low as 10-25% (Cooper, 2001; Martinez and Briz, 2000; Van Trijp and Steenkamp, 2005). This raises the question of how to improve the predictability of new product performance in the market. One possible answer could be arrived at by developing an understanding of how and why new products are accepted by consumers (where acceptance is expressed in terms of actual buying behaviour).

A vast amount of literature on the acceptance of new products has focused on personal characteristics of consumers (e.g., Hirschmann, 1980; Foxall and Haskins, 1986; Venkatraman and Price, 1990; Im et al., 2003; Lassar et al., 2005), identification of innovators and adopters (e.g., Raju, 1980; Labay and Kinnear, 1981; Goldsmith and Hofacker, 1991; Goldsmith and Flynn, 1992; Steenkamp and Baumgartner, 1992), consumer attitudes towards new products (Rogers, 1995; Venkatraman and Price, 1990; Bäckström et al., 2004; Geissler and Edison, 2005; Hirunyawipada and Paswan, 2006) and barriers to and motives for accepting new products (e.g., Foxall, 1995; Rogers, 1995; Bäckström et al., 2004).

The aim of this paper is to identify what determines consumer acceptance of novel fruit products by presenting a literature review and developing a theoretical framework. First, a review of the most up-to-date literature in consumer innovativeness will be presented and discussed. The novel theoretical model, which is based on this literature, will be the basis for further empirical research by means of focus group interviews and a quantitative study across four European countries.

The research context of the current study is fruit and fruit products. In this paper, we first deal with consumer innovativeness. Second, we consider how the characteristics of the fruit market can influence consumer behaviour toward novel fruit products. Although prior research into consumer innovativeness was conducted in specific markets (e.g., electronic goods, food products, or online shopping), the characteristics of those markets were seldom

considered to be predicting variables (Goldsmith and Hofacker, 1991; Im et al., 2003). In this study, we suggest that an approach in which both consumer and market characteristics are considered will result in better understanding and predictability of consumer behaviour towards novel fruit and fruit products.

APPROACHES TO INNOVATIVENESS

Most studies that treat consumer innovativeness comprise two approaches: 1) innovativeness as a general personality trait (e.g., Hirschman, 1982), and 2) innovativeness as a domain-specific construct (e.g., Goldsmith and Hofacker, 1991). Both approaches are described below.

CONSUMER INNOVATIVENESS AS A PERSONALITY TRAIT: EARLY CONCEPTUALISATIONS

The concept of consumer innovativeness has been of great interest in the literature for decades and has developed tremendously in recent years (Roehrich, 2004). Early notions of the concept were introduced by Rogers (1962), who defined innovativeness as the "degree to which an individual is relatively earlier in adopting a new idea than other members of the system" (Rogers, 1962; p.475). Rogers' approach was used to categorise consumers at various stages of adoption. His approach offered basic concepts and definitions for subsequent research into consumer innovativeness. However, Rogers' concept of categorisation was also widely criticised. According to several scholars, this approach cannot be used for future behaviours, as it is not possible to evaluate its validity and reliability and the research findings among different studies are not comparable (Hurt et al., 1977; Midgley and Dowling, 1978; Goldsmith and Hofacker, 1991).

A major body of research into consumer innovativeness has appeared in the consumer psychology and marketing literature. This research has focused on the concept of innovativeness as a personality trait (Hirschman, 1980; Venkatraman and Price, 1990; Venkatraman, 1991; Steenkamp and Baumgartner, 1995; Manning et al., 1995; Steenkamp et al., 1999). The goal was to identify consumer innovators based on their predisposition toward innovative products. The trait of innovativeness was defined as "the degree to which an individual is receptive to new ideas and makes innovation decisions independently of the communicated experience of others" (Midgley and Dowling, 1978, p.47). Innovativeness as a general personality trait reflects an innate tendency to seek out new information, stimuli or experiences (Hirschman, 1980). Steenkamp et al. (1999) described it as the preference to try out and buy a new and different product rather than maintaining prior behaviour. Innovativeness as a personality trait can be referred to using several different terms, such as variety seeking (Van Trijp et al., 1991), need for stimulation (Raju, 1980; Steenkamp and Baumgartner, 1992; Baumgartner and Steenkamp, 1996), novelty seeking (Pearson, 1970; Hirschman, 1982; Manning et al., 1995), dispositional innovativeness (Steenkamp and Gielens, 2003), willingness to change (Hurt et al., 1977) and global innovativeness (Goldsmith et al., 2006).

All consumers possess innovativeness to a certain extent. Innovators are people who have a higher degree of this personality trait, which makes them eager for novel products to a greater extent than other people.

The aforementioned studies mainly focus on aspects of innate innovativeness. From these studies it is possible to create measurement instruments that can be used to identify innovators. However, identifying innovativeness was found to be insufficient to explain consumer purchase behaviour with regard to innovative products. It turned out to be a weak predictor of such behaviour (Foxall and Bhate, 1993b; Goldsmith et al., 1995; Im et al., 2003).

PRODUCT CLASS RESEARCH - DOMAIN SPECIFIC INNOVATIVENESS

Research into innate innovativeness (innovativeness as a trait) was unable to comprehensively identify antecedents of consumer adoption behaviour. Results published to date are insufficient to explain consumers' actual behaviour. Innate innovativeness has a global character and is applied across product classes. Although it is positively correlated with adoption of new products (Foxall and Bhate, 1991, 1993b), it appears to be a weak predictor of actual innovative behaviour (Foxall and Bhate, 1993b; Goldsmith et al., 1995; Im et al., 2003). Consequently, there exists a need for a construct of consumer innovativeness that can be applied to different product domains and that will predict consumer innovative behaviour more precisely (Goldsmith and Hofacker, 1991; Goldsmith and Flynn, 1992).

Such a domain-specific approach was first suggested by Midgley and Dowling (1978). They proposed an intermediary level of innovativeness specific to product category. Their approach mediated the effect of innovativeness on the actual adoption of innovations by taking into account other variables and situational factors. Following this approach, Goldsmith and Hofacker (1991) introduced the concept of domain specific innovativeness (DSI), which refers to a tendency to acquire new products or new product-related information within a specific domain. Successful application of DSI has been reported in many studies across various domains (e.g., food domain - Bäckström et al., 2004; travel services and fashionable clothes - Flynn and Goldsmith, 1993; Internet users - Goldsmith, 2001). DSI appears to predict actual adoptive behaviour more precisely than does innate innovativeness. Furthermore, DSI has been described in the literature as a mediator between innate innovativeness and actual behaviour (Goldsmith, 2002). DSI seems to be an answer to the drawbacks of the innate innovativeness framework – it can be more readily applied to specific product categories.

CORRELATES OF INNOVATIVENESS

Socio-Demographic Data

Various studies have explored the influence of socio-demographic status on consumer innovativeness as a personality trait (Steenkamp and Burges, 2002; Clark and Goldsmith, 2006). Other research has explored the impacts of socio-demographic status on domain-specific innovativeness (Goldsmith and d'Hauteville, 1998; Goldsmith et al., 2005). In all cases, the results were ambiguous. Summers (1971) found that income is an important personal characteristic that influences new product adoption. Rogers (1962) stated that innovators control substantial financial resources, which are helpful in covering potential losses associated with buying novel and unfamiliar products. Similarly, Labay and Kinear (1981) indicate that personal characteristics such as age, education, income, occupational status and life stage influence adoption process. In contrast with these studies, Ostlund (1974) reports that socio-demographics are weak predictors of new product adoption. Furthermore, Im et al. (2003) found no significant correlation between education and innovative behaviour. Steenkamp et al. (1999) found that only age had a significant influence on innovation adoption, while income and education did not.

Steenkamp and Gielens (2003) proposed an explanation for these contradictory findings. They studied the effects of consumer disposition and market factors on actual new product purchasing behaviour. The magnitudes of these interactions suggested that the effects of consumer characteristics were heavily influenced by both marketing and product category variables. Systematic moderating effects were uncovered for socio-behavioural covariates (age, income, education). For two constructs (age and education), the moderating role of market factors was so strong that no evidence was found for a generalised main effect of those socio-demographic variables on innovation adoption. Steenkamp and Gielens (2003) indicate that new product adoption literature has typically focused on either consumer or

market variables, but their findings suggest that detailed analysis of their interplay is necessary to understand the full complexity of the relevant adoption processes.

In summary, the results of socio-demographic research are not consistent for the construct of global consumer innovativeness. However, socio-demographic data might still constitute a relevant group of variables for certain specific domains. One possible explanation for the inconsistencies articulated by Steenkamp and Gielens (2003) is that these variables should be studied together with the characteristics of the domain and the influence of marketing. Socio-demographic data are therefore included in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Opinion Leadership

The construct that seems most strongly related to consumer innovativeness is opinion leadership. Rogers and Cartano (1962) defined opinion leaders as "individuals who exert an unequal amount of influence on the decisions of others" (p.435). Opinion leaders are likely to communicate with others and seem to have a high involvement with a specific product category. Opinion leaders influence the attitudes and purchasing behaviours of other consumers (Flynn et al., 1996; Gatignon and Robertson, 1985; King and Summers, 1970). They are eager to use new products and are profound consumers of mass media (Rogers, 1962). Furthermore, they are conscious of their appearance and self-confident (Baumgarten, 1975; Summers, 1971). Several studies show positive relationships between opinion leadership and innate innovativeness (Hurt et al., 1977; Workman and Kidd, 2000; Bertrandias and Goldsmith, 2006), domain specific innovativeness (Goldsmith and Hofacker, 1991; Grewal et al., 2000) and actual innovative behaviour (Ruvio and Shoham, 2007; Summers, 1971). Studies on opinion leadership all show unambiguous results, and opinion leadership is said to be domain specific (Engel et al., 1993). Accordingly, we include this metric in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Market Mavenism

The concept of market mavenism (MM) has received substantial attention in recent marketing literature (Feick and Price, 1987; Clark and Goldsmith, 2005; Geissler and Edison, 2005). A market maven is a consumer who has extensive knowledge and experience with markets rather than in a specific domain. Market mavens are described as "expert shoppers" (Geissler and Edison, 2005, p.74). Market mavens are unique in their searching activities for new products and information related to it. They use numerous sources of marketing information, and they use each source extensively. They intensively participate in marketing activities such as couponing and loyalty programmes. Marketing activities, shopping and acquiring product knowledge give market mavens a great deal of satisfaction (Feick and Price, 1987; Geissler and Edison, 2005). Market mavens are immediately recognisable to other consumers and are aware of their specific qualities. They enjoy playing the role of "expert shopper" among other consumers as this generates significant respect from their peers. At the same time, eagerness to maintain this influential position makes them susceptible to normative influences (Clark and Goldsmith, 2005). As they do not wish to lose the respect of their fellow consumers, they form opinions carefully and generally tend to avoid controversy. They will purchase and promote to others only those products that do not openly violate social norms consistent with their geographic location. Feick and Price (1987) found that the construct of market mavenism is related both to early awareness of products and to disseminating product information to other consumers. Furthermore, several recent studies have shown positive correlations between market mavenism and consumer innovativeness (Goldsmith et al., 2003; Girardi et al., 2005; Ruvio and Shoham, 2007). As MM seems to be strongly related to innovativeness in different domains, we include it in our

conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Product Characteristics

Characteristics of novel products have played a prominent part in studies of consumer innovativeness (e.g., Goldsmith and Flynn, 1992; Agarwal and Prasad, 1999; Blythe, 1999). Product characteristics seem to be of great importance in consumer decision-making. For the product to be classified by the consumers as an innovation, some level of novelty or differentiation is necessary. Rogers (1995) identified five characteristics of innovation as important factors influencing the innovation-decision process: relative advantage, complexity, compatibility, trial ability and observability. All these indicators are widely used in research into innovativeness (e.g., Tornatzky and Klein, 1982; Blythe, 1999; Goldenberg et al., 2001; Steenkamp and Gielens, 2003).

Goldenberg et al. (2001) found that, when an innovation is radical, consumers might not be willing to accept it, on account of its complexity. According to Goldenberg et al. (2001), complex products are 1) difficult to understand, 2) difficult to learn and 3) perceived as very risky. Even a high relative advantage might not be sufficient compensation for the complexity of a given innovation. On the other hand, products that are not complex but that offer minimal relative advantage may be perceived by the consumers as insufficiently distinct from other products in the marketplace. These products therefore do not offer sufficient added value to merit a positive purchase decision. Goldenberg et al. (2001) found that market success has an inverted U-shaped relation. Adoption of the innovation is lowest when product novelty is low (low perceived added value has a negative influence on consumer decision-making). When the novelty is very high, adoption is also low (high complexity reduces product appeal).

In contrast, Steenkamp and Gielens (2003) found that innovative products of intermediate novelty generate a lower rather than higher trial probability when compared with incrementally new or completely new products. Based on their results, Steenkamp and Gielens (2003) suggested that the relation between novelty and trial probability might be better described by a cosine-shaped relation instead of an inverted U-shaped graph.

In conclusion, studies by Goldenberg et al. (2001) and Steenkamp and Gielens (2003) indicate that it is not sufficient for new products to only possess specific characteristics such as relative advantage and complexity. The relative weighting of those characteristics in the final product is of much greater importance. Furthermore, there should be a balance between the different product characteristics. This balance is vital to ensure a product's appeal. In summary, the available research strongly suggests that several product characteristics should be incorporated in studies of consumer innovativeness.

Intercultural Differences

Several studies that explored consumer innovativeness showed significant differences in innovativeness among various cultures (Venkatraman and Price, 1990; Steenkamp et al., 1999; Singh, 2006). Engel et al. (1993) stated that culture determines which product consumers choose and the structure of the consumption. Culture also influences individual decision-making and even the way people communicate about the product. Singh (2006) stressed the importance of culture in consumer decision-making processes. She stated that national culture "affects the drives that motivate people to take further action, determines what forms of communication are permitted about problems at hand and even the degree of search behaviour that an individual deems appropriate" (Singh, 2006, p.176).

The first four dimensions of Hofstede's (1983) culture approach (individualism, power distance, uncertainty avoidance and masculinity) have been applied to consumer innovativeness research and have revealed interesting results. Both Steenkamp et al. (1999) and Singh (2006) found that differences between nations, when explained in terms of

Hofstede's dimensions, significantly explained differences in relative innovativeness. Cultures with higher levels of individualism and masculinity, and lower uncertainty avoidance and power distance, appeared to be more innovative.

In short, intercultural differences may be expected to influence the process by which innovations are adopted. They will be included in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Marketing Communication

Recently, marketing communication was introduced as a possible important correlate of consumer innovativeness. So far, only one study has found that all three marketing instruments (mass and feature advertising and in-store display) are important predictors of consumer innovativeness. According to Steenkamp and Gielens (2003), mass advertising is effective in creating product awareness among consumers and in conveying product information. Feature advertising (which includes advertising in store flyers and local door-to-door marketing/newspapers) and in-store displays also positively influence new product awareness. These factors directly influence consumer adoption because they are visible at the point of purchase. Steenkamp and Gielens found an effect of both instruments. Mass advertising and in-store display were both positively correlated with new product adoption.

In summary, there seems to be an influence of marketing communication on consumer innovative behaviour in other contexts, and to date, no research has been conducted on this topic with respect to fruit purchasing decisions. Accordingly, we include marketing communication in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

CONSUMER INNOVATIVENESS WITH RESPECT TO FOOD PURCHASES

We have elaborated on certain important general correlates of innovativeness. In this section, we focus on correlates of innovativeness in the context of food purchasing decisions. First, we describe food neophobia and food involvement. Second, we explore the idea of social representations in the context of novel foods. Third, we focus on product characteristics in the context of fruit and fruit products.

Food Neophobia

Food neophobia is a personality trait that is triggered when a consumer is confronted with novel, unfamiliar foods. Food neophobia can be defined as "the extent to which individuals are reluctant to try novel foods (food products, dishes, cuisines)" (Eertmans et al., 2005, p.714). Pliner and Hobden (1992) first conceptualized this personality trait as the food neophobia scale (FNS). FNS is widely used for studying the attitude of consumers toward (ethnic) foods (e.g., Tuorila et al., 2001; Bäckström et al., 2004). Food neophobia is a significant barrier to consumer adoption of innovative food products (Eertmans et al., 2005; Pliner and Hobden, 1992). Decreasing food neophobia could therefore be an important strategy to improve consumer acceptance of novel food products. Accordingly, food neophobia will be included in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Food Involvement

In general, consumers' involvement with a product shows a strong correlation with consumer innovativeness in several respects (Goldsmith and Hofacker, 1991; Girardi et al., 2005; Sun et al., 2006). A specific form of product involvement is food involvement. Bell and Marshall (2003) defined food involvement as "the level of importance of foods in a person's life" (Bell and Marshall, 2003, p.236). It can be described as the level of enjoyment in talking and thinking about food and in engaging in any activity related to food products.

Consumers who are highly involved with food are better able to distinguish differences among foods and flavours and generally eat more healthily; their diets are rich in fruits and vegetables. Bell and Marshall (2003) suggest that highly involved individuals seem to be eager for new food experiences; i.e., they are more food neophilic.

Foxall and Bhate (1993a) studied the early adoption of new food brands and offerings promoted as "healthy products". They found that a consumer's level of involvement in the relevant product category was an important predictor whether or not he or she would be an early adopter. Several other studies confirmed that food involvement was a possible predictor of consumer choice among various food products (e.g., Bell and Marshall, 2003). Moreover, high involvement in a specific domain was found to facilitate the process of innovation adoption. Food involvement will be included in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

Product Characteristics – in the Context of Fruit Marketing

Tuorila (2001) differentiated five major categories of novel (innovative) foods within modern food marketing. These categories are linked with new production trends and/or consumer preferences. Tuorila (2001) mentions: 1) functional foods that have a beneficial health effect, 2) genetically modified products, 3) nutritionally modified foods (having higher fibre content or reduced fat/sugar), 4) organic foods, and 5) ethnic foods (i.e., foods from unfamiliar cultures). These categories combine innovative characteristics (representing new directions) with food characteristics – such an approach is very promising in the case of fruit marketing. For example, following Tuorila (2001), examples of novel fruit products with the appropriate categorisations might include fruit juice with added vitamins/fibres/calcium (functional food), a disease-resistant apple (GM food), or natural fruit without pesticides (organic food).

In conclusion, there seems to be an influence of product characteristics on consumer innovative behaviour in other contexts. To date, there has been no research into these characteristics as they relate to fruit marketing. Accordingly, we provisionally plan to include these elements in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products. However, their role will be further refined using focus group discussions.

Social Representations with regard to Novel Foods

Social representations study how people deal with unknown and unfamiliar ideas, products, or situations in a group. Social representations are concerned with thoughts, feelings and actions expressed in behaviour (e.g., Wagner et al., 1999; Bäckström et al., 2004). Moscovici (1973, p.xiii) has stated that social representations function as a "code for social exchange". Bäckström et al. (2003, p.300) have suggested that social representations can be interpreted as "modern society's equivalents for the myths and belief systems of traditional societies". Therefore, studying social representations may provide some insight into consumers' everyday thinking about some new topics, ideas and products.

To date, several studies have been conducted into the social representations of consumers with respect to novel foods; however, all these studies have been in a Finnish context (Bäckström et al., 2003, 2004; Huotilainen et al., 2006). This research used Tuorila's (2001) five food categories as outlined previously. Exploring the social representations of novel food products within Tuorila's categories led the researchers to define the following five dimensions of social representation (SR): 1) resistance to and suspicion of novelties, 2) adherence to technology, 3) adherence to natural food, 4) food as an enjoyment, and 5) food as a necessity. These dimensions can explain five typical consumer attitudes across the five types of novel food.

Bäckström et al. (2004) found that the willingness to try genetically modified

products was predicted by a consumer's level of adherence to technology. Nutritionally modified products were best predicted by adherence to natural foods, adherence to technology and low resistance to and suspicion of novelties. Willingness to try organic products was best predicted by adherence to natural foods and by significant importance attached to food as an enjoyment. Finally, quite different results were found for ethnic foods where the predictive ability of any SR dimension was low.

Other interesting results of food-related research into SR were discovered by Huotilainen et al. (2006). They found that innovativeness is predicted by some of the SR dimensions, namely, resistance to and suspicion of novelties and eating as an enjoyment. When considering the personal characteristics of innovators using SR dimensions, food innovators generally have lower levels of resistance toward new foods and regard eating as an enjoyment. The results of Huotilainen et al. (2006) are consistent with earlier data from Bäckström et al. (2004). In both studies, social representation quotients seem to be strong predictors of a consumer's willingness to try new foods.

In summary, including social representation elements could be an interesting approach. We will include them in our conceptual model that treats consumer innovativeness with respect to fruit and fruit products.

CONCEPTUAL MODEL

In the previous sections, distinct approaches in the area of consumer innovativeness were presented and discussed. Furthermore, different correlates of consumer adoption of novel (food) products were identified. These approaches and correlates are combined in this section into a conceptual model for consumer innovative behaviour with regard to fruit and fruit products. Figure 1 presents the conceptual model.

The conceptual model focuses on consumer characteristics that are believed to be important in the innovation adoption process. At the same time, it does not neglect market and product characteristics. The previously discussed concepts were included in this group of characteristics: 1) socio-demographic status, 2) opinion leadership, 3) market mavenism, 4) domain-specific innovativeness, 5) intercultural differences, 6) food neophobia, 7) food involvement, and 8) social representation dimensions of novel foods. All these concepts are relevant to consumer decision-making with regard to innovative products. We do not intend to be all-inclusive, but this conceptual model should provide a meaningful overview of the possible determinants of consumer innovation adoption in the context of fruit and fruit products in European markets.

Consumer characteristics used in our model are as follows: consumer characteristics in the global context, the domain (food) context, and in a joint context that exists between the global and the domain. A global context is explained here as one that is universal, no matter what kind of product category is being considered. As a consequence, this part of the model can be applied beyond studies that treat only fruit and fruit products. By contrast, the domain context in this study is food, and more specifically fruit and fruit products.

The part of the model that treats the global context of consumer characteristics includes four elements: 1) socio-demographic data, 2) opinion leadership, 3) market mavenism, and 4) intercultural differences. First, although the results for socio-demographic information in other studies are often ambiguous, we expect global demographics to be somewhat influential in the context of fruit, based on earlier research findings. Second, opinion leadership seems to be the most important correlate of consumer innovativeness. Third, market mavens' unique searching activities for new products and product information can significantly influence the dissemination of information about innovation to other consumers. Since market mavens have an expertise in shopping and extensive knowledge and experience with markets, this concept is not domain specific. Fourth, our literature review confirmed that various studies have shown differences in innovativeness among different

cultures. Because our research will be conducted internationally, the role of culture in consumer decision-making is especially important and is therefore included in our model. We expect these global consumer characteristics to be partly moderated by marketing communication and product characteristics (Steenkamp and Gielens, 2003). Furthermore, global consumer characteristics are expected to have direct effects on consumer adoption behaviour.

Within the domain-specific (food) context, two constructs are included in the model. The concepts of food neophobia and food involvement seem strictly connected with the food domain and are placed on the right-hand side of the model. We assume food neophobia to have a negative effect and food involvement to have a positive effect on consumer adoption behaviour.

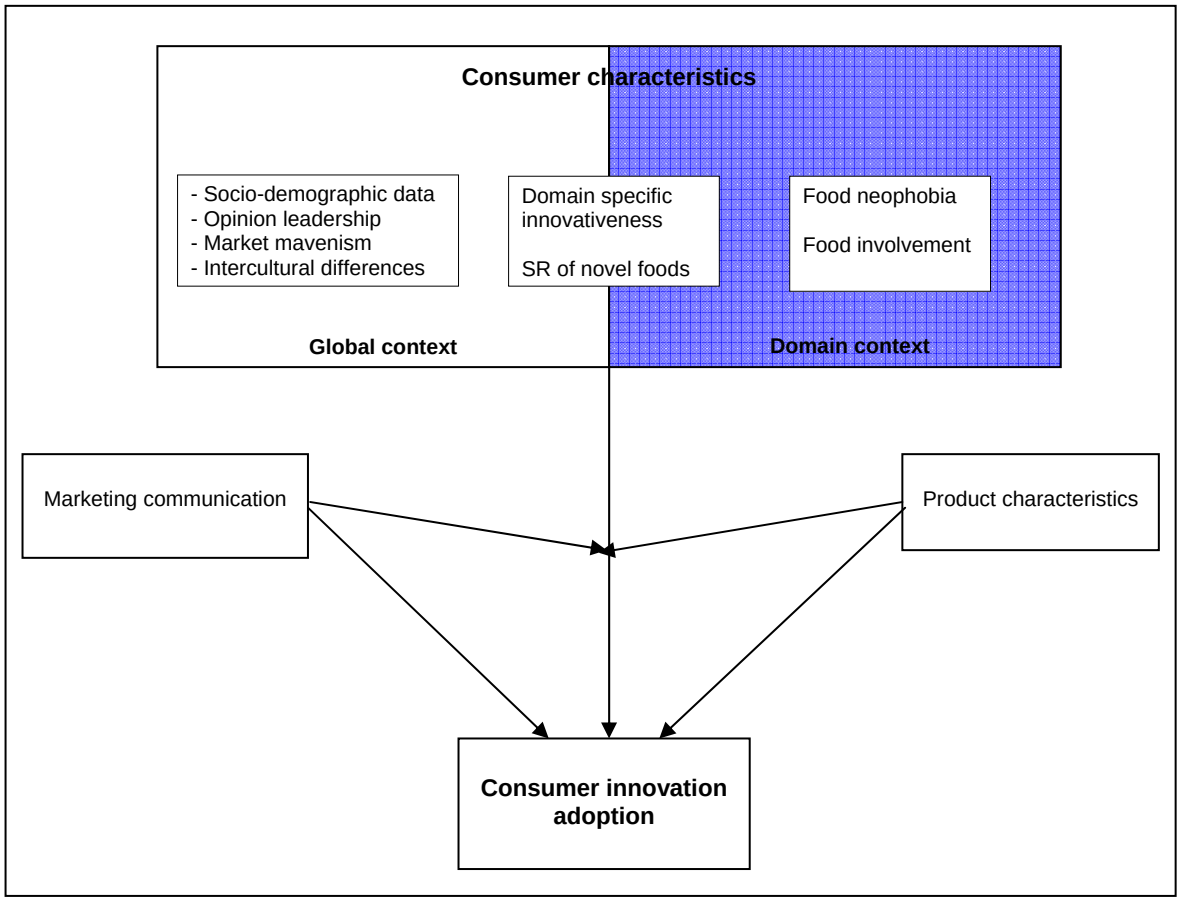

Fig. 1. Conceptual model of consumers' willingness to adopt new products in a European food context.

Domain-specific innovativeness appears in the middle of the consumer characteristic dimensions. This construct seems to possess characteristics that indicate that it should belong to both categories. The same reasoning applies for social representations. Social representations have been linked to various dynamic and controversial topics, but, in this study, the specific Bäckstrom et al.'s (2004) concept of SR dimensions for novel foods is used. Furthermore, we assume that there is a direct link between the social representation dimensions of new foods and domain specific innovativeness (DSI) on the one hand and new fruit adoption behaviour on the other hand. Both constructs are supposed to have significant individual effects.

For product characteristics and social representations of new foods, we plan to incorporate the approach of Tuorila (2001). Which specific product characteristics to include will first be explored using qualitative research. Thereafter, the content and influence of marketing communications in the context of fruit and fruit products will be elaborated using a qualitative approach.

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Improving Consumer-Driven Innovation in Fruit Supply Chain Networks

R.L.M. van Uffelen M.Sc.[1], Dr. J.H. Trienekens[2] and C.N. Verdouw M.Sc.[1]
[1]Agricultural Economics Research Institute, PO Box 29703, 2502 LS, The Hague, The Netherlands, email: ruud.vanuffelen@wur.nl; cor.verdouw@wur.nl
[2]Wageningen University, PO Box 8130, 6700 AE, Wageningen, The Netherlands, email: jacques.trienekens@wur.nl

Keywords: consumer-driven innovation, performance, innovativeness, fruit supply chain network

Abstract

Fruit consumption can be increased by anticipating on consumer demands and needs. This research aims to develop insight in ways to improve consumer-driven innovation in supply chain networks (SCN's) for fruit and fruit products. Research questions are:

1. **How do fruit (products) supply chain networks in Europe operate?**
2. **How do these SCN's innovate, and to what extent is this consumer-driven?**
3. **How can consumer-driven innovativeness of fruit (products) SCN's be improved?**

Based on a literature review a chain framework has been developed. After that, in each of four participating countries, Greece, Poland, Spain, and The Netherlands, two products have been selected, meeting the requirements concerning motives and barriers of fruit consumption and being innovative in the perception of consumers. The companies in the chains behind these products were interviewed twice, first on chain operation and secondly on their performance and innovativeness: the ability to innovate.

Out of the results it appeared that hardly any of the products were put on the market in a collaborative supply chain effort. The companies mainly operated and communicated with their own supplier and customer, sometimes based on contracts. Consumer-driven innovation was mainly done by the lead company that determines the product-market combination. They produce the actual product that consumers can buy; they are the last link that adds value to the product. Most of the lead companies do not really have an innovation strategy and planned or structured way of innovating. Most of the other chain members innovate on products and processes on their own or with their customers. There is also not something like an overall innovation strategy.

Because the research is still in progress (August 2008), the preliminary conclusion is that the fruit industry still can improve on consumer-driven innovation and adjust to the market in order to increase fruit consumption. In their role, policy makers can increase the awareness of the positive effects of consumer-driven innovation, by stimulating knowledge transfer on these issues. From there the fruit industry can be accompanied in taking action to improve its consumer-driven innovativeness.

INTRODUCTION

In the European Union, fruit consumption has been decreasing over a longer period of time. Consumption of fruit and fruit-based products is perceived as healthy and improves the human health by diminishing the chances on, for instance, cardiovascular diseases. In the EU-project ISAfruit, research is being done to find the rationales behind the negative trend, the effects of fruit consumption and ways to increase fruit consumption.

The assumption within ISAfruit is that fruit consumption can be increased by playing into consumer demands and needs, like healthy products, higher quality fruit, safer fruit, sustainable production, more convenient products, better availability, a better consciousness and a lower price of fruit products. This study aims to develop insight in ways to improve

consumer-driven or demand-driven innovation in supply chain networks for fruit and fruit products.

A demand-driven Supply Chain Network (SCN) senses and reacts to real-time demand information of the ultimate consumer and meets those varied and variable demands in a timely and cost-effective manner.

From this definition it follows that the essential aspect of consumer-driven chain networks is that they are driven by market intelligence. Market intelligence is information about customer demands, needs and preferences and factors that influence this like competition, regulation, technology, demography, social trends and other environmental forces (adapted from Kohli and Jaworski, 1990).

An important dimension of demand-driven SCN's is innovativeness, since in demand-driven SCN's the ability to deliver customized solutions and the ability to fulfill changing customer-demand flexibly are of crucial importance (Deshpande et al., 1993; Hult et al., 2004; Verhees and Meulenberg, 2004). Thus we define innovativeness as "the ability of the SCN system to develop product, process, marketing or organizational innovations".

In this paper we address the following research questions:

- How do fruit (products) supply chain networks in Europe operate?
- How do these SCN's innovate, and to what extent is this consumer-driven?
- How can consumer-driven innovativeness of fruit (products) SCN's be improved?

RESEARCH MATERIAL AND METHOD

First a literature study has been carried out on performance, innovation and management of supply chain networks (van Uffelen et al., 2008). Next, a framework for analysis, design and implementation of fruit chain business systems was developed. This is a conceptual model in which major elements of such SCN's are defined and elaborated (especially categorized listings and different models).

The developed conceptual model defines the following major elements of demand-driven SCN's:

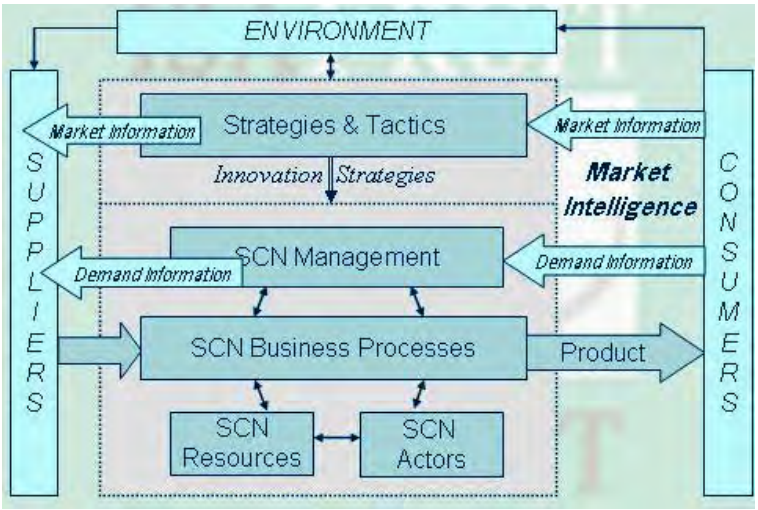

Fig. 1. SCN framework (Source: Verdouw, 2008, adapted from Van der Vorst et al., 2005).

- SCN Strategy & Tactics: generic strategies operationalized into measurable performance indicators and implementable innovation strategies;
- SCN Business Processes: primary (transaction and transformation processes) versus supporting processes;
- SCN Actors: network structure that depicts which companies are involved in the analyzed SCN and how the (especially buyer-supplier) relations in this network are formed;
- SCN Management: the way in which the chain processes performed by the actors in the SCN are governed and controlled, both formally and informally:
  - Governance structures for allocation of property and decision rights among different involved actors;
  - Control structures for planning and monitoring of business processes of the different actors within a certain governance structure.
- SCN Resources: capacities, being people or means, capable to develop, produce and deliver the required products.

The framework was tested in in-depth interviews with key industry informants in four countries: Greece, Poland, Spain, and The Netherlands.

Table 1. Number of interviews in each phase and country.

Country / Phase	Poland	Spain	Greece	Netherlands	***Total***
Testing Conceptual Framework	4	4	3	4	*15*
Mapping European SCNs	6	7	5	10	*28*
Assessment SCN performance and innovativeness	6	7	5	10	*28*
Total					***71***

To explore the way European fruit supply chain networks work, a diverse set of 8 cases was studied. Next, based on the results of ISAfruit WP1.2 and WP 1.3[1], a case selection has been made of products which are perceived as innovative and appeal to motives and barriers of consumers. In Poland, Greece, Spain and the Netherlands a total of eight products has been chosen of fresh, prepared and processed fruit, on the in-home and out-of-home market (see Table 2).

Table 2. Diversity of cases studied through the companies within the supply chain networks.

Poland	1	Fresh apple	Home market
	2	Organic fruit products	Home market
Greece	3	Fresh apple with special taste	Home market
	4	Canned fruit products	Home market
Spain	5	Watermelon for kids	Home market
	6	Peach with improved taste	Home market
The Netherlands	7	Fruit salads	Out-of-home market
	8	Black currant as ingredient	Home market

[1] Retrieved by personal communication with the project leaders, K. Zimmermann and M. Kraszewska

Within the supply chain networks behind those products, the linking companies were interviewed twice with a questionnaire to get the answers on research questions 1 and 2. In total 71 in-depth semi-structured interviews were held with the managers of in total 43 companies in 10 Supply Chain Networks. Comparing the results of the way innovation in chains takes place will give insights to answer research question 3.

The first round, 28 companies were interviewed to get comprehension of the functionality of the different links, the governance structure of their chain and their past and future innovations. In the second round, most of the same 28 companies were interviewed. These interviews were going in-depth concerning the innovativeness of the companies and the supply chain network as a whole. Innovativeness was defined as "the ability of the SCN system to produce product, process, marketing or organisational innovations".

Studying the innovativeness in the different cases was done on different elements: Within the context of a certain organization of the supply chain network, a company might have an innovation **strategy**. To create innovations, there will have to be idea-generation and then innovation projects will have to be **managed**; where in an **innovation process** is made use of **resources** and **actors**.

RESULTS

Mapping Current Configuration of European Fruit SCN's

An overview on chain operation was created by so-called chain mapping; analyzing 28 interviews against the chain framework (see Fig. 2 as an example of summarizing results). This led to the following insights:

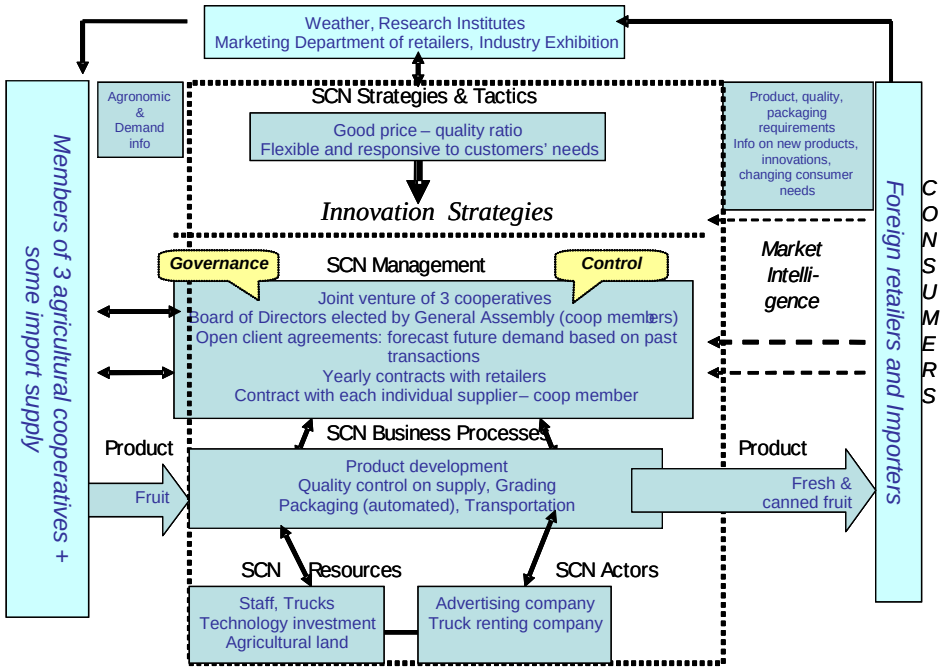

Fig. 2. Example of a summary of findings on the different aspects within a SCN.

1. SCN Strategy & Tactics.

- Mission statements and objectives differ between chain partners; most chain partners focus only on their direct customer;
- The difference in market-orientation of chains, local or global, is often related to their scale of production;
- Product quality is an important item in almost all the cases; there is no difference between fresh and industrial processed fruit. Costs, flexibility and service are important aspects as well;
- Concerning research and development:
  - Companies work on products and processes to continuously increase the product quality;
  - For most chains and links, it is important to have new products (new varieties, improved quality, new packaging, improved availability); therefore they work on product innovation continuously;
  - In the nearby future there will be more attention for marketing, focusing on new market channels, new customers and new promotion campaigns.

2. SCN Management.

- In the case studies a variety of organizations of the chain was found (i.e. see Fig. 3 and 4); chains produce for different markets: fresh – processed product, retail – foodservice for local or export markets;
- The variety in organization can be brought down to two basis functions: 1) Production / collecting and 2) Trading / distribution;
- In most cases there are a large number of chain links; however not all the links were interviewed in this study. Because of fruit production, there is a breeder, plant or tree nursery and grower in every chain. In some cases there are facilitators / cooperations in production and trade; they play a coordinating role. Growers are often organized in cooperatives; with several hundreds to a few thousand members who in total generate quite some produce;
- In most of the cases there are so-called lead companies that play an important role. They coordinate production, logistics, storage, sales and product development. Sometimes they even take care of the processing;
- The combination of companies providing a product to the market, hardly cooperate as a whole. They have no agreements or arrangements from seed to shelf so to speak. Most chain links focus only on their own customer.

3. SCN Actors: Suppliers and Customers.

- Most customers demand for specific requirements i.e. on product quality, product specifications (e.g. size, organic, IPM) certificates, delivery time and place. Sometimes arrangements are very detailed specified like packing size, number of pieces per box, barcode, country specific packaging. Furthermore customers also demand flexibility of their suppliers i.e. in delivery;
- The type of relations vary: repeated transaction, long term relationship, partnership and vertical integration. Furthermore they can be formal with contracts or not so formal (oral agreement);
- Most growers have a long-term relation with their cooperative. Most processors try to have long term relations with grower cooperatives to ensure fruit supply. On the other hand processors and retail organizations have long term relations and repeated transactions as well. In some cases contracts are used but it is not always clear which requirements are in a contract and which not;
- Price, quality and quantity play an important role in the relationship;
- Customers expect of their suppliers (information on) development of new products.

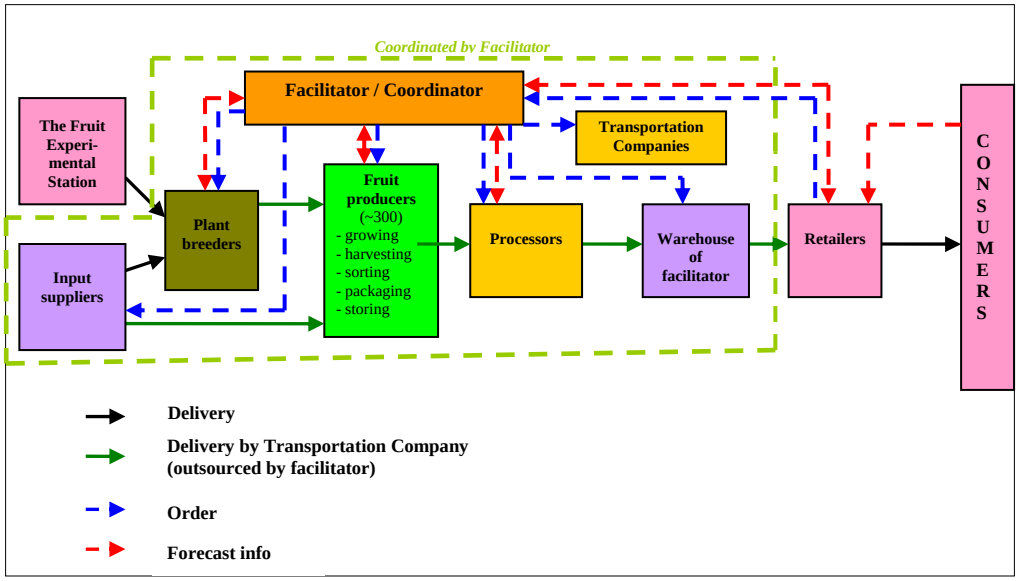

Fig. 3. A supply chain network where a coordinating company makes the arrangements with the partners concerning production and storage facilitates.

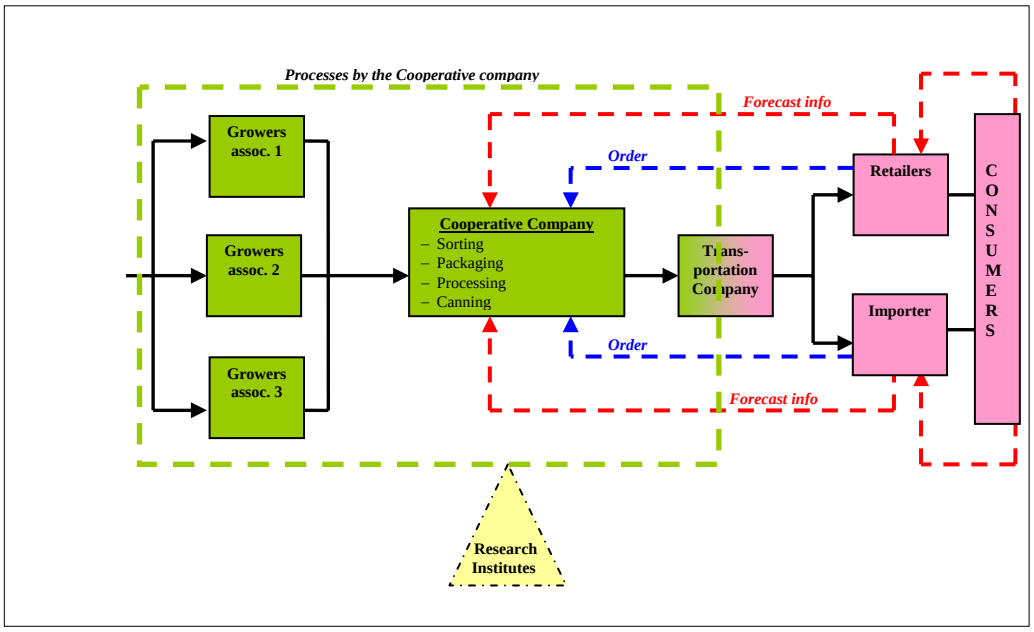

Fig. 4. A supply chain network where cooperation plays an important role in the middle between producer associations and the market.

4. SCN Business Processes.

- Production (including production planning, product development, cooling, sorting, distribution and transport) is the most important process in all cases, followed by 'product development';

- It is remarkable that quality control is not mentioned as an important process. The explanation is probably that one of the most important changes in processes over the past five years is the introduction of quality management & control;
- The production planning depends on market information, sales information, market research but supply and demand in previous years is important as well.

5. SCN Resources.

- Every chain partner has to deal with critical resources. Human capital and production facilities are mentioned frequently and very important critical factors. All chain partners share information frequently, especially with partners who corporate closely. Information sharing is more or less structured: sometimes it is automated and in others cases contacts are less frequently and depend on reports or personal contacts.

Realized and Future Innovations

In addition to a mapping of chains, an inventory was made of realized and future innovations. Despite a difference in the sense of urgency, the companies in most chains have the awareness that innovation is important to keep working on the competitive edge. These innovations can be distinguished to different types (see also Appendix A):

1. Product Innovation. In many cases the use or development of new varieties and raw material is mentioned. Also the development of new types of prepared and processed products is mentioned. With new ways of labeling and information they want to adapt better to consumer needs. Remarkable aspects for innovation in the future might be producing an assortment, increasing the production period, and use of additives / techniques to improve on the presentation on the shelf to the consumer.

2. Process Innovation. In many cases the implementation of quality management systems, production protocols and quality standards has been mentioned. Next to that companies and chains have invested in new machinery with new possibilities in sorting, weighing, and packaging. This way they play into market needs, otherwise the production has become more efficient and less labor intensive (= lower costs). Remarkable innovations mentioned for the future are improving the traceability of products and an increase of automation of quality management aspects.

3. Marketing Innovation. In different cases companies and chains have explored new market channels, i.e. shops in supermarkets and on-line selling through the internet. Also the launching of a new type of promotion campaign was mentioned. New innovations to be realized in the future that have been mentioned are building a new trademark and promotion offers of seasonal combinations of fruit.

4. Organizational Innovation. A whole set of different realized innovations was mentioned. They can be collected in cooperation with other actors and internal reorganization to make growth possible or to be more effective. For the future introduction of new computer and communication systems were mentioned, just as investing in the relationship with suppliers and customers.

Innovativeness of the Chain

From the second round of interviews, the following observations on chain innovativeness emerged.

1. SCN Organization in General. It could be seen as that (fruit) SCN's basically carry out two functions: 1) producing and 2) commercializing the product. In some cases these functions were strongly coordinated; in others quite a number of different links formed chain. In a case with a high level of coordination, also (the) innovation (process) was highly coordinated. In most of the other cases, existing out of a number of links, the urgency for innovation, to play into consumer needs, was mostly passed on in the subsequent customer-supplier relationships in that chain.

2. SCN Strategy and Tactics. Most of the companies, as link in the chains, indicate they do not have an innovation strategy. On the other hand, a lot of innovations have been mentioned (see Appendix A), thus it can also be that they do not recognize this term for what they do.

In one case with a high level of coordination on the side of production, they have a clear strategy and have clear vision on the different types of innovation (improvement on products, processes, etc.) and what they want to achieve. They base that on the interaction with the different links in production / processing and their contacts with retail. In one such case the coordinator hardly has means to innovate but involves all kind of partners to achieve these goals. In another such chain the coordinator invests in this innovation itself. These are not so much chain strategies, but most part of the chain is involved.

In most of the other cases the chain is based on links with a strategic fit. They all aim at offering high quality products and create a strong brand and provide a high level of clients' service. Because all actors know that continuous improvement is important, they pass on information back to the direction of the producers, more or less expecting (hoping) they are able to develop the appropriate innovation based on this. This is more like a collection of different strategies of companies than a chain strategy. The strategic fit of cooperating however, aims the innovation more or less in the same direction (the consumer).

3. SCN Management. In the cases where one link functions as a coordinator or facilitator ideas are generated based on carefully collected information, projects are formed and they are carried out by themselves or outsourced to innovation partners or chain partners. Together the planned innovation is realized. In other cases there are no formal and specific procedures on innovation.

4. Business Process (on Innovation). From the theory we see that steps within the innovation process are: information gathering, developing ideas, selecting best ideas, realizing the idea, testing and implementation. These steps are not always followed subsequently; sometimes stepping back is necessary. These process steps seem to be the same for innovation in new products, processes, marketing and organization. But this is not certain yet.

In some of the cases the innovation process seems to be more recognized than in others. In the case with the coordinating actor they recognize:

- Information gathering from open sources (magazines, fairs, exhibitions and paid assignments (i.e. market research);
- Creating new ideas on the different types of innovation;
- Realizing the idea, sometimes outsourced to other technical or processor companies;
- Testing the innovation in laboratories, with research from universities, etc.

In not all of the cases they are this specific on the innovation process. Links that are close to the consumer, like supermarkets, have direct insight in consumer behavior and demands. This information is used to start off or organize innovations in the shop. In most cases links start off innovation with their supplier and customers, bringing together information on the demand and (technical) solutions. Realizing the innovation mostly seems to be done by links or outsourced by them to business partners (see Fig. 5).

5. Resources. Gathering information plays an important role in innovation. In most cases the retail or food service channel is the link dealing with the consumers and their behavior. This way they gather insights in consumer needs, which is an important source of information for innovation in the chain. In some cases this information is actively gathered from the retail. In others the retail organization actively passes on this information back in the chain. There are also cases in which this information is not actively shared.

There are also cases where (coordinating) links actively search for information. Next to retail they use open sources: scientific institutes, magazines, (international) fairs, congresses, etc.

6. Actors. In quite a few cases links mention that innovation projects are carried out with

their customer or supplier in the chain.

In most cases is mentioned that depending on the innovation, the whole or part of the innovation project is outsourced to others (not chain partners) because: they are specialists, have the knowledge, have finances, have the men power, etc. Examples are cooperation with universities, market research agencies, etc.

Concluding Remarks on Innovativeness

Interviews with links in different chains have led to the (preliminary) insight that:

- Innovation strategy is something most of the companies do not recognize for themselves and on chain level;
- In discussion with companies, innovation is mainly perceived as product innovation. According to appendix A, also aspects of production, organization and marketing are improved;
- Innovation is mostly induced by supplier-customer contact. In only one or two cases there was found a structured way of working to create innovations (see Fig. 5) or working with an innovation funnel as one company outside the selected cases is using;

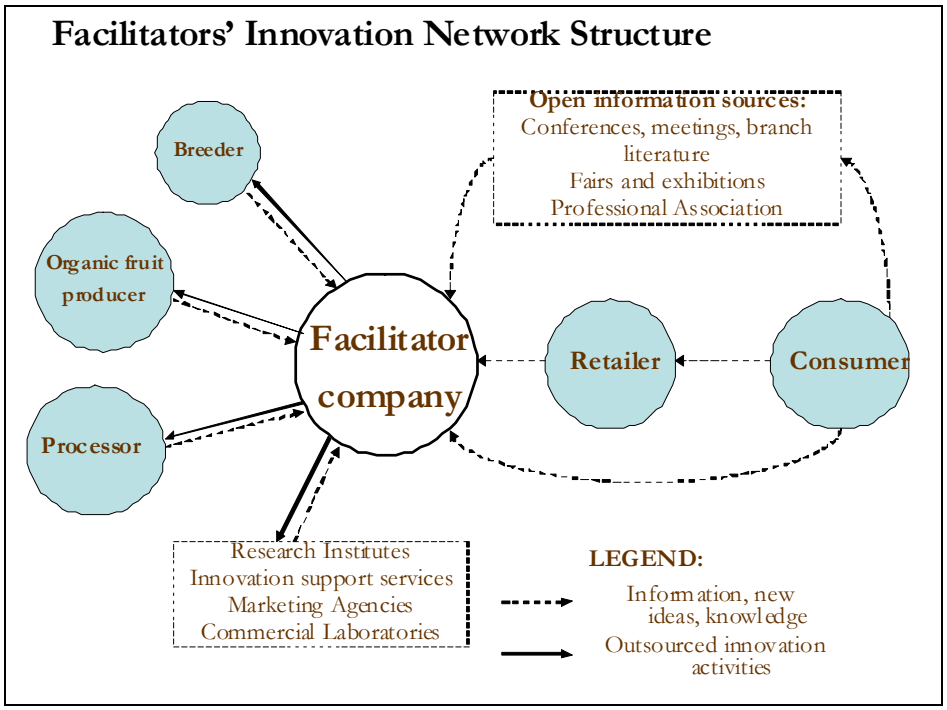

Fig. 5. Example of how signals for innovation can be organized in a chain.

- In only a few interviews, companies mentioned they have market research carried out to gather information as a basis for innovation. Companies are also inspired to product innovation at fairs, from articles, congresses and exhibitions;
- Product innovation is mainly induced and implemented by the lead companies that are the main important players in the chain. Depending on the type of product-market combination the lead company can have a different position in the chain; i.e. it can be a growers association looking for new varieties of fresh apples as a brand; it can be

processors of brand of fruit based drink or the food service company innovating in new fruit salads for their consumers;
- Developing and implementing the innovation mostly was done by the companies themselves. In some cases they mentioned they carried out a mutual project with their customers, supplier or knowledge institution;
- Outlets like supermarkets do not innovate when it comes to fruit products alone. They sell the products they get, being part of an assortment on the shelves.

DISCUSSION

This research was set up to be an exploratory study to get comprehension of how fruit supply chains operate, if they innovate in a consumer-driven way and how they may improve their way of innovating. The conclusions are based on 8 cases and about 28 interviews spread over 4 European countries. In the selection of these cases we have aimed for a diversity in chains and product-market combinations. Thus the results are not representative, but they give an indication. Maybe we haven't found a high level of consumer-driven innovativeness because of the way the cases were selected. Not all of the chains behind perceived innovative products were willing to cooperate in this research.

Because the results have the status 'preliminary', further collection of results and subsequent analysis will have to give additional insights: For example: To what extent do Strategy & Tactics of SCN's and their links influence their consumer-driven innovativeness? How is the chain organization of influence? What induces innovation in new products, processes, ways of marketing and improvement of the organization that appeal to consumer needs and how is the innovation organized? In which way do the (organization of) resources play a role in consumer-driven innovativeness?

CONCLUSIONS

Because the research is still in progress (August 2008), based on the 8 cases in our research, the most important preliminary results are:
- Of the different types of innovation, product innovation seems to be recognized as the most important by far;
- Companies hardly have market research carried out to get a better understanding of consumer demands, needs and wishes. Most of them are stimulated by requests or demands from their direct customer. In this 'passing on market demands' the companies act like a chain. They also use open information sources like fairs, exhibitions and articles in magazines to get ideas to innovate;
- Only one or two companies mentioned having an innovation strategy or a structured way of developing and implementing innovations;
- If chain functions are coordinated to a higher extent, they seem to have more organizational power to coordinate innovation and to adapt to changing market and consumer demands;
- The innovations that we have come across can be characterized as incremental improvements other than radical and system innovations.

More analysis and studies are needed to come to the final conclusions.

From our findings, we recommend that the fruit industry still can improve on consumer-driven innovation and adjust to the market in order to increase fruit consumption. In their role, policy makers can increase the awareness of the positive effects of consumer-driven innovation, by stimulating knowledge transfer on these matters. From there the fruit industry can be accompanied in taking action to improve its consumer-driven innovativeness, i.e. by increasing awareness by increasing the availability of market intelligence and increasing cooperation (or coordination even) to generate ideas and realizing innovation to play into consumer demands and needs.

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Appendix A. Innovation mentioned in cases

Table A.1. Innovations realized over the last 5 years mentioned by the links in the cases.

Product	Process	Organization	Marketing

• New variety (to meet changing consumer demands)
• New raw material
• New fruit juice
• New fresh prepared convenience products
• Healthier products
• New (forms of) packages / containers i.e. to better preserve and secure during transportation
• New labeling
• Adapt product information to local markets
	• Implementing Integrated Pest Management
	• Implementing quality management system (i.e. ISO 9000 / 22000)
	• Implementing production protocol
	• Introduction of quality standard under brand
	• Improvement facilities:
	  • New sorting line
	  • New weight machines
	• Modern central warehouse
	• New store model
	• Implement labour extensifying techniques automate (picking, sorting, cutting)
		• Reorganization due to expansion and diversing business process
		• Communication system
		• Vendor managed inventory
		• Creation of processing
		• Reorganization R&D; set up center of excellence / new laboratory
		• Cooperation with similar entities / Joint venture with 2 cooperatives
		• Cooperation with University (control of pest residues) / partnership in research
			• Introduction of new brand
			• New market channel
			• New (type of) promotion campaign
			• Participate in private labeling system
			• On-line selling (webshop) / Distribution through internet
			• New shops in supermarkets

For the next 5 years companies and chains will have to overcome all kind of bottlenecks. Therefore they will focus on new types innovations (see Table A.2).

Table A.2. Innovations mentioned for the future, that differ from those in Table 1.

Product	Process	Organization	Marketing
• Producing an assortment • New type of apple (shape, size) • New varieties to spread production (year round) • Constant production and avoid peaks in season • Availability: expand field production • Use of new additives to increase shelf life • Research of impact of light on presentation of products	• Refrigeration of the product to increase quality • Improve traceability system • Implementing HACCP, Eurep Gap • Increase automation by implementing of VMI, QMS, RFID, EAN, etc.	• Stimulate to replace orchards in time to ensure production on the long term • New computer system • Invest in relations with customers and growers • Company growth • More backward integration	• New trademark / trademark promotion • New shop network • Promotion of seasonal combination offers

Health Benefits of Increased Fruit Intake – Integrating Observational Studies with Experimental Studies on Fruit Health and Nutrigenomics

Lars O. Dragsted[1,*], Anne Tjonneland[2], Gitte Ravn-Haren[1,3], Mette Kristensen[4], Morten Poulsen[3], Witold Plocharsky[5] and Susanne G. Bügel[1]
[1]Department of Human Nutrition, University of Copenhagen, Frederiksberg, Denmark
[2]Danish Cancer Society, Copenhagen, Denmark
[3]Danish Food Institute, Danish Technical University, Søborg, Denmark
[4]Department of Food Science, University of Copenhagen, Frederiksberg, Denmark
[5]Institute of Pomology, Skierniwice, Poland
[*]Correponding author: 30 Rolighedsvej, 1958 Frederiksberg C, Denmark

Abstract

It is well known from studies of different populations that variations in fruit and vegetable intake are associated with differences in risks of chronic disease. In the later years several large cohort studies have reported very strong inverse associations between fruit intakes and risk of cardiovascular and cerebrovascular disease (CVD). From human dietary intervention studies it is known that several well known risk factors for CVD are affected by fruit and vegetable intake. These risk factors include high total or LDL-cholesterol, low HDL cholesterol, high blood pressure, high homocysteine and decreased insulin sensitivity. In some studies these risk factors have been favourably affected by dietary intervention with fruit alone or even with single fruits such as apples. The factors in fruit responsible for the health promoting actions have not yet been identified. One way by which these factors may be identified is by testing fruit fractions such as juices, pomace and other processed fruit products. Relatively little is known about the health effects of processed fruit but preliminary evidence points towards some potential health effects of fruit juices, especially the more cloudy juices. The ISAFRUIT project has set out to systematically investigate the effects of the fruit fractions formed upon processing using evidence from dietary intervention studies, animal studies and epidemiology. By combining these studies with nutrigenomics it is possible to identify new biomarkers of fruit intake and differentiate between the different fractions of fruit. This in turn will open the possibility to finally identify the components in fruits which confer their health promoting actions.

INTRODUCTION

Cultural terms and botanical definitions of fruit overlap but they also show several differences. In the botanical sense, a fruit is the part of the plant carrying the seeds no matter if they are edible or not, whereas fruits in food culture are generally sweet and used as snacks and for production of juices and nectars. Since cultures vary between countries some fruits in one culture are regarded as vegetables in others. The consequence of this is that the world scientific literature on fruit and health is inhomogeneous with respect to the foods investigated. Within Europe this is a somewhat minor problem, however berries may be regarded as a third class of commodities in some countries so that population studies on fruit may not include berries or may list effects of berries separately. Fruits may also be used in hot dishes together with meat or fish, e.g. as vegetables, and this may also to some extent affect interpretation of questionnaire-based studies on fruit and health. While most people are quite aware of how much fruit they snack or how much juice they drink, they may have difficulties in assessing accurately their intake of fruit used as ingredients in hot dishes or even as components in desserts. Since a large fraction of fruit is actually ingested as fresh commodities or as juice, the intake data on fruit and juice are generally of good quality.

Fruit intake has been associated with decreased risks of chronic disease in a large

number of studies. Prospective studies have reported that a high intake of fruit is associated with a 10-40% reduction in the risk of cardio- and cerebrovascular diseases (CVD) (Bazzano et al., 2002; Hung et al., 2004; Johnsen et al., 2003; Joshipura et al., 2001; Singh et al., 1993). Some of the most abundant fruit groups in the European diet, including apples and other stone fruits (Hertog et al., 1993; Knekt et al., 1996; Sesso et al., 2003; Mink et al., 2007), citrus fruits (Dauchet et al., 2004; Joshipura et al., 1999) and berries (Mink et al., 2007; Rissanen et al., 2003) are also associated with significant protection in some studies. Some evidence from cohort studies also points to reduction of several risk factors for CVD in those having a habitual diet rich in fruit or in fruit and vegetables. Thus, these foods have been associated with decreased risk of increased blood pressure, plasma cholesterol and fasting blood glucose. The effect of fruit on early CVD risk factors has also been tested in a few randomized controlled dietary intervention studies. A significant lowering of plasma total and LDL cholesterol was demonstrated in some studies and additional effects on blood pressure in others (Djousse et al., 2004; Dragsted et al., 2006; Jenkins et al., 1997; Obarzanek et al., 2001). The specific effects of single fruits, fruit fractions and processed fruits are less well studied. Thus there is good mechanistic evidence for fruit as a protective factor against CVD but current lack of insight into which part of the fruit contains the active principles.

For cancer diseases the evidence for protective actions of fruit based on case-control studies was originally regarded as quite strong, but more recent evidence from large prospective studies has shown much weaker associations. There is not a range of early risk markers for cancer, so it is not possible to achieve a similar level of mechanistic evidence and only few population-based studies have been concerned with the putative cancer risk markers under present investigation. Also as for CVD there is little evidence for specific actions of any particular part of the fruits.

The bioactive components in fruit responsible for protective effects are not yet identified and based on the weak epidemiological evidence there might be both soluble and insoluble factors involved. Fruit varies considerably in composition with respect to contents and type of phytochemicals and fiber. There is a considerable experimental evidence for the presence of bioactives in various fruits. The possible specific preventive actions of citrus fruits and apples on diseases such as cancer, vascular diseases, diabetes and other health conditions have been reviewed (Boyer and Liu, 2004; Silalahi, 2002). Citrus fruits and apples are the most highly consumed fruit groups worldwide, and apples are among the best studied. High consumption of berries is more specific to the northern part of Europe where they are abundant but strawberries have a much wider distribution. Observational and experimental studies on specific fruit groups may help clarify the effect of fruit in general on chronic disease risk and on the specific CVD risk markers.

This review aims to provide answers, based on currently available evidence on whether 1) fruit may affect the risk of chronic disease and of specific risk markers, 2) there may exist differences in the effect of whole fruit and of processed fruit.

THE POTENTIAL BIOACTIVE CONSTITUENTS OF FRUIT

Fruit diversity is large but within Europe stone fruits, citrus fruits, grapes and berries are some of the major fruit groups consumed. These fruits are composed mainly of water, carbohydrate, and fibre. Fruit contains only small amounts of protein and lipid and even smaller amounts of other plant metabolites which serve a wealth of necessary functions in the fruit acting as vitamins or enzyme cofactors, antioxidants, natural pesticides, aromas, etc. Three of these groups of constituents have attracted considerable interest as candidates for the bioactive actions of fruit, namely the fibers, vitamins and antioxidants.

The fibers may also vary between fruits but pectins are the most important soluble fiber in European fruit. Besides soluble pectin, there is a considerable amount of insoluble cell wall materials consisting mainly of cellulose and unsolubilised pectin chains. Whereas

solubilised pectins have been tested to a large extent for health bioactive effects, the complex cell wall materials are less well studied. The studies on pectins are somewhat inconsistent but point towards some effect of pectins on plasma cholesterol. The inconsistencies may be explained by the large variation in the way by which the pectins are extracted and enzymatically altered before testing. In that case the whole fruit would be expected to have better health promoting effects than processed fruit where the pectin structure has been destroyed or even enzymatically removed. Such enzymatic treatment is most often done during production of clear fruit juices.

The vitamins in fruit are dominated by vitamin C, but the contents of folate, vitamin E and the pro-vitamin A carotenes may also have nutritional significance. The vitamins obviously may have health promoting effects as nutrients, but this effect has only been shown unequivocally in individuals with vitamin-deficient diets. Single antioxidants, including vitamin C (Gale et al., 2001; Vita et al., 1998), vitamin E (Iannuzzi et al., 2002) and vitamin E plus beta-carotene (Gale et al., 2001) and other antioxidative carotenoids (McQuillan et al., 2001; Rissanen et al., 2003) are associated with weak effects on decreased intima:media thickness ratios and with slightly lower prevalence of plaques in the vessel walls.

Interventions with mixed antioxidant supplements have shown either a preventive action (Azen et al., 1996), no effects (McQuillan et al., 2001) or adverse effects (Brown et al., 2001). Interventions with vitamin E (400 mg/d) for 3-5 y have shown no effect on markers of atherosclerosis in diabetics (Lonn et al., 2005) and in volunteers with high cholesterol levels (Hodis et al., 2002). Intervention in males with vitamin E (100 mg/d) and vitamin C (250 mg/d) in a slow-release formulation had a significant effect on the age-dependent rate of increase in intima:media thickness, whereas no effect was observed in females in the ASAP-study (Antioxidant Supplementation in Atherosclerosis Prevention) (Salonen et al., 2003). None of the antioxidants alone had an effect. No effect on this marker was observed following six years treatment with an antioxidant mixture in the French SU.VI.MAX study in comparison to the placebo group (Zureik et al., 2004). In the American trial, the HDL-Atherosclerosis Treatment Study, randomisation to an antioxidative cocktail with vitamin E, beta-carotene, vitamin C and selenium had an adverse effect by inhibiting the positive effect of simvastatin plus nicotinic acid on atherosclerosis (Brown et al., 2001).

It has been hypothesized that antioxidant vitamins (A, C, E) in high doses may impact positively on health, and some large human trials with these vitamins have been carried out, albeit mainly with a neutral or negative health outcome as determined in meta analyses (Heart Protection Study Collaborative Group, 2002; Bjelakovic et al., 2008). However, vitamin C has not been thoroughly tested for its actions on chronic disease so there is still room for hypotheses of specific health effects of this vitamin (Bjelakovic et al., 2008). Anyhow, the overall message is that the antioxidant vitamins cannot explain the overt health promoting effects of a high intake of dietary fruit. Folate intake has been shown to decrease the plasma level of homocysteine, an independent risk factor of CVD (Herrmann et al., 2006) and might consequently have protective effects, but no randomised studies have evaluated this outcome thoroughly. It is therefore possible that folate may explain some of the protective actions of fruit on CVD.

Antioxidant contents in fruit are to a large part identical to the vitamin contents, but there are also non-nutrient antioxidants, mainly belonging to the large and chemically diverse group of polyphenols. The polyphenols are potent antioxidants when they are used as additives in foods but their absorption is often low and their antioxidant actions in humans seem uncertain despite numerous studies. Polyphenols may be subdivided into several groups, including the different flavonoid subclasses, the phenolic acids, and the proanthocyanidins. Flavonoids and proanthocyanidins in general have low bioavailability in humans, whether as aglycons or as glycosides (Nielsen et al., 2002). Others, such as specific flavonol glucosides may enter the gut cell lining at relatively high concentrations but most of

it is then excreted again into the gut flow (Day et al., 2003). Exceptions include catechins, common in most fruits and flavanones from citrus, for both of which 3-10% may be absorbed (Nielsen et al., 2002; Young et al., 2002). Following absorption the flavonoids are often methylated and conjugated by sulphate or glucuronide (Li et al., 2001). Bacterial degradation products of most flavonoids are formed and comprise numerous phenolic acids most of which have high bioavailability just like the phenolic acids present in the fruits (Gross et al., 1996; Hollman et al., 1999). Good and exact exposure biomarkers exist for flavonols, flavones, catechins, flavanones, anthocyanins, and proanthocyanidins (Fuhr og Kummert, 1995; Nielsen et al., 1998, 2002; Young et al., 2002), making it possible to evaluate the impact of flavonoids and phenolic acids in prospective studies where initial samples from the volunteers have been stored in central facilities (biobanks). Less exact exposure evaluations may come from calculations based on questionnaire data on food intakes combined with analytical data on polyphenol contents in different foods. Since contents may vary considerably and since questionnaires suffer from inaccuracies these calculated intake estimates may be rather imprecise.

In conclusion, the vitamins in fruit, except folate, are most likely not the cause of the preventive effects, whereas folate, fibres, and polyphenols may all contribute to these effects. Apart from the health effects of whole fruit and processed fruit it is therefore of major interest also to review potential health effects of folate, fruit fibre and fruit polyphenols.

FRUIT AND PREVENTION OF CARDIOVASCULAR DISEASE

More than ten large prospective epidemiological investigations have been reported during the last 10 years on the relationship between the intake of fruit and vegetables and total or specific forms of CVD. These include several North American studies, the Nurses' Health study, Health Professionals Follow-up Study, Women's Health Study, Physicians' Health Study, National Health, Artherosclerosis Risk in Communities and Nutrition Examination Survey (Bazzano et al., 2002, 2003; Hung et al., 2004; Joshipura et al., 1999, 2001; Liu et al., 2000, 2001; Steffen et al., 2003), some European studies, the Prospective Epidemiological Study of Myocardial Infarction (PRIME) and some studies based on the European Prospective Study in Cancer (EPIC) cohort (Dauchet et al., 2004; Johnsen et al., 2003) and two studies from Japan, the Nagasaki Life Span Study and the Japan Public Health Center-Based Prospective Study (Sauvaget et al., 2003; Takachi et al., 2008).

Most of these studies report a significant inverse association of fruit and vegetable intake with CVD or stroke. In some of these studies the strongest association was with fruit intake. In the combined analysis of the Nurses' Health Study and the Health Professionals' Follow-up Study the association with fruit per 3 portions increase in intake was 0.87 (95% CI 0.80-0.94), whereas the CI for the association with vegetables included unity (Hung et al., 2004). In the PRIME study, only the association of CVD risk with citrus fruit was significantly inverse (Dauchet et al., 2004), and a similar finding was reported in the Danish branch of the EPIC study (Johnsen et al., 2003) but here there was also a significant inverse association with total fruit (RR: 0.60; 95% KI 0.38-0.95; P = 0.02). However, in both studies the risk had been corrected for a range of risk markers, including blood pressure and cholesterol which may be strongly affected by fruit intake, thereby possibly obscuring most of the effects. In a recent large study from Japan following up on more than 450,000 person years, higher consumption of fruit, but not vegetables, was associated with significantly lower risk of CVD. Multivariate hazard ratios for the highest versus lowest quartiles of fruit intake was 0.81 (95% CI 0.67-0.97; P = 0.01).

Some investigations are concerned only with cerebrovascular (Joshipura et al., 1999), others solely with cardiovascular disease (Hung et al., 2004; Joshipura et al., 2001; Liu et al., 2001), but the picture is still quite uniform. The risk reduction varies between 4-15% per extra portion of fruit or vegetables included into the diet. In the large follow-up on the Nurses

Health study and the Health Professionals' Follow-up Study there was a total 13% reduction in CVD risk among the study persons with the highest fruit intake (Hung et al., 2004).

Several meta-analyses have systematically combined the information from larger and smaller prospective studies on fruit and vegetables and CVD. A total of six meta-analyses have been reported, three of these are based on older data, combining ecological, case-control and smaller cohort studies (Law and Morris, 1998; Ness and Powles, 1997; van't Veer et al., 2000). Although older studies have generally shown a weaker effect of fruit and vegetable intakes on CVD risk, all three found a significant inverse association. One of these meta-analyses calculated a predicted 16% decrease (5-22%) in the risk of CVD if the mean population intake of fruit and vegetables increased to 400 g/day.

A more recently completed meta-analysis included only larger cohort studies and found a strong significant reduction in the risk of ischemia with increased fruit and vegetable intake (Dauchet et al., 2006). The analysis included more than 200,000 males and females and included over 7,000 cases. The risk reduction per portion of fruit was strongest and could be calculated to 7% (RR 0.93; CI 0.89-0.96; $P<0.0001$). Two other recent meta-analyses have focused on risk reduction of cerebrovascular disease (Dauchet et al., 2005; He et al., 2006). Both found strong inverse associations, the latter calculated a risk reduction by 26% for a mean intake of 400 g/day. The former study found a protective effect of fruit intake by 11% per portion (RR 0.89; CI 0.85-0.93) (Dauchet et al., 2005), and no significant effect of vegetables.

Intervention studies are difficult to perform with hard endpoints such as CVD but some studies have used dietary intervention in secondary prevention, e.g. in studies with CVD patients in order to investigate altered risk as an effect of dietary change. A significant 30-70% risk reduction was observed in the Lyon Diet Hart Study by transferring the patients to a Mediterranean type diet with high intakes of fruit, vegetables and fish as compared to a prudent Western diet (de Lorgeril et al., 1999). It is not clear from this study what the contribution of fruit is to this risk reduction.

The evidence for a protective effect of fruit on several different diagnoses of ischemic disease and stroke is strong and consistent with calculated risk reductions from 4-11% per portion increase per day.

Fruit and Atherosclerosis

There was a significant decrease in development of atherosclerotic lesions in coronary arteries in the American randomised Life Style Heart Trial one year after a life style change, which included a vegan diet, smoking cessation and psychosocial support in comparison to a normal recommended healthy diet (Ornish et al., 1990), and the effect still persisted five years later (Ornish et al., 1998). It is uncertain to what extent the fruit intake contributed to this decerase.

Lycopene, a carotenoid primarily found in water melon and tomatoes has also been associated with lower levels of atherosclerosis whereas other carotenoids were inactive, especially among ex-smokers (Klipstein-Grobusch et al., 2000).

Fruit and Risk Factors for CVD

In the cross-sectional National Heart, Lung and Blood Institute Family Heart Study, conducted among 4,466 Americans, there was a significant inverse relationship between their reported dietary fruit and vegetable intakes and serum LDL-cholesterol levels while HDL cholesterol and triglycerides were unaffected (Djousse et al., 2004). Vegetarians have been repeatedly found to have lower levels of blood lipids than omnivores in observational studies (Thorogood, 1994); this has subsequently been shown to be true also in intervention trials where vegetarian diets reduce LDL-cholesterol compared to control diets containing meat and animal fats (Barnard et al., 2000; Jenkins et al., 1997). Intervention trials with fruit and

vegetables on top of a non-vegetarian diet also lowers LDL-cholesterol moderately (Dragsted et al., 2006; Obarzanek et al., 2001). These effects of fruit and vegetable rich diets are probably not caused by their higher content of antioxidants but are more likely consequences of their high contents of fibre, and in the case of vegetarian diets the effects are further increased because they are lower in fats.

A diet containing a high level of fruit and vegetables decreases blood pressure. In the DASH-study (Dietary Approaches to Stop Hypertension), 459 volunteers with a normal or moderately increased blood pressure were offered a diet rich in fruit and vegetables or a placebo diet (ordinary recommended American diet) for 8 weeks. A significant decreased blood pressure and LDL-cholesterol was observed in the fruit and vegetables group after intervention (Appel et al., 1997). In the English Oxford Fruit and Vegetable Study there was also a significantly lower blood pressure among the volunteers randomised to the intervention with '5-a-day' (5 daily servings of fruit and vegetables) for six months compared with controls (given 3.7 servings/day) but no effect was observed on plasma cholesterol (John et al., 2002).

Similar findings have been observed in cohort studies, for example in the Chicago Western Electric Study, where blood pressure increased less during seven years among those who had 14-42 monthly servings of fruit and vegetables compared with those having less than 14 servings per month (Miura et al., 2004). Vegetarian diets have also been found to influence blood pressure favourably compared to diets rich in meat (Berkow and Barnard, 2005).

In the prospective CARDIA-study (Coronary Artery Risk Development in Young Adults) a higher increase in blood pressure was observed among young adults with low intakes of fruits and nuts after 15 y follow-up whereas no such effect was observed for vegetables (Steffen et al., 2005). There is also some evidence for an increase in insulin sensitivity among individuals with a high intake of fruit and vegetables (Ard et al., 2004). Effects on blood pressure and insulin sensitivity may partly be due to the high contents of potassium and magnesium in these foods.

Effects of Single Fruits and Fruit Constituents on CVD Risk Markers – Apple as an Example

Older studies have indicated that apple and apple fibre may have cholesterol lowering effects (Gormley et al., 1977; Mee and Gee, 1997; Hyson et al., 2000; Sable-Amplis et al., 1983; Mayne et al., 1982; Pirich et al., 1992) but these investigations do not live up to present demands on design and quality control. In one of these investigations a total of 76 males were matched pairwise with respect to plasma cholesterol and one male from each pair received two apples a day, whereas the other had only two per week through 113 days. There were no diet restrictions and volunteers were followed up every 3-4 weeks. At the end of the trial serum total and LDL cholesterol was lowered by around 8% more in those who were given two apples every day. HDL cholesterol was slightly increased in this group (Gormley et al., 1977).

In another study a group of 28 healthy non-smokers was divided and given either 340 g apples or 375 ml apple juice daily for six weeks without any restrictions on the diet. After six weeks they switched to the other product. There was no difference between the two products with respect to plasma lipids (Hyson et al., 2000). In a third study, 30 male and female volunteers were followed through 4 weeks during which they were consuming 2-3 apples daily. Plasma cholesterol decreased by 14% (Sable-Amplis et al., 1983).

In an investigation of the cholesterol lowering effect of apple juice, 110 hypercholesterolemic volunteers after an 8-week run-in had a daily intake of 720 ml pectin and guar gum fortified apple juice for 12 weeks and then clear apple juice for 6 weeks. There was a significant increase in plasma cholesterol levels in both apple juice periods, indicating

that the juice and solubilised fibers do not harbour the effect of the whole apple on cholesterol (Judd and Truswell, 1985).

Together these studies give a clear indication that whole fruit (apples) may lower plasma cholesterol and consequently have a beneficial effect whereas the health effect of clear juice and purified fruit fibres are uncertain. On the other hand there is some evidence to suggest that cloudy juices which retain some of the intact fruit fibre also retain some of the health effects.

THE ISAFRUIT APPROACH TO INVESTIGATE HEALTH EFFECTS OF FRUIT

In ISAFRUIT we are using several approaches to increase our knowledge on the mechanisms by which fruit may increase protection against CVD.

In one approach we are looking at health effects of fruit consumption using data from the Danish branch of the EPIC study. These cross-sectional and prospective studies enable us to look more carefully into the effects of fruit on early risk markers of CVD.

In a second approach we are using several new nutrigenomics techniques in order to investigate the biochemical effects of fruit and fruit fractions using apples as an example. We have first looked at the effects of apples and apple fractions in experimental animals and subsequently in a human dietary study.

The Epidemiological Approach

The "Diet, Cancer and Health" study is a prospective cohort study, established with the primary purpose to evaluate the etiological role of diet on cancer risk, however CVD risk factors were also included. A more detailed description of the cohort has been published elsewhere (Tjonneland and Overvad, 2000). In brief, between December 1993 and May 1997, 80,996 men and 79,729 women were invited to participate in the study. All women and men who lived in greater Copenhagen and Aarhus and fulfilled the following inclusion criteria: age between 50 and 64 years old, born in Denmark and not registered with a previous cancer diagnosis in the Danish Cancer Registry were invited. After recruitment and exclusions, data on 29,365 women and 26,791 men were left for analyses. At baseline, each participant filled in a food frequency questionnaire (FFQ), waist circumference was measured and blood samples were drawn for serum cholesterol determination. We estimated intakes of apples, remaining fruit, vegetables, grain products and juices from the FFQ, in which the participants reported their average intake of different food items over the previous year within 1 of 12 possible intake categories, which ranged from never to $\geq$ 8 times/d. Daily intakes were calculated from the FFQ for each participant by using the software program Food Calc.

Apples are the most consumed fruit in the cohort covering almost 50% of the total fruit intake. For the analyses of fruit and health we have therefore grouped intakes into 'Apples' containing all apple sorts, 'remaining fruits' consisting of pears, oranges, mandarins, grapefruits, bananas, nectarines and peaches, strawberries, kiwifruits, and melons, and 'juices' including all juices reported. The analyses of the association between these intakes and the observed serum cholesterol and waist circumference were based on single and multiple linear regression analyses. Variables were entered stepwise into the model and slopes were calculated. First, the crude associations of the two fruit groups with the risk factors were investigated. In the next step, a mutual adjustment between the different plant food groups was made along with adjustments for BMI, age, activity level, smoking status (never/past/current smoker), alcohol intake, energy intake (waist circumference only) and waist circumference (for cholesterol only).

For cholesterol it is obvious from Table 1 that we observe a beneficial effect of fruit intake of almost similar magnitude for apples and for other fruit. This effect is stronger among males, possibly because this group has higher cholesterol levels and therefore may have higher benefits. The effect of total fruit (apples + others combined) on lowering of

serum cholesterol was also significant in men and in women with or without adjustments. Adjustments tend to decrease the observed effects. This may partially be caused by some correlation between life style factors such as activity level and fruit intake. If individuals having a high activity level also tend to eat more fruit, some of the effect of fruit on serum cholesterol may be removed by the correction for activity level. The effect of juices is less clear albeit with a trend in the same direction as seen for whole fruit. It seems from these data that juices may not retain the full health beneficial effect of fruit. So the resulting picture is that whole fruit seems to be more beneficial than juice with respect to serum cholesterol levels.

A high waist circumference is a major risk factor for diabetes and for CVD and may be the underlying cause of the low grade systemic inflammation which is believed to be the major cause of morbidity from overweight. We have therefore evaluated the effects of fruit intake also on waist circumference (Table 2). In the crude analysis we see no effect of apples and an adverse effect of whole fruit whereas juices seem to cause slimness. This is somewhat surprising given the relatively high sugar content and low level of fibres in most juices. However, we see a much larger influence of the adjustment, which turns the whole picture to show a beneficial effect of fruit and no effect of juices. The stepwise analyses showed that this was caused by the adjustment for BMI and energy intake. This may indicate that fruit increases waist circumference among those with a low energy intake and decreases waist circumference among those with a high energy intake. Stratifying for waist circumference we could find some support for this interpretation since the increased waist circumference with a higher fruit intake was observed only among those in the lowest quartile of fruit intake. A slight increase in waist circumference in this group may actually be healthy since some studies have indicated an adverse effect of being too slim (Jee et al., 2006). Thus whole fruit may give the correct balance by affecting the slim and the overweight persons in opposite directions. In order to conclude firmly on this, the same findings must be confirmed in a longer-term human dietary intervention study.

Table 1. Crude effect of the intake of 100 gram of different plant food groups on serum cholesterol.

	Men (n=26791)		Women (n=29365)	
	crude	adjusted[a]	crude	adjusted[a]
Apple	-0.077*	-0.048*	-0.043*	-0.022*
Other fruit	-0.059*	-0.019*	-0.037*	-0.010
Juices	-0.020	-0.003	-0.021*	-0.014

* Slope significantly below 0

[a] Plant food groups mutually adjusted and extra adjusted for waist circumference, BMI, age, activity level, smoking status, and alcohol

Table 2. Crude effect of the intake of 100 gram of different plant food groups on waist circumference.

	Men (n=26791)		Women (n=29365)	
	crude	adjusted[a]	crude	adjusted[a]
Apple	0.116	-0.103*	-0.104	-0.170*
Other fruit	0.242#	-0.037	-0.003	-0.186*
Juices	-0.256*	0.073	-0.459*	-0.005

* Slope significantly below 0 ($p<0.01$), # Slope significantly above 0 ($p<0.01$)

[a] Mutually adjusted and adjusted for age, activity level, smoking status, alcohol, BMI, energy intake and grain fibre intake

The Experimental Approach Using Nutrigenomics

It is now well known that dietary changes also induce changes in many biological phenomena, including gene expression, protein and lipid metabolism and different metabolic pathways. Our aim is to study these changes applying modern technologies of gene expression, metabolomics and lipidomics. We have done this first in animal studies using normal, healthy rats as a model. We have been able to show that apples lower cholesterol also in rats and that the solids fraction rather than the juice fraction is responsible for this effect (data to be published elsewhere).

A large human intervention study with apples and apple fractions (Sampion variety) has recently been concluded and preliminary data from this study indicate similar findings but again data must be published first elsewhere.

In addition to plasma and serum samples we have also collected urine, fecal samples, erythrocytes and white blood cell (PBMC) samples at the beginning and end of the intervention to perform gene expression studies and to analyze in detail early biomarkers (Fig. 1), which may be related to the health effects of fruit and which may change differently by the experimental diets during the trial. Figure 1 shows the ISAFRUIT strategy for biomarker development using experimental and observational studies.

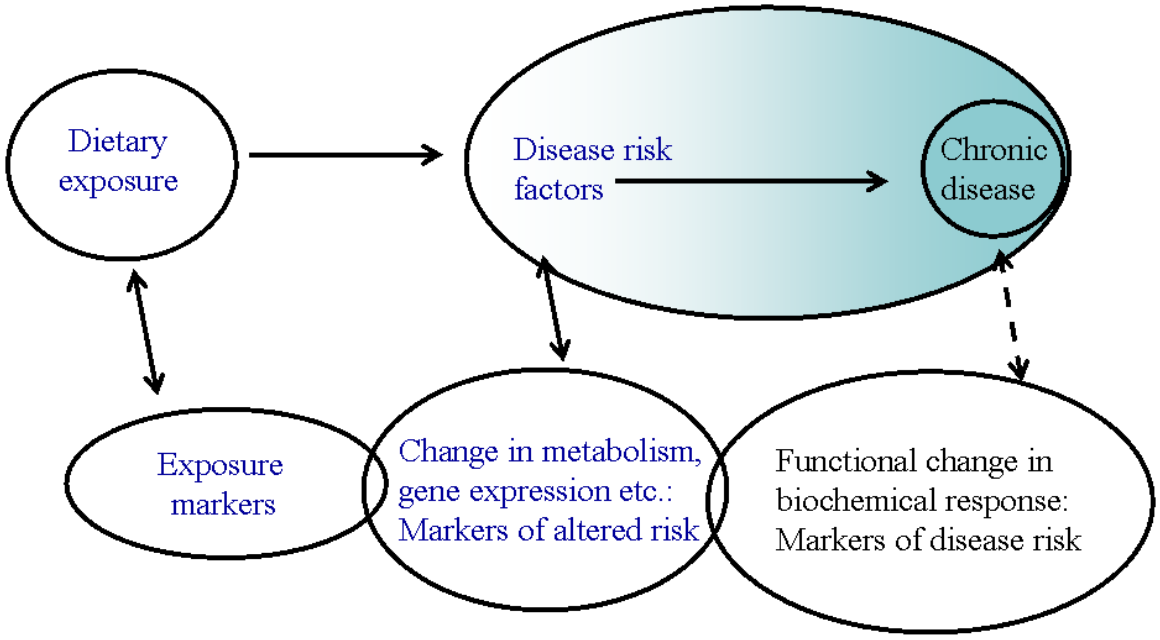

Fig. 1. The ISAFRUIT strategy to identify health mechanisms of fruit combines experimental and observational/biobank studies to identify and group biomarkers relating to exposure, early risk markers and disease risk.

As an example, a plasma profiling study was done on a subset of the plasma samples from the human dietary study using LC-MS. Principal components analysis shows clear separation of the samples collected before and after apple consumption in the scores plot (Fig. 2), except for samples from one individual. Using the loadings plot from this analysis we have been able to identify more than 100 markers relating to apple intake. A few of these are known metabolites of apple components which seem to be good exposure markers for

intake of plant-based foods (e.g. hippuric acid) or of apples specifically (e.g. phloretin metabolites). Others are newly identified compounds which also seem to be unique exposure markers since the compounds are not observed unless apples are consumed. This leaves us with good fingerprints of apple and fruit intake which will prove useful in the biobank based study to discrimitate objectively between samples from individuals eating different levels of fruit. The loadings plot also points to markers which are endogenous metabolites but change as a response to apple intake. These markers may be related to the health effects of apples and further analyses to identify and investigate the biochemical pathways involved are underway and should point to markers explaining the effect of fruit on risk factors such as cholesterol levels in the different lipoprotein fractions as well as effects on waist circumference.

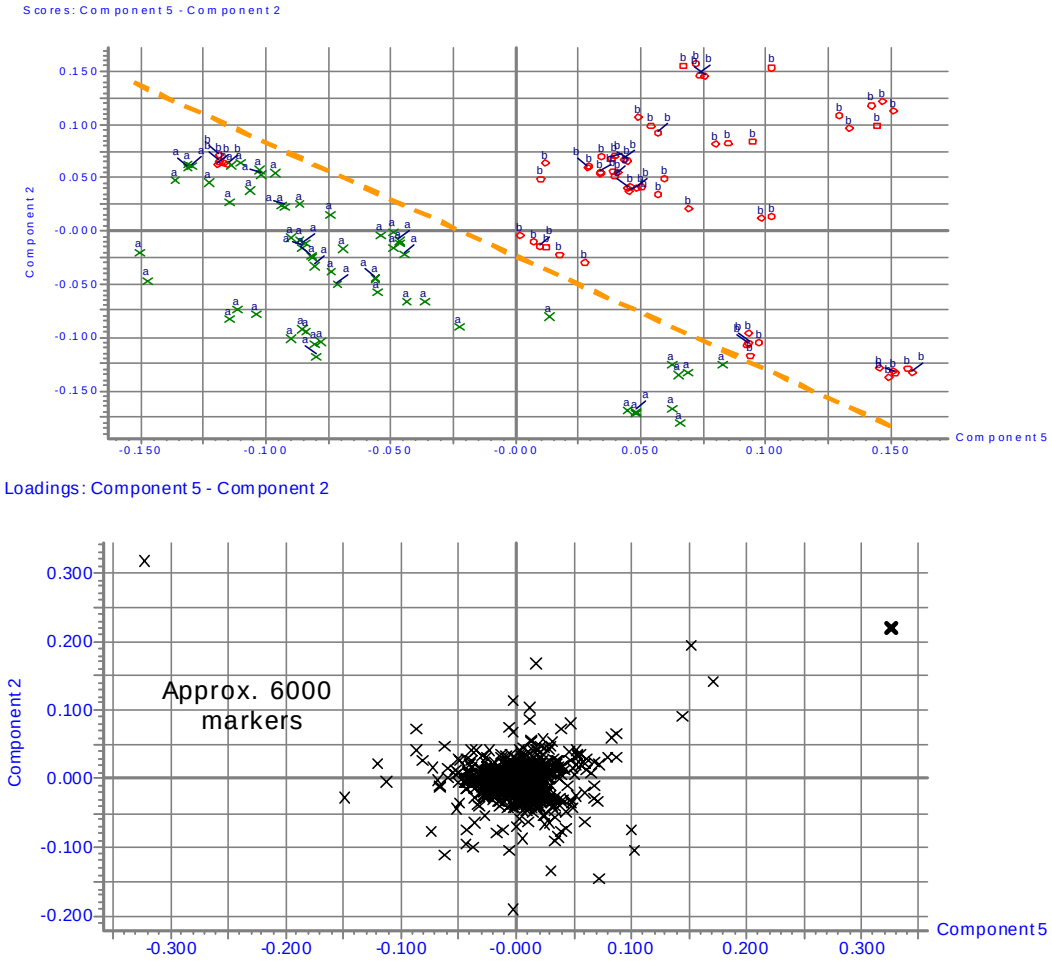

Fig. 2. Principal components analysis of profiles obtained from liquid chromatography – time-of-flight mass spectrometry analysis of a subset of urine samples from individuals before and after apple consumption in a human dietary study. Upper panel is the scores plot and a line separating (most) scores from control (a) and apple (b) periods. Lower panel is the corresponding loadings plot with a symbol for each marker according to its contribution to the scores.

CONCLUSION

There is now very good and consistent evidence for a protective effect of fruit intake leading to lower risk of cardiovascular disease, cerebrovascular disease and stroke. These beneficial actions are explained by a strong effect of fruit intake on several known risk factors for these conditions, including a lowering of plasma cholesterol, blood pressure and plasma homocysteine and an increased sensitivity to insulin. The components in fruit responsible are largely unknown. While there is evidence that some of the beneficial effects may also be present after intake of juice, the evidence is weaker and indicative of a better effect of cloudy juices than clear juices. ISAFRUIT has set out to investigate the mechanisms behind the protective actions of fruit on CVD risk factors and can largely confirm the effects on risk factors in observational and experimental studies. By using several novel chemical and molecular techniques we have identified a large number of new biomarkers that will help explain some of these health effects and help to identify new fruit processing procedures to increase the health effects of fruit products.

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The Role of Fruit in Prevention of Obesity

I. Tetens and S. Alinia
Department of Nutrition
National Food Institute, Technical University of Denmark
Mørkhøj
Denmark

Keywords: overweight, satiety, glycaemic index, prospective studies, intervention studies

Abstract

The global obesity epidemic is associated with a sedentary lifestyle and diets rich in high-fat, high energy foods. The potential role of fruits in preventing overweight and obesity is related to their relatively low energy density, high content of dietary fibres and associated increasing satiety effects. The physical disruption of fruits is of considerable importance for satiety as shown in studies where fruit juices were less satisfying compared to sugar-equivalent intakes of purées and whole fruits. A potential role of fruits in the prevention of overweight and obesity may be connected with the dietary pattern of fruit intake and with the possibility that fruit intake may substitute other more energy dense foods. A majority of human prospective cohort studies in adults suggests a preventive effect of increased fruit intake on body weight gain whereas a few studies have suggested the opposite in the case of fruit juices. Prospective studies on children are few and inconclusive but suggest associations between fruit intake and body weight that are related to the initial nutritional status. In behavioural intervention studies subjects are often advised to undergo several changes towards a healthy diet and lifestyle making it impossible to quantify a specific effect of fruit intake on body weight. In the few available intervention studies in adults the study period is often too short to allow measures of body weight changes and studies in overweight/obese subjects may not apply to normal weight subjects. Intervention studies targeted at school children show that such schemes can be effective in increasing fruit intake but a convincing role of an increased fruit intake in the prevention of overweight and obesity in children still needs to be shown. The present evidence suggests that fruit has a potential role in the prevention of overweight and obesity.

INTRODUCTION

The global obesity epidemic is a complex multifactorial condition resulting from an imbalance between energy intake and energy expenditure. Apart from a predisposing genetic background overweight and obesity are associated with environmental factors of which a sedentary lifestyle and overconsumption of high-energy yielding foods are main contributors. Many national and international food based dietary guidelines recommend an increase in fruits and vegetables consumption to protect against several chronic diseases such as cardiovascular diseases and certain types of cancer (WHO, 2003; World Cancer Research Fund, 2007; He et al., 2004). The scientific evidence for an inverse association between risk of overweight and obesity and consumption of fruits and vegetables was considered convincing (WHO, 2003). However, the role of fruits alone and of fruit and fruit products on the risk of development of obesity and overweight has not been addressed separately.

The objective of this paper is to discuss and evaluate the possible role of fruit intake in the prevention of obesity and overweight.

THE RATIONALE

The rationale for a potential role of increased intake of fruits in the prevention of

overweight and obesity is related to several factors in whole fruits: the high water content, relatively low energy density and the relatively high content of dietary fibres of which soluble dietary fibres constitute a considerable part (Table 1). Dietary fibres and in particular soluble fibres that are present in fruits in considerable amounts have been shown to increase postprandial satiety and decrease subsequent hunger in short-term studies (Howarth et al., 2001). In the long term, this may lead to decreases in energy intake and thereby body weight.

Table 1. Content of energy, water, sugar and dietary fibres in selected fruits and fruit products[1] (per 100 g).

	Energy (kJ)	Water (g)	Total sugars (g)	Dietary fibres (g)
Apples	192	87.6	8.1	2.2
Apples, dried	1666	2.5	41	-
Oranges	234	86.6	8.2	2.1
Orange juice	182	89.0	8.4	-
Orange marmalade	865	47.0	47	-
Bananas	391	76.6	16	1.6
Grapes	274	84.0	15	1.4
Pears	255	85.1	9.5	2.9
Apricots	185	88.8	ND	1.6
Apricots, dried	1244	26.1	42	9.3
Watermelon	264	90.2	7.6	0.5

ND = not determined
[1]Source: Saxholt et al., 2006.

Processing of fruits, including drying, cooking, etc., may result in a reduction of the water content, addition of sugars and other substances, which may increase energy density of the fruit product consumed (Table 1). The processing of fruits into juices leaves a fruit beverage that may or may not contain added sugar. The pattern of fruit juice consumption has changed over time and its role in the diets of adults and in particular of children and its possible association with caloric intake has been discussed extensively throughout the last decade.

An essential aspect of fruit consumption in relation to obesity is the impact of fruit on satiety. In one of the classical studies of the nutritional role of dietary fibre in fruits, the effects of intact apples, apple purée and fibre-free apple juice were studied on satiety, plasma glucose (blood sugar) and serum insulin (blood insulin) (Haber et al., 1977). After ingestion of sugar-equivalent amounts of meals, apple juice was significantly less satisfying than purée that again was less satisfying than whole apples (Fig. 1). The study showed that plasma glucose rose to similar levels in all 3 types of meals whereas significant differences were measured in serum insulin levels with the juice giving rise to the largest postprandial levels followed by the purée and then by the whole apples. The conclusion from the study was that the removal of dietary fibre from fruits and also the physical disruption of the dietary fibres resulted in faster and easier ingestion and in decreased satiety. This study formed an important basis for the hypothesis about a correlation between dietary fibre, physical properties, satiety and subsequent short-term food consumption. The study was repeated with other fruits like oranges and grapes (Bolton et al., 1981). The conclusion from the latter study was that both satiety and the postprandial glucose and insulin responses to intakes of fruits and fruit products depend on the content of dietary fibre, the physical structure and the content of various types of sugars. Fructose, which is the main sugar present in fruits, is metabolized slowly and thus contributes to the relatively slow rise in blood glucose after ingestion of fruits.

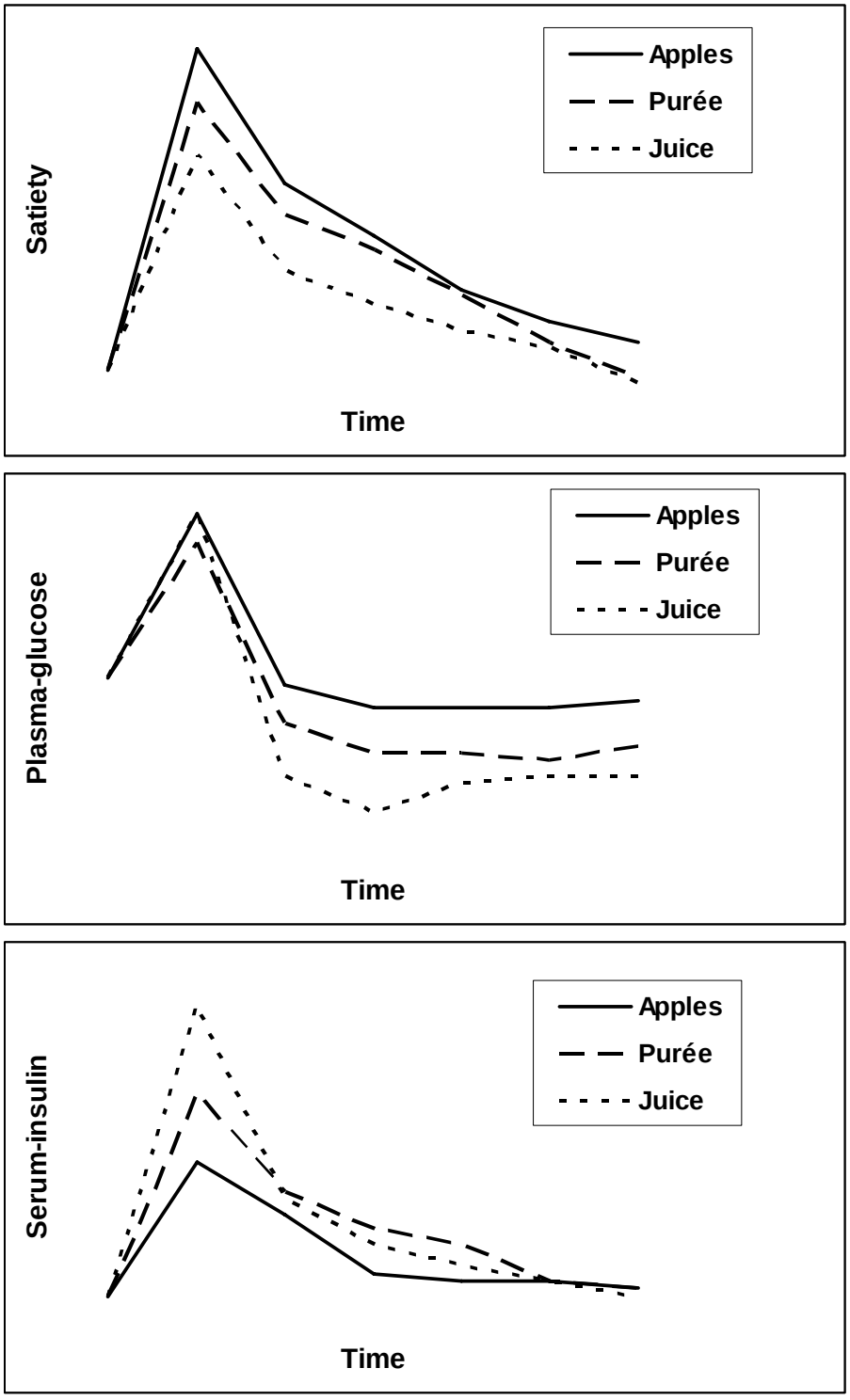

Fig. 1. Satiety, blood sugar (plasma-glucose) and serum-insulin before and after 3 test meals consisting of apples, apple purée and apple juice (mod. a. Haber et al., 1977).

GLYCAEMIC INDEX

The postprandial rise in blood glucose levels following ingestion of meals containing fixed amounts (usually 50 g) of available carbohydrates is measured as the area under the two-hour glucose response curve (AUC) and expressed as the glycaemic index (GI). The GI of fruits differs considerably with whole fruits like cherries, apples, and pears in the lower end of the GI scale (between 32-54 compared to white bread of 100) to the tropical fruits like oranges, bananas, mangos, kiwi and watermelon in the higher end of the GI scale (between 60-103) (Table 2).

Table 2. Glycaemic index (GI) for selected fruits and fruit products compared to white bread as the reference meal with GI of 100 (mean ± SD)[1].

Fruits and fruit products	GI
Cherries	32
Apples	52 ± 3
Apple juice	57 ± 2
Apples, dried	41 ± 7
Pears	54 ± 3
Oranges	60 ± 5
Orange juice	74 ± 4
Orange marmalade	69 ± 12
Bananas	74 ± 5
Mangos	73 ± 8
Kiwis	75 ± 8
Watermelon	103

[1]Source: Foster-Powell et al., 2002.

The relationship between GI and satiety is complex. Apart from the suggested role of insulin as a major player, low- and high-glycaemic carbohydrates may have an impact on satiety through their different time courses of hormonal responses. In an earlier review it was concluded that low-glycaemic carbohydrates appear to have a satiating effect over 2 to 3 hours whereas high-glycaemic carbohydrates are associated with a more immediate reduction in appetite and food intake in the short term (e.g. one hour) (Anderson and Woodend, 2003). This finding is important in relation to the possible role of fruit intake on appetite and subsequent food intake. The complexity may increase when the possible differences in responses between healthy subjects and overweight subjects are considered. In a recent study on different breakfast meals the role of blood glucose and insulin levels in short-term appetite sensation and subsequent energy intake in normal weight and overweight subjects was studies (Flint et al., 2007). It was found that only in healthy subjects, insulin, but not blood glucose, was associated with short-term appetite regulation whereas this relationship was disrupted in overweight and obese subjects (Flint et al., 2007).

DIETARY PATTERNS

Fruits may play a role in obesity prevention because they can add to the dietary variety between and within food groups and add palatability to the overall diet. Palatability has been shown to be an important predictor of body fatness (McCrory et al., 2000). Besides, several studies have shown that fruit intake is related to a distinctly different intake pattern compared to other foods. In a Dutch study on eating patterns, fruit intakes at morning, afternoon and evening snack times contributed substantially (more than 50%) to the total fruit intake and high fruit consumers were not necessary also high vegetable consumers (Kearney et al., 2001). In the same line as in other studies, a Danish intervention study targeted at

healthy adults showed that high fruit intakes were part of a 'Modern' diet (Lau et al., 2008). These examples are important as they leave substantial scope for dietary changes related to fruit intakes in the 'healthy' direction.

Several human prospective cohort studies investigating simultaneous changes in fruits and vegetables intake and degree of obesity suggest that an increase in fruit and vegetable consumption contributes to the reduction in the intake of other and especially energy-dense foods and thereby results in body weight maintenance and/or even prevents body weight gain (Hallund et al., 2007). In a recent worksite fruit intervention study undertaken as part of the ISAFRUIT project, the results showed that this may also be true when considering fruit intake alone. During the fruit intervention, the intervention group substituted more energy dense foods, rich in added sugar with the fruits provided (unpublished).

HUMAN STUDIES

Prospective Cohort Studies and Cross-Sectional Studies

Different types of human studies are available to study the possible association between dietary exposure and risk of disease. Prospective human cohort studies are studies where different exposure factors in the diet or in the general lifestyle that are hypothesized either to promote diseases or protect against them are assessed. Typically information is self-reported at baseline in a defined population (the cohort). The cohort is then followed forward in time until sufficient disease endpoints have accrued. Not all exposed subjects will develop the disease just as some unexposed subjects might develop the disease. The relative risk of developing the disease is estimated by comparing the disease incidence in the exposed group with the incidence in the unexposed group.

In cross-sectional studies data on exposure factors and outcome are assessed at a single point in time, preferably in a representative sample from the population. One of the limitations with this type of study is that it cannot be determined whether the exposure preceded the disease or vice versa.

In a review focusing on the epidemiological studies on fruit and vegetable intake and body weight, 15 cross-sectional studies and one prospective cohort study among adults were identified (Tohill et al., 2004). Five of the studies, all cross-sectional, had assessed fruit intake and weight status separately (Flood et al., 2002; Lin and Morrison, 2002; Liu et al., 2000; Serdula et al., 1996; Trudeau et al., 1998). Three studies, two of which including fruit juice in the fruit category, found an inverse association between fruit intake and body weight. Since then, several prospective cohort studies on fruit and/or fruit juice intake and changes in body weight among adults have been published. The overall findings suggest an inverse association in adults between consumption of whole fruit and body weight, while consumption of fruit juice seems to increase the risk for excess body weight gain. However, the evidence for this association is insufficient at present.

Prospective cohort studies on children and fruit and/or fruit juice intake are rather few and the majority from the US. In a US cohort of preschool children no significant relation was found between fruit intake and body weight changes after 1 yr follow-up (Newby et al., 2003). Another US cohort study of preschool children from low-income families showed that increased fruit juice intake was associated with excess adiposity gain among children who were initially either at risk for overweight or were overweight (Faith et al., 2006). Thus, this study supported the recommendation from the Institute of Medicine recommendations to reduce fruit juice intake as a strategy for overweight prevention in high-risk children (Fait et al., 2006). In an Australian prospective cohort study children were followed from mid-childhood into early adolescence. At the 5 yr follow-up, no association was found between intake of fruit juice with excess weight gain at the 5 yr follow-up (Tam et al., 2006). In a recent German study (the DONALD longitudinal study) consumption of beverages and body

weight were measured at baseline and at the 5 yr follow-up. Separate analyses of different groups of beverages revealed that for girls only, the intake of fruit juice was positively correlated with increases in excess body weight gain (Libuda et al., 2008).

Thus, prospective studies in children and adolescents about the role of fruit intakes and prevention of overweight and obesity are few and direct comparisons are difficult.

Intervention Studies

Intervention studies can roughly be divided into two types; they are either relatively long-term behavioural intervention studies where the subjects, often free-living individuals, are advised to make overall healthy changes in their lifestyles including their dietary habits, or they are clinical trials with strict dietary restrictions for a relatively short period. If designed properly, both types of studies are randomized and have a control group, which the intervention group can be compared to. Randomized, controlled intervention studies are one of the highest graded studies in the medical science (Harbour and Miller, 2001). This point of view is also adopted by the nutritional science.

A recent review of intervention studies examined the effect of increased fruit intake on body weight among adults (Rolls et al., 2004). The review identified two clinical trials and four behavioural intervention studies. In the clinical trials subjects received low energy-dense diets high in fruits and vegetables and low in fat. In the behavioural intervention studies subjects were advised to increase both their fruit and vegetable consumption. Results showed that subjects in the clinical trials reduced their body weight significantly, whereas the body weight of those in the behavioural intervention studies remained unchanged or even increased in one of the studies. However, subjects in the latter study also increased their intake of fruit juice. Moreover, fried potatoes, dried fruits, and tomato sauces were included in the fruit category.

For future intervention studies it is important to separate between fruits and vegetables and also to assess information on the types and preparation forms of fruits and vegetables. The short-term clinical trials suggest that increased fruit intake decreases body weight. However, it is not possible to determine whether body weight reduction is caused by the increased fruit intake or by the reduced fat intake. Furthermore, it cannot be confirmed whether the weight reduction will persist in the long-term. Additional long-term intervention studies considering the aforementioned criteria are needed before a firm conclusion can be made on the effect of fruit intake on body weight in adults.

In a recent review of the effectiveness of school intervention programmes to promote fruit and/or vegetables consumption, 30 studies that fulfilled the criteria of having a control group and at least a 3 months follow-up period were identified (de Sa and Lock, 2008). Seventy percent of the studies resulted in an increased consumption of fruits and vegetables. Twenty three studies had follow-up periods >1 yr and thus provide some evidence that fruit and vegetable schemes can have long-term impacts on consumption. However, only one study was identified that led to both increased fruit and vegetable intake and reduction in body weight (de Sa and Lock, 2008).

The European Pro Children Study, a school-based randomized controlled intervention study was carried out in Norway, Spain and The Netherlands where focus is on both fruit and vegetable (F&V) intakes (Te Velde et al., 2008). The intervention consisted of different components, among others the provision of fruits and vegetables (for free or as part of the school meals) and a special fruit break. The study showed that in the short term, school-based interventions are promising means especially to increase fruit intakes. In Norway where the intervention was best implemented, the intervention might also result in longer-term effects (Te Velde et al., 2008). Such long-term effects are needed in order to show any modifying effect on body weight status.

CONCLUSIONS

Consumption of fruits plays a vital role in the overall diet by providing diversity and palatability. Unprocessed fruit has a low energy density and relatively high dietary fibre content which overall has been shown to increase postprandial satiety and decrease subsequent hunger in normal weight subjects. Prospective human cohort studies in adults suggest an inverse association between fruit intake and body weight gain whereas the association – if any – with processed fruits is less definitive. Human intervention studies are often inconclusive as to the specific role of fruits in the prevention of overweight and obesity due to confounding effects of simultaneous changes in fruits and vegetables intake, the initial body weight and other lifestyle changes. The length of time over which most interventions are being conducted in both adults and children is too short to modify body weight status. Fruit intervention strategies targeted children and adolescents suggest a promising perspective that warrants further studies. Based on the present evidence it is concluded that fruit has a potential role in the prevention of overweight and obesity.

ACKNOWLEDGEMENTS

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Increasing the Consumption of Fruit & Vegetables by School Children: Which Role for the European Union?

Felix Mittermayer*
European Commission, DG Agriculture and Rural Development
Brussels
Belgium
Email: felix.mittermayer@ec.europa.eu

*The author is a staff member of the European Commission. Nevertheless, the opinions expressed in this paper represent solely his private point of view and can under no circumstances be attributed to the Commission.

Abstract

In June 2007, on request of the European Council, the European Commission (EC) General Directorate for Agriculture undertook to assess the impact of a European School Fruit Scheme (SFS) providing fruit & vegetables to school children. This was linked to the reform of the Common Market Organisation (CMO) fruit & vegetables which in response to the needs of the sector also addressed the stagnating fruit & vegetables consumption. However, contrary to other Commission policies of making food available to certain groups of society under preferential conditions, this policy incorporated from the start public health as an objective: In establishing an EU-wide network of NGO and scientific public health experts, the actual problem was defined. Project promoters in several Member states served as the source of experience-based know-how in the design and management of such schemes, mirroring the diversity of European eating habits and education systems. The outcome of this process, although not yet an approved legislative act, is a list of key elements forming the core of a new EC policy and in addition, a set of lessons learned for the stakeholders involved. Incorporating these experiences in future policies, will have a much wider and deeper effect on the way policies are designed and justified, than the actual policy of an EU-wide SFS regardless of which form it takes.

This paper is written from the perspective of a Commission staff member, working within the market unit and in charge among others of the dossier of promotion fruit & vegetables since May 2005; involved in the first attempt to launch the idea of a School Fruit Scheme (SFS) in June 2006 in the context of the CMO reform; following the Council declaration in June, the Inter-service Steering Group (ISG) for the Impact Assessment (IA) exercise was launched for which he served in the secretariat; contributing to the IA Final report, i.e., economic and social dimension, budget and administrative impact; establishing a network of experts which delivered the dimension on public health; due to his assignment as market analyst, active cooperation with the sector; active role in establishing the dedicated web page as part of the publicity activities and participation in a series of public events. Currently focusing on the elaboration of the implementing rules notably with a focus on administrative requirements and control obligations as well as networking activities.

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INTRODUCTION

This paper is focused on the policy design process defining a role for the European Union in the provision of fruit & vegetables to school children by a 'School Fruit Scheme' (SFS). Three main issues are being addressed: **what** are the reasons for this policy initiative;

which stakeholders are driving the process; and **how** will this policy be implemented. In conclusion, the role of the different institutions and key elements identified in the process is assessed, especially with a view to their role in future EU policy design and implementation.

This paper, therefore, does not aim at setting out the issue of poor nutrition with children but rather the policy process on-going within the EU and its stakeholders in defining and addressing the issue. It should, therefore, serve as an example for future policy initiatives in this and related areas, orientating the Common Agriculture Policy in a new direction, which directly responds not only to the agriculture sector needs but even more so, the concerns of the EU citizens.

POLICY ENVIRONMENT

The idea of enticing and educating children to eat healthy food is a logical consequence of the intention to feed children as such. Poor nutrition is a phenomenon which always has a quantitative and also a qualitative component. Providing food to children – as part of or outside regular school meals, that is – to avoid poor nutrition especially, but not exclusively, in urban and impoverished areas is a policy existing in various forms in many Member States of the European Union.

The European Union has been involved in this exercise within different policies over the years. However, given the fact that regular school meals remain within the exclusive competence of the Member States, the EU measures have been market-based, supply-sided and sector-focused as opposed to responding to the concern of the citizens and granting them the power to choose.

School Milk Programme

The most extensive application of this policy took place at the end of the 80s with the introduction of the **School Milk Programme**, funded by the EU. This initiative aimed at using excess stocks of milk due to community-policy induced over-production. It took over or replaced existing schemes in several member states. Upon the accession of new Member States, their programmes were integrated in the EU framework as well. However, the aim remained to "force-feed surplus milk fat to children" as one Commission Official put it so bluntly.

The scheme, revised in 2008[1], now aims to take nutritional and publicity elements into consideration, with simpler rules and covering all children, from nurseries to secondary schools. The EU scheme includes a wider range of dairy products, from traditional drinking milk to cheeses, including also certain plain or fruited fermented milk products, such as yoghurt. The Member States have the possibility to choose the products they wish to distribute, and for instance, pay particular attention to low-fat dairy products.

In the 2006/2007 school year, the equivalent of 305.000 tonnes of milk was distributed in schools in 22 Member States with the Community providing more than €50 Mio. With the new scheme, it is expected that in the future even more schools will participate, allowing and encouraging children to replace low-quality food and drinks with convenient, high-quality dairy products.

Deprived Person Scheme

This scheme has been in place since winter 1987, when intervention stocks were used as **food aid for the most deprived persons**. The only major amendment was made in 1995 to allow market purchases to supplement the dwindling stocks available from intervention and to permit a wider range of produce to be provided. Main recipients of this programme are

[1] Council regulation (EC) No 1234/2008 Art. 103 (Single Common Market Organisation).

non-governmental and charitable organisations, certified by Member States[2].

Following the recent developments on the agriculture world markets, which left intervention stocks empty due to rising demand, the Commission performed an Impact Assessment exercise in 2008 which examined several different options, from cancellation of the measure to adopting a voucher system to allowing market purchasing. The outcome, published in September 2008[3], taking into account the current debate on the social implications of rising food prices, and thus, the cost of living for Europe's poor, proposes to not only maintain but increase the measure by an additional EU contribution and extend the system on a more sustainable basis to provide food stuffs, independent of market developments or policies, to Europe's poor.

Market Withdrawals

Under the Common Market Organisation (CMO) 'fruit & vegetables' before the reform in 2007, there were two types of market withdrawals for **free distribution of fruit & vegetables** eligible to community support: a total of 16 main products were fully compensated by the EU while other fruit and vegetables were compensated through the Producer Organisations (POs) with EU co-financing.

In the reformed CMO[4], operational since begin 2008, market withdrawals can be compensated only within the activities of the POs, with 50% co-funding by the EU. Only those withdrawals for free distribution are financed at 100% by the Community. Transport, sorting and packing costs for free distribution will continue to be fully supported by the EU, covering also those under the POs activities.

The measure itself depends largely on a well-organised sector of big and efficient PO as well as an adequate structure of recipient institutions, mostly NGO.

As an overall assessment of the current state-of-play, putting the above analyses into perspective, the 2008 situation for other AGRI policies is as follows.

Scheme	Number of participating Member States	Number of beneficiaries (in millions)	EU budget (in € Mio)
Most deprived persons	19	13.4	305.1
School Milk	22	16.5*	50.7
Market withdrawals	7*	n.a.	22

*estimate only

All three measures reflect the need for CAP based policies to better take into account the increasing importance of health within the CAP, the necessity to work closely with other sectors (education) and stakeholders (civil society), and also, to aim at minimising the administrative burden for Member States and recipients alike.

ISSUE AT STAKE

The introduction of Public Health in community policies dates back to the Treaty of Amsterdam. According to its Article 152, a 'high level of human health protection shall be ensured in the definition and implementation of all community policies and activities', which includes the CAP.

[2] For the current valid list see: http://ec.europa.eu/agriculture/markets/fruitveg/liste.pdf.

[3] Deprived persons IA Final report COM(2008)563.

[4] Council regulation (EC) No 1234/2008 (Single Common Market Organisation).

Stagnating Consumption

During the discussion of the reform of the Common Market Organisation (CMO) 'Fruit & Vegetables', the issue of stagnating consumption was a major issue. It was addressed two-fold:

- Increasing the **funds for promoting agriculture products** from €6 Mio to €12 Mio: Currently, the fruit & vegetables sector already receives the major part of the EU funds under the promotion programmes for agriculture products on the internal and external market (regulation 3/2008). But due to the heavy administrative requirements with many obligations (multi-country participants) and the lengthy procedure (call for project in member states, approval of selected projects by Commission), the pick-up rate is rather low.
- Increasing the co-financing rate of **promotion activities** targeted at young consumers from 50-60%: This measure is likely to increase such activities in those Member states where the sector is already able and willing to manage such activities. But it most probably will do little to initiative such programmes where the sector has not yet become active.

Just as with the existing food-distribution policies, the Commission remained cautious in the fruit & vegetables sector, choosing a conventional and purely supply-sided approach. This means the citizens are getting what the sector wants and not vice versa.

In June 2006, a first initiative from within the Commission services itself was rejected under the pretext that any direct involvement of the Commission in managing any such intervention programme involved incalculable risks with regards to the proper handling of EU funds.

The background of this approach was of course the example of the School Milk Programme, with limited appeal in several Member States and haunted by severe criticism on its implementation rules, lack of publicity, missing assessment data and in addition, for providing unhealthy food to children.

This rejection of the initial idea, however, did not stop the efforts of the very same services – actively supported by the sector and NGOs – to pursue on an informal basis the possibilities for an EU initiative, drawing on the lessons learned from existing intervention programmes, most notably School Milk Programme. Also, communication and promotion activities were scrutinised in order to gain a deeper understanding on how – if ever – a School Fruit Scheme could be implemented.

At the same time, a certain change of attitude could be registered within the agriculture sector; contrary to the previous reform in 1995/96, when the sector did not embrace the idea of a scheme to distribute fruit & vegetables to school children, this time both material and immaterial support was mobilised right from the start. One reason might be that since the mid-nineties, the declining trend in the consumption of fruit & vegetables has steadily progressed (Fig. 1).

An additional factor herein is the obvious impact of the media, most of all the lack of advertising pressure of the sector as opposed to the power of the beverage and junk food producers[5].

Consequently, the sector supported the initiative from the start, such as in organising a pre-conference briefing in the European Parliament before EGEA. Bringing together scientists and promoters from EU27, but also, witnesses from other countries (USA 'School Fruit & Vegetables Snack Programme'), this meeting demonstrated to the Commission Officials present the issue so clearly, that it has since been called the 'kick-off event'.

[5] Estimations say, that on every € spend by Government on promoting healthy food, the industry spend €100 on all types of fast food, soft drinks and fast food restaurants (Tim Lobstein IOTF, EGEA conference 2007).

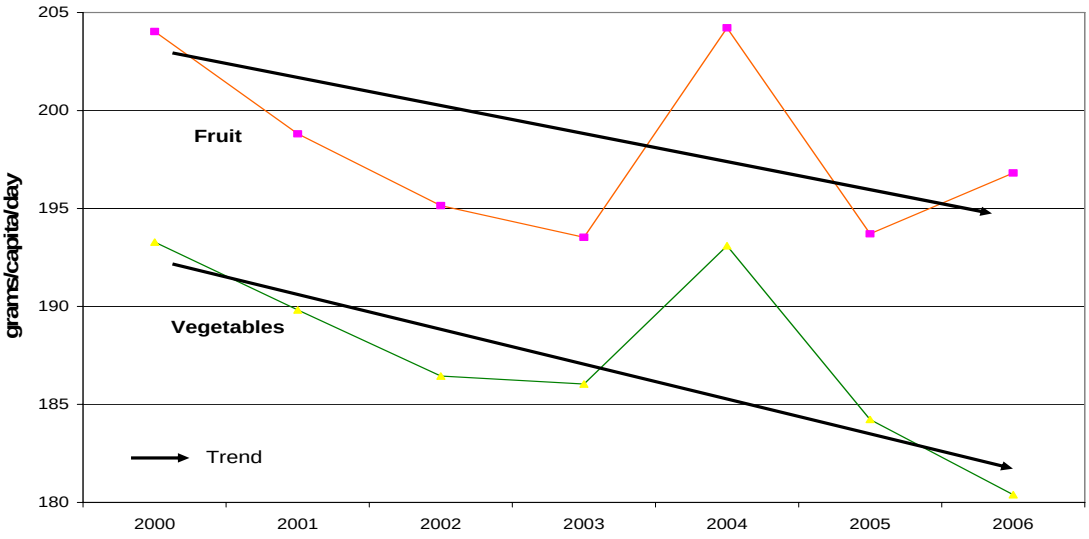

Fig. 1. Consumption trends in EU27. Source: EUROSTAT 2007.

Poor Nutrition

At the same time, the Commissions services for Public Health and Consumer Protection (DG SANCO) have continuously addressed the issue of obesity, poor nutrition and physical activity.

First, the 'EU Platform on Diet, Physical Activity and Health', an inter-sector body bringing together stakeholders from all sectors concerned, based on voluntary obligations was established under Commission chairmanship. Then, in May 2007, the Commissions White paper[6] on 'Obesity and related issues' raised the issue of an EU-wide SFS; participating in the consultation and assessment process, AGRI succeeded in introducing that a 'School Fruit Scheme is a step in the right direction' into the final report. Nevertheless, the exercise failed to create crucial support, both within and outside the institutions for direct action.

The need for action becomes the most evident indicator – apart from the number of obese and overweight children – by regarding the consumption of fruit & vegetables, however, roughly estimated (Fig. 2).

The direct involvement of AGRI in this SANCO policy-design process had a major side effect; it brought AGRI in contact with the respective scientific community and public health NGOs, especially with their view on the CAP's impact on public health. One of the most important documents in this context is the FAO/WHO joint report (2003) on the scope of obesity and poor nutrition[7] and the subsequent WHO strategy papers[8]. At the same time this process demonstrated the need for concrete action, with an active involvement of the Member states and also the fact, that public health expertise is not available in the Commission.

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[6] European Commission 2007. White Paper on 'Nutrition, Overweight and Obesity', 2007.

[7] FAO/WHO 2003. Diet, Nutrition and the Prevention of Chronic Diseases. Report of a Joint WHO/FAO Expert Consultation, FAO/WHO, Geneva.

[8] WHO 2007. The challenge of obesity in the WHO European Region and the strategies for response, WHO, Copenhagen.

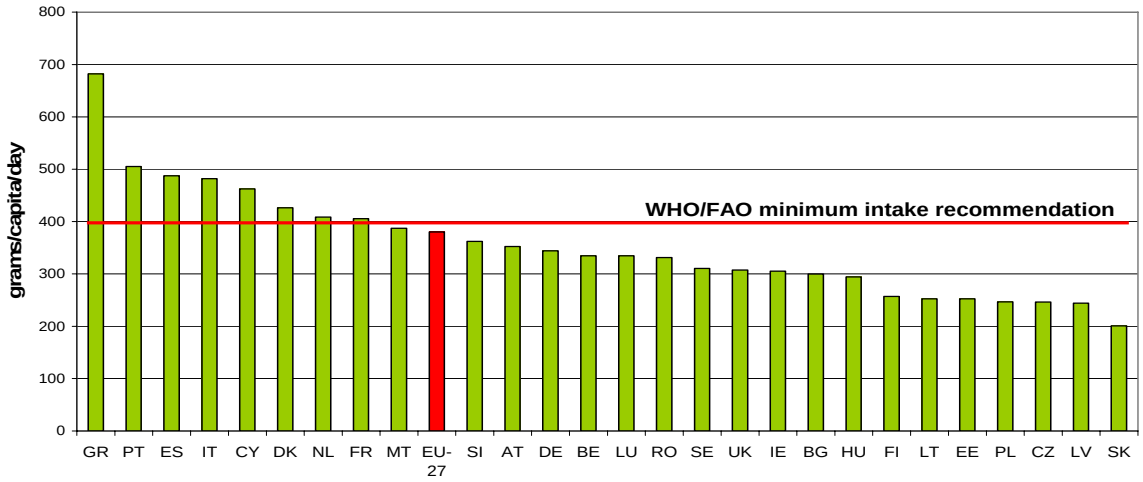


Fig. 2. Consumption of fruit & vegetables in EU27 Member States. Source: DG AGRI/C.2 estimates elaborated on basis of WHO and FRESHFEL data, 2007.

So when in May 2007 the final discussion of the EU fruit & vegetables sectors reform came slowly to an end, the initiative of Denmark in the Council to ask for a 'School Fruit Scheme based on the same principles as the School Milk programme' ran in open doors within certain elements of the Commission services.

STAKEHOLDERS ROLE

As a first step, Commission services acted upon the main knowledge deficits identified: first, a lack of know-how on public health and its link with agriculture; second, to draw on the experiences in managing such a scheme successfully in as many Member States possible; and thirdly, mobilising support within agriculture but also linked sectors and the general public in making these policy a reality. The major stakeholders in the policy design process were also identified.

NGO and Scientific Community

The first step was to establish a network of experts outside the Commission to provide scientific and public health related advice, which as the SANCO exercise of the 'White paper' had demonstrated, did not exist within Commission services. This was undertaken following the EGEA conference on fruit & vegetables in Brussels in April 2007[9].

Second, in order to informally mobilise support outside the Commission services for this initiative as well as providing first-hand experience in SFS management, a network of NGO and sector partners was established. The first obvious result was the expert hearing in September 2007 and the subsequent continuous consultation process.

However, this close cooperation also brought to light the difficulties in bringing scientific evidence into quantifiable terms for arguing the necessity of a certain policy. Three issues of crucial importance can be identified in this context which has to be based on quantifiable facts and figures:

[9] In 2008, this event published a declaration stating that "*we urge the EU and all national Governments to move forward quickly to fund and implement School Fruit Schemes*".

1. Participation in a School Fruit Scheme, whichever approach chosen in detail, increases consumption of fruit & vegetables by school children;
2. Such an increase leads directly to a decreased risk of chronic disease;
3. These lower health risks together with a sustainable increase in fruit & vegetables consumption amount to substantial savings of public spending as compared to the funds necessary for such an SFS.

Figure 3 documents an effort to demonstrate the effectiveness of SFS based on various information from academic studies and on-going SFS.

In conclusion, this model suggests that for €156 Mio invested an estimated €4 Bio in increased market value and reduced health costs can be expected per year.

The model was elaborated within the internal discussion process in the Commission and although the underlying estimations and assumptions are reflecting probabilities rather than reality, it does provide evidence that the potential gains of an EU-wide SFS by far outnumber the finances necessary to implement it.

For the purpose of this paper, it also demonstrates a basic problem administrators in the Commission are facing: quantifying the impact of a policy on such a complex matter as human health and well-being. Here, requirements from within the policy design process and subsequently, the decisions makers collide with the impossibilities to put a price tag on probabilities and long-term behavioural changes.

Irrespective of the limitations encountered in translating complex scientific information into input for the legislative process, the advice provided by the network of experts remained crucial. Since its start in April 2007, it was continuously expanding to include representatives of the scientific community and public health NGOs[10]. Their input was decisive in two respects:

First, they provided AGRI with unique know-how, thus resolving the issue of technical competence from the very start. No challenge was ever launched at AGRI on this basis.

Second, opening the agriculture-focused policy area to public health increased the dialogue within the stakeholders themselves, raised public awareness especially in Member States institutions and in consequence created a sustained interest of other players in the process, such as the European Parliament, Community research and development programmes and other donors.

The main lessons for AGRI of this first structured encounter with the public health sector lead to the definition of the problem at hand and even more so, the possible role of AGRI itself:

- Poor nutrition is a European-wide problem which needs a European solution;
- The EU should act as catalyst and facilitator, involving all stakeholders across the EU Member States and institutions, helping to develop and implement appropriate policies;
- An EU programme would promote social equity at EU level and also, avoid distortion of the market by individual Member States actions;
- Free distribution is a key element in order to reduce social inequalities in fruit and vegetable consumption;
- The EU should use this opportunity to address an issue of immediate concerns to its citizens and thus demonstrates its closeness to its citizens.

In summary, the fruit & vegetables sector as well as public health experts demanded both an active role of AGRI in promoting increased consumption of healthy foodstuffs.

[10] A selection of the most prominent contributions is included in the bibliography.

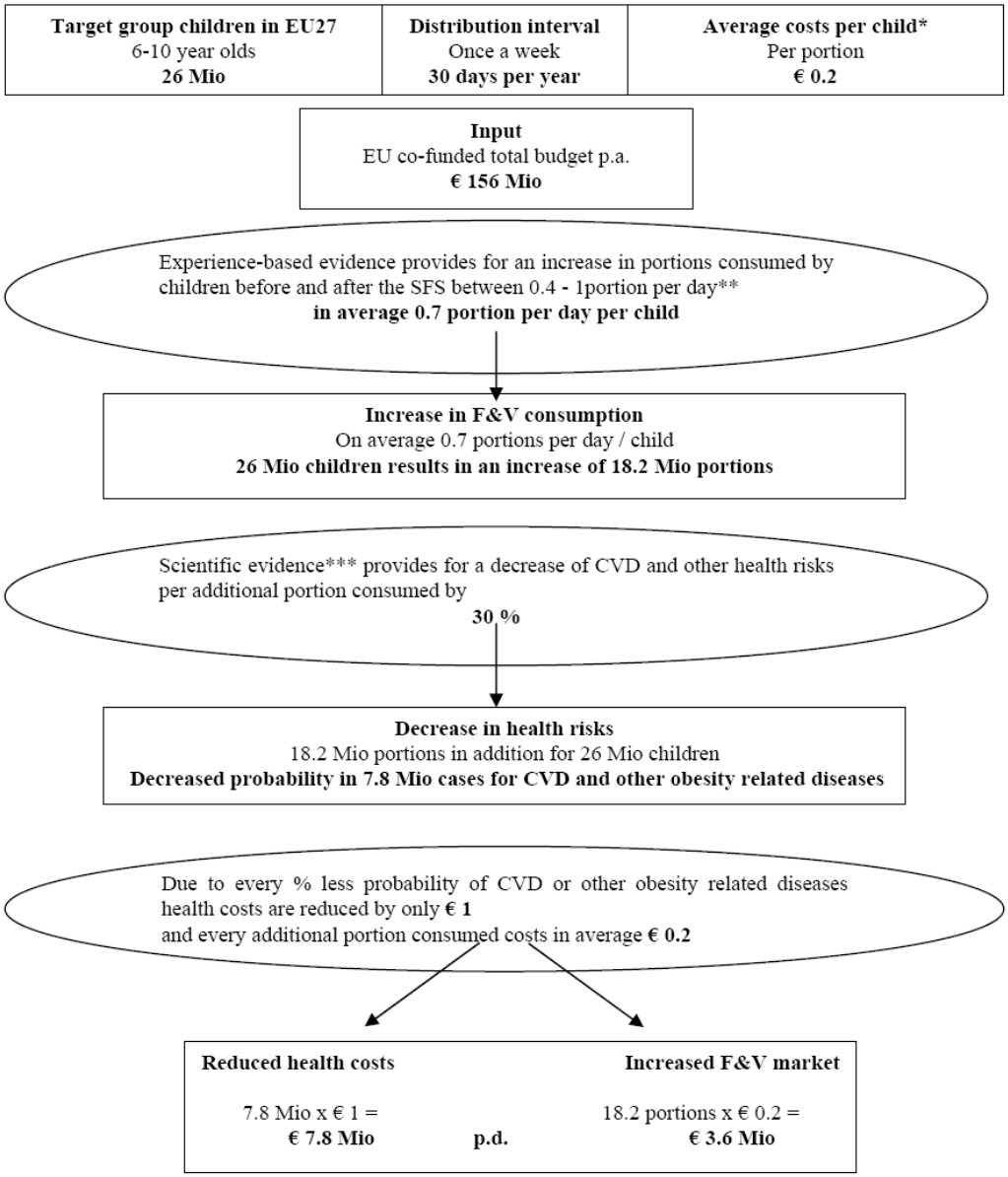


Fig. 3. Effectiveness of SFS based on various information from academic studies and on-going SFS.

*Experience-based evidence originates from the SFS in DK, IE and UK demonstrating a cost of €0.15 to €0.64 per portion.

**Experience-based evidence originates from the SFS in DK, IE and UK and provides for an increase in portions consumed by children before and after (one to two years) the SFS between 0.4 and 1.1 portions per day per child.

***Bazzano, L.A., He, J., Ogden, L.G., Loria, C.M., Vupputuri, S., Myers, L. and Whelton, P.K. 2002. Fruit and vegetable intake and risk of cardiovascular disease in US adults: the first national health and nutrition examination survey epidemiologic follow-up study. The American J. of clinical nutrition; and Lock, K., Pomerleau, J., Causer, L. and McKee, M. 2005. Low fruit and vegetable intake. p.597-728. In: M. Ezzati et al. (eds.), Comparative quantification of health risks: global and regional burden of diseases due to selected major risk factors, WHO, Geneva.

Member States and Project Promoters

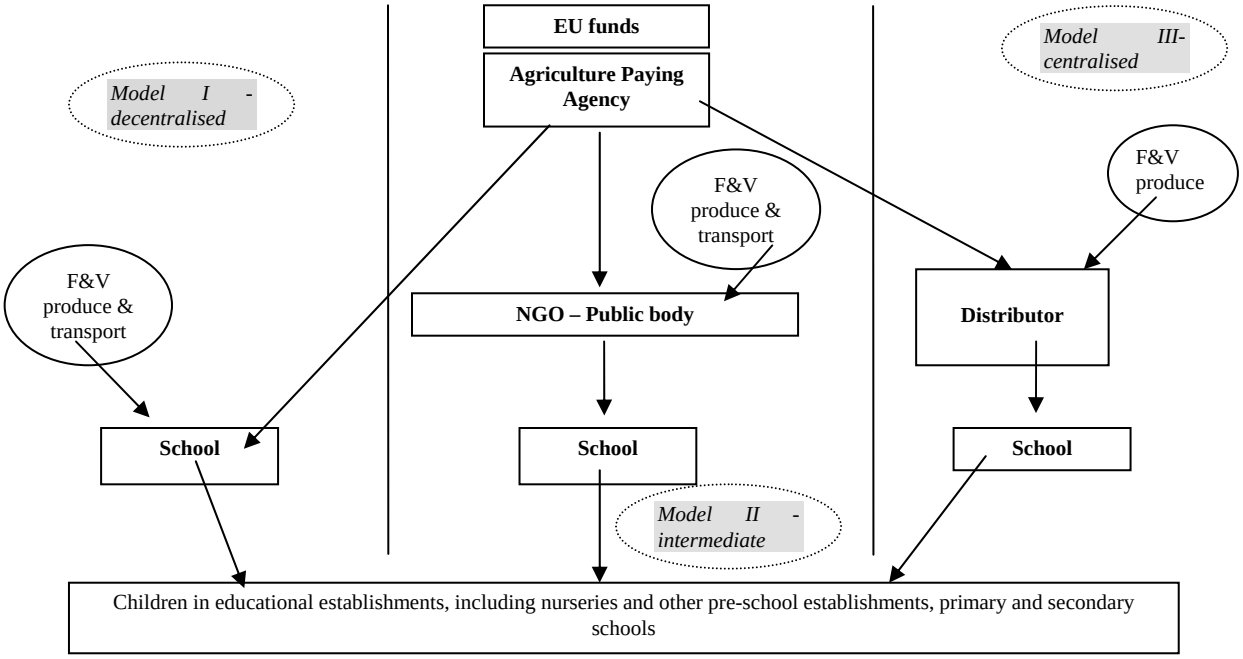
Parallel, Member States already active in School Fruit schemes were contacted and systematically visited to identify the reasoning and the instruments of their schemes. Not surprisingly, the rich diversity of European culture in food, agriculture, education and public health is reflected in the multitude of approaches in School Fruit Schemes. In order to achieve long term sustainable changes in behaviour these have to be positive reinforced not forcefully changed.

An analysis of the existing models revealed three basic approaches:

	Enticement	Kick-Start	Provision
Aim	Exposing children in a very brief period (17 days) to a maximum of fruit & vegetables and healthy diet related information.	Providing children over the period of several (four to eight) weeks as part of a comprehensive program with information, education and fruit & vegetables.	Free distribution of fruit & vegetables to children in all public schools over a full school year, to be consumed during school breaks.
Approach	Close cooperation with education and health sector providing information to children and parents and training to teachers, free distribution of fruit & vegetables.	Close cooperation with education and health sector, focusing also on parents and teachers and agriculture by local sourcing and site visits.	Initial information provided and information packs for every school year but no accompanying measures and no inter-sector integration.
Costs	Small quantity provided in a short period of time, thus the costs per child are high but overall costs are low, including a major budget allocation for accompanying measures.	Due to the possibility to time the program in a season when local production provides for cheap and easily available fruit & vegetables, costs are not high.	Low costs on the amount per portion due to economics of scale but high overall costs (180 to 200 school days), multi-annual contracts allow for sector to plan ahead.
Follow-up	Children are encouraged by small gifts to bring fruit & vegetables to school as part of their normal diet.	Children are encouraged to bring fruit & vegetables as part of their school lunch.	Systematic external evaluation of the impact on children's fruit & vegetables consumption.
Member State	'Food Dudes', Ireland	'Fruit break', Denmark	'School Fruit & Vegetables Scheme', England

Much the same applies to the management models. Again, reflecting Member states particularities, ranging from federal to centralist states, from degree of involvement of the agriculture sector, importance of environmental concerns to the contribution of the education sector and the health authority's definition of healthy products.

Subsequently, the actual model of distribution can be defined as (I) decentralised, (II) intermediate and (III) centralised (from left to right) model:



The main lessons for AGRI in this permanent dialogue, reinforced by several missions and participation in events lead to the definition of the key issues in designing an SFS and even more so, in the actual implementation:

- A European framework should provide for level playing ground for the sector in all Member states;
- It should allow for maximum flexibility in implementation, in respect of the Member States competence in education, and also, public health;
- A multi-annual approach should provide for the necessary long-term approach to achieve sustainable results as adopting healthy habits is a long term issue;
- The target group has to be defined only in general on EU level, the details being left to Member states with respect to the various school systems;
- Parental contribution should not be ruled out, ensuring sustainability and parents support;
- Type of product should be left to Member States reflecting habits and traditions as well seasonality of produce available;
- Flexible approach to co-financing is preferred taking into consideration funds already in place for on-going schemes but insisting on additional activities in relation to EU funds received;
- All real costs should be eligible for co-funding including logistics, control, etc.
- The focus should lay on health promotion and education rather than expecting health effects – that should come from the spill over effect;

The majority of Member States proved to be favourable towards an EU-wide SFS. However, strong resentments based on previous experience with AGRI policies in regards to lack of consideration for the administrative burden implied by several (also recent) activities could be registered.

POLICY DESIGN AND IMPLEMENTATION

The elaboration of the policy by AGRI was based on all three sources: existing (and currently reformed) polices within AGRI (School Milk, deprived persons, market withdrawals) were analysed in order to provide for guidelines, including audit and evaluation reports. The actual problem definition originates from the public health sector and the academic community. And of course, the target group itself was actively involved, i.e., Member States on-going SFS.

Policy Design

In the Commission proposal for the School Fruit Scheme legislative framework, the above defined key issues have to be addressed in a way accommodating the needs as identified by the scientific community and public health sector with the Member States political and administrative requirements as well as the objective of the CAP, the legal basis of the policy and the source of its funding. Main elements are:

The **allocation key** of EU funds is based on the model used for deprived person's scheme, allowing for maximum transparency and easy reallocation of unclaimed funds between Member States before programme implementation. Some substantial changes include the fact that children not products are the calculation basis and co-financing keys have been calculated according to convergence regions (regional level within individual Member states).

Drawing from the negative example of School Milk, with its lack of visibility of EU funding (until recent revision), the obligatory **communication** of EU funding in any Member state initiative is foreseen.

Referring to the principles of EU-regional intervention programmes, the **programming** (definition of a multi-annual approach with target group, measures and accompanying measures identified) and the **partnership principle** (multi-stakeholder approach and integration of the sector) are implemented by the obligatory elaboration of a 'Strategy' by each Member State wishing to participate in the scheme. The **additional principle**, however, is limited to activities only, otherwise penalising those Member States already active by requiring them to allocate even more national funds.

Drawing from rural development programmes, **monitoring and evaluation** as integral part of any EU-funded scheme, both on the national level as well as by a Commission managed horizontal evaluation is foreseen. To allow for operational input for this meta-evaluation (include in the legislative act as a report to be submitted to the relevant EU institutions after three years of SFS running time), minimum criteria should be established for Member States;

Drawing from the sectors input and the experience in various Member States programmes, total costs are reimbursed for the **produce including logistics costs** (for which an estimated share of 30% is foreseen). This reflects the reality in the sector, where these costs make up a substantial part of the final costs of fruit & vegetables.

Regarding Member States **distribution models**, all three described have to be allowed, however, with a common set of key control and reporting requirements. The aim of the respective Commission rule will be to define as little as possible control points but enough to ensure the proper handling of EU funds. Notably to define schools, not children as final beneficiaries is an aim in this respect, thus avoiding cases of EU controllers checking on school children's lunch boxes.

Reflecting the political-administrative (federal and centralised) reality in Member States, **regionalisation** which means the creation of schemes on sub-national level is also possible. This mirrors the fact that convergence regions with higher degree of Community co-funding are defined on the sub-national level. However, the submission of a strategy remains obligatory for every such scheme within of course the wider framework of the Members States 'National strategy'. Details on distribution of funding as well as of the other SFS core elements to be covered in national respectively regional level remain to be clarified.

In order to make the scheme even more effective, funds of Member States not wishing to participate will be distributed to those participating. This **reallocation** of funds, however, will take place before the respective school year starts and not during. And it certainly will not preclude the next year's allocation, which remains principally reserved to every member states according to the distribution key.

Policy Implementation

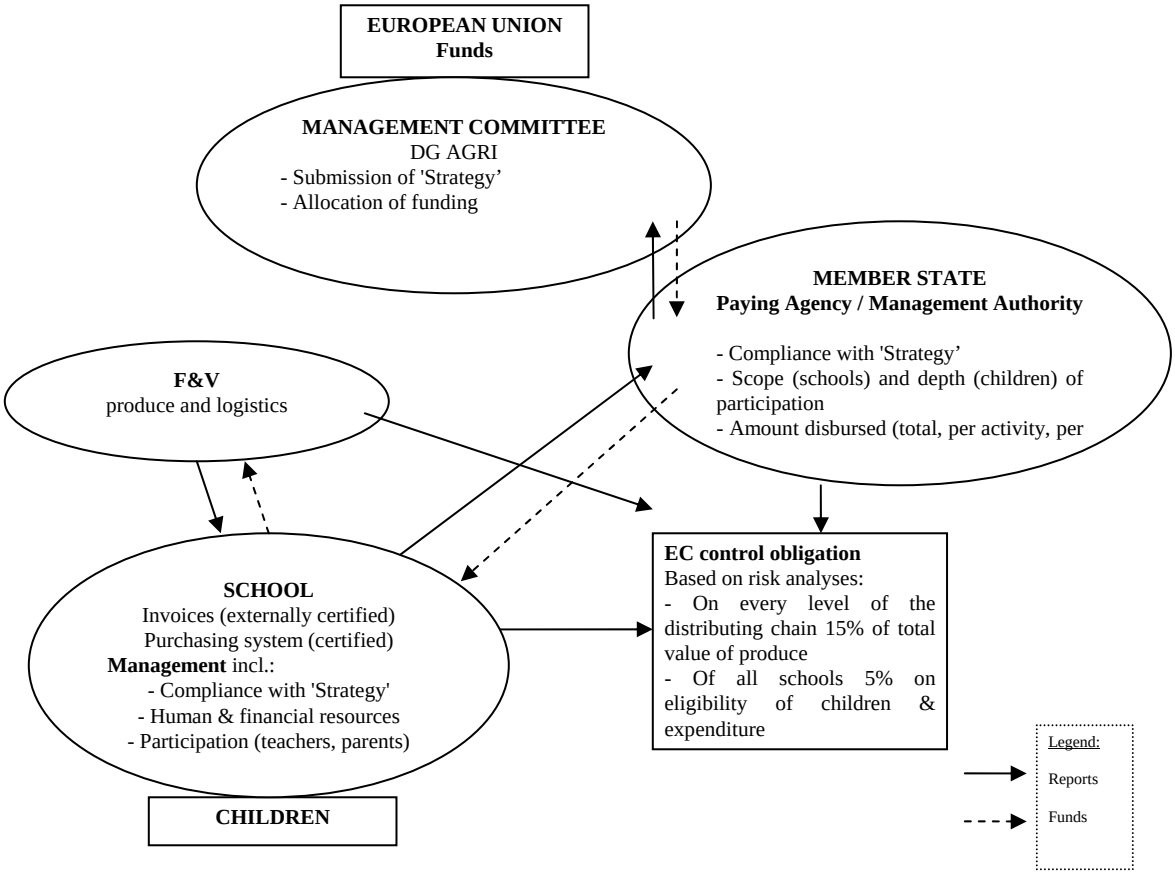
Logically following the design of policy is the issue of actual establishing and managing such a scheme in a Member State. This comprises first of all the requirements to draw down Community funds, fulfilling the necessary preconditions. Secondly, it is necessary to live up to the obligations imposed by financial rules safeguarding the financial interest of the Community. And thirdly, to communicate to the wider target group, parents and teachers as well as the interested public the objective and scope of the initiative. Finally, to ensure continuous improvement by analysing and assessing on-going Member States schemes.

In realisation of the programming principle, Member States are requested to submit a **Strategy** to the Commission, which outlines the key elements of the respective program. This document in the form of simple checklist (details are being elaborated in close cooperation with project promoters) is to provide an overview on the financial basis (Community, Member states and private funds), set out the duration (three years), define the number of schools and children within the respective target group, comprise the list of eligible produce, name a single contact point (in charge of regular reporting obligations), establish the distribution model (including control points) and describe the funding, instruments and objectives of the accompanying measures.

Based on the experiences in on-going SFS and scientific evidence, the obligatory **integration of health and education sector** is foreseen, as defined by the partnership principle, and in practice, in the respective national/regional strategy. This entails the approval of the list of eligible produce by the competent health authorities as well as the integration of an SFS into the standard school curriculum.

A specific issue is the **choice of produce**. The example of the US 'School Fruit & Vegetables Snack Program' (SFVSP) launched within the recent Farm Bill, granting exclusive access of domestic produce to such a scheme has been found to be compatible with WTO obligations. However, within the EU27 any limitation would risk to have counterproductive effects on the prices, the variety and the general objective of the scheme. It is therefore enough to leave the freedom of choice of eligible produce to Member States, taking into consideration environmental and social concerns as well as availability and seasonality of produce and thus, allowing for the exclusive purchasing of organic or local produce, for instance, without imposing general applicable restrictions.

A major issue for the success of any Community policy are **audit and control** requirements. These are necessary to provide for proof of proper handling of Community funds. However, if designed too heavy-handed, they might make management so demanding that Member States do not join the scheme.



Reflecting the approach chosen in designing the SFS, **communication and information** form an integrative part of implementation too.

First, information to all stakeholders in the scheme itself, like parents and teachers, form intrinsically part of any SFS. This concerns objective and scope of the SFS, participation, accompanying measures and follow-up (including a possible parental contribution if Member States so decide). An important element herein is to address food safety concerns, such as in providing information on the strict adherence of all distributed produce with EU legislation.

Second, communication with the interested public provides for multiplier effect and transparency in the spending of public funds as well as crucial support in extending the duration or event the funding of the SFS in the future.

Third, integration of Member States by using peer pressure in the regular meetings of the Member States with Commission services to present selected Member States programmes as an example, and thus, foster comparison between schemes. Also, by the publication of 'National Strategy' of Member States on the web in order for interested public to assess their own authorities activities in relation to other Member States.

In addition, Commission services will continue to play an active role in SFS communication: a separate budget line has been made available to AGRI to pursue **networking activities**. These are directly managed by the Commission and will fund activities on three levels.

First, an annual conference, following the example of the conference organised in December 2008 in Brussels with existing Commission funds[11] will be organised in cooperation with partner organisations.

Second, building on the current web page, established within the limited capacities of AGRI, an interactive Internet portal is to be established, largely drawing on the results of the conference, comprising a database of projects, experts, case studies, contact addresses and other tools to provide input to project promoters.

Third, a series of regional seminars in Member States wishing to gain access to experiences on how to establish and manage a SFS, and thus, encourage the establishment of SFS in as many Member States as possible. This programme could start in early 2009.

And finally, continuing presence of Commission staff at agriculture and public health events to join the dialogue and disseminate information to the interested public and project promoters.

CONCLUSIONS

The focus of the final part of this paper is on the lessons learned in the process for the different stakeholders and the perspectives for the future, specifically in designing new policy initiatives on EU level within a reformed agriculture policy.

Key issues for policy design and implementation:

- **Common Agriculture Policy** to take on board the broad issue of public health as a new objective much as what has happened with environmental aims in the series of CAP reforms leading to cross compliance and special rural development programmes;
- **Demand-driven policy** introduced in CAP market measures granting citizens/consumers the right of choice of produce rather than dumping surplus production on the market;
- **Partnership** with public health and education sector institutionalised as part of the schemes on Member States in accordance with the respective Member States rules and regulations;
- **Programming** principle for providing sustainability in financial and institutional terms allowing for a long term approach in achieving sustainable impact;
- **'Mid-term assessment'** in the form of a Commission report, drawing on a meta-evaluation of the results of Member States evaluations which in turn form an integral part of each scheme;

Main lessons for stakeholders:

- **Member States:** Early involvement in the policy process through direct contact to bring in 'end users' point-of-view in the design of a policy thus integrating administrative requirements in implementation mechanisms;
- **Commission:** Taking public and sector consultations seriously by providing for adequate staff support to deal with requirements of networking, maintain open network, throughout the design and implementation of policy allowing for input and feedback, no hesitation to draw on outside expertise, while balancing the sources;
- **NGO:** Public health as an possible new objective within CAP offers chances for the post-2013 period, building on the only recently established position by provision of input and transparency, offering reliability and a link to non-agriculture groups of society and experts as an asset;
- **European Parliament:** Non-binding role in consultation process reduces actual impact but role in introducing and maintaining public pressure on policy design crucial, especially with a view to the need for more legitimacy for CAP in post-2013 process.

[11] Details can be found on www.aimgroup.eu/2008/schoolfruitschemes.

With a view to the recent quite dramatic events on world agriculture markets, it seems safe to assume that the next Community financial period and linked CAP approach will offer the possibility for deep-reaching changes. Based on the experience of the yet-unfinished 'School Fruit Scheme' exercise of policy design, this should offer the chance to further enhance public health as an objective of agriculture policy as well as active involvement of all stakeholders an essential tool in policy design.

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ISAFRUIT and the ISHS Commission on Fruits and Vegetables and Health: Converging Pathways to Improve Human Health

Yves Desjardins, Ph. D., Agr.
Chair CFVH, ISHS
Institute of Nutraceutical and Functional Foods/Horticulture Research Center
Laval University, Québec City, Québec, G1V 0A6
Canada

Recently, fruits and vegetables (FAVs) have been associated with protective or preventive effects against many human chronic diseases. Indeed, many epidemiological studies have demonstrated the benefits of FAVs on health (Van't Veer et al., 2000; Trichopoulou et al., 2003). The World Health Organization has recognized this fact and actively promotes the consumption of FAVs to reduce the incidence of chronic diseases (FAO/WHO, 2004). It is now recognized that bioactive compounds in FAVs have positive effects against cardiovascular diseases (Griffiths et al., 2002; Kris-Etherton et al., 2002), diabetes (Williams et al., 1999; James et al., 2004), and obesity (Rolls et al., 2004). However, the evidence for this effect is not as solid for neurodegenerative diseases (Singh and Ramassamy, 2008) or cancer (Fund, 2007). Many of the studies published over the last 15 years have focused on the identification and demonstration of the activity of bioactive compounds in FAVs in vitro. The majority of studies linking FAVs intake to health continue to be observational and data are often conflicting. Indeed, the responses of humans to the food they consume are complex and influenced by many factors. The nature and type of food, the way it is grown, processed and eaten impact on its assimilation and by extension the effect it has on health. Collaboration and inter-discipline studies are definitely needed to come up with comprehensive recommendations about the health benefits of FAVs.

Fig. 1. Fruits and vegetables are associated with protective or preventive effects against many human chronic diseases and, many epidemiological studies have demonstrated their benefits of on health.

The ISAFRUIT project and a number of initiatives of the International Society for Horticultural Sciences (ISHS) are notable examples of such comprehensive approaches to tackle the complex topic of human health improvement through nutrition and especially through the consumption of fruits and vegetables. While ISAFRUIT is using apples as a case study to demonstrate the benefits of this fruit to health, ISHS is fast becoming a hub for scientists from around the world working on health effects of FAVs. We will thus briefly expose why an integrated and collaborative approach is needed to study the health effects of FAVs, and how ISAFRUIT and ISHS share common goals and should work together to answer some of the burning questions in the field.

ISHS: A HUB FOR SCIENCE ON HEALTH AND WELL-BEING

ISHS is a thriving scientific society which strives "to promote and to encourage research in all branches of horticulture and to facilitate cooperation of scientific activities and knowledge transfer on a global scale by means of its publications, events and scientific structure". The Society has more than 7000 individual members from all over the world and 49 Country members. Through the years it has become a major source of up-to-date information on global horticultural research and increasingly on human health and well-being. It provides, through meetings and publications, both context and ongoing support for professional decision-making. For example, 2008 will see more than 45 symposia and activities like this meeting of the European Economic and Social Committee – Increasing Fruit Consumption to Improve Health – organized under the auspices of ISHS and leading to the publication of an equivalent number of conference proceedings published in *Acta Horticulturae* or *Scripta Horticulturae*. More than 800 volumes of *Acta* have already been published and are accessible on line from the ISHS web site. This constitutes a wealth of information of more than 40,000 articles available at minimal cost. The popularity of this database is evidenced by more than 28,000 page views per day.

Health and well-being of the world population is a leitmotiv of the Board of ISHS. In this context, many new initiatives have been implemented to improve health of populations in both developed and developing countries. For example, the ISHS 'Outreach program' seeks to have more professionals from developing countries participate in the Society's activities, and fosters the development of horticultural technologies and programs to increase economic opportunities and food security for the poor. Moreover, and in the same line of thought, the Society has created a new Commission on Fruits and Vegetables and Health to bring together the different disciplines working in this area and to create a hub for information and activities relating to production, processing, recommendation and validation of the health functionality of FAVs. The activities are mainly channeled in the flagship event, FAVHEALTH, the International Symposium on Health Effects of Fruits and Vegetables held every second year. It also seeks to provide information exchange opportunities between research groups and institutions in the field. Through the publication of position papers, it wishes to provide unbiased information to professionals in the field and alert decision makers to the importance of FAVs consumption as a means of improving public health and reducing the burden of chronic diseases. In this sense it is highly complementary to the activities of ISAFRUIT.

FAVs AND THE BURDEN OF CHRONIC DISEASES

A huge body of evidence indicates that our current lifestyle, which includes smoking, low physical activity and poor diet, has a major influence on our health. The WHO global report entitled 'Preventing Chronic Diseases: A Vital Investment' (WHO, 2007), informs us that 60% of all death on the globe are due to chronic disease and that 80% of these deaths occur in low and low-middle income countries. Shockingly, a large proportion of these casualties could be avoided by simply adopting a healthier lifestyle. Indeed, a recent paper by

Khaw et al. (2007) evaluated the impact of behavioral factors to health and clearly demonstrated that adopting a healthy lifestyle could improve life expectancy of a population by 14 years. It can also reduce the incidence of diabetes by 80% and cancers by 40% (FAO/WHO, 2004). Nutrition is probably the most important single component affecting the health status of the population; diet has long been linked to the development of chronic diseases (WHO Technical Report Series 916, 2003) and dietary modifications are one of the cornerstones of chronic disease prevention. There is a substantial and growing body of evidences showing that increasing FAVs consumption reduces the risk of chronic diseases and increases lifespan and quality of life, while decreasing medical costs (Tomas-Barberan and Gil, 2008). Yet, it is not definitely known which components of FAVs are the main contributors to the health effect. FAVs have long been recognized for their nutritive value and their low energy density. They are excellent sources of minerals and fibre, but are also unique sources of vitamins (C, E, B, and folic acid). Moreover, FAVs accumulate several thousands phytochemicals in response to a variety of stresses like insects and pathogens attacks (Osbourn et al., 2003; Kliebenstien, 2004), mineral deficiencies, cold temperatures, high light/UV, low nitrogen, etc. (Dixon and Paiva, 1995). These substances, known as secondary metabolites, are specific to certain plant species or families. Epidemiological studies have indicated that some of these phytochemicals have biological activity with respect to a number of illnesses. For instance, glucosinolate and isothiocyanate found in *Brassicas* have been linked to cancer prevention (Talalay and Fahey, 2001); polyphenols have been linked to cancer prevention, anti-inflammatory responses and prevention of cardiovascular diseases (CVD) (Williamson and Manach, 2005); carotenoids found in leafy vegetables and carrots have been associated with a reduced incidence of certain types of cancers (Limpens et al., 2006), of CVD (Voutilainen et al., 2006), with macular degeneration (Snodderly, 1995) and with the strengthening of the immune system (Riso et al., 2006); sulphur compounds found in onions have been related to CVD and cancer prevention (Griffiths et al., 2002).

It happens that many of the phytochemicals accumulated by FAVs, and especially polyphenols, also display high antioxidant activity in vitro and are able to scavenge a wide range of reactive oxygen, nitrogen and chlorine species like superoxide, hydroxyl radical, peroxyl radicals, etc. FAVs antioxidants have received lots of attention for their protective effect against the detrimental effect of biological oxidants. This interest stemmed from the ample scientific evidences indicating that increased oxidative damage is associated with the development of chronic diseases (Ames et al., 1993; Diaz et al., 1997; Boots et al., 2008). It was thus reasonable to ascribe the alleged effects of phytochemicals to their antioxidant activity. However, this tenet is now contested since very few studies have provided direct evidence that these benefits are actually due to in vivo or cellular antioxidant activity (Halliwell et al., 2005; Frankel and German, 2006). These authors assert, "*whether or not antioxidants can account for the strong epidemiological evidence that consumption of FAV is associated with reduced coronary heart diseases, cancer and other age-related diseases is a crucial question that remains unanswered*".

Thus, we still have to make sense of all the contradictory results and provide mechanistic explanations for the alleged epidemiological benefits of FAVs. For instance, epidemiological evidence is still lacking to strongly recommend the consumption of FAVs to prevent many types of cancers (Fund, 2007). Indeed, many studies have failed to demonstrate the protective effect from FAVs and phytochemical supplements on diseases. For example, a pooled analysis of cohort studies suggested that no significantly reduced breast cancer risk is associated with FAVs consumption (van Gils et al., 2005). Also, a large meta-analysis published in the Cochrane Reviews (Bjelakovic et al., 2008) could not demonstrate that antioxidant supplements prevented gastrointestinal cancer in high risk patients. Actually, they uncovered a higher mortality rate in the group receiving antioxidant treatment versus the

placebo group. In addition, Halliwell et al. (2005) caution that reports of increase in plasma total antioxidant activity after flavonoid intake, for example, must be interpreted with care since these may be caused by other factors like changes in plasma uric acid concentrations. Health benefits conferred by the consumption of FAVs are not simply and solely explained by their antioxidant properties. All in all, research must thus aim at unraveling the direct effect of phytochemicals on the etiology of diseases. Better more representative bioassays must be developed and biomarkers must be identified to measure anti-inflammatory, anti-mutagenic, anti-tumor, and anti-platelet activity in vivo. Greater emphasis should also be placed on human intervention studies, since in vitro studies have been somewhat misleading.

NEED FOR AN INTEGRATED APPROACH TO DEMONSTRATE THE HEALTH EFFECTS OF FAVs

Nowadays, improving health of the population is not only the business of doctors and health specialists. Everyone is responsible for their own health. Yet, people are awaiting the unbiased recommendations from scientists to foster their nutrition choices. Horticulturists, food chemists, nutritionists, biochemists, and clinical doctors must thus collaborate more than ever to demonstrate the positive effects of FAVs on health and develop new ways to increase the consumption of FAVs and phytochemical supplements. Yet, despite the strong indications that FAVs can improve health and prevent diseases, consumption remains low and people remain impermeable to the messages from health organizations.

Fig. 2. Research must aim at unraveling the direct effect of phytochemicals on the etiology of diseases. Greater emphasis should also be placed on human intervention studies, since in vitro studies have been somewhat misleading.

Contribution of Horticultural Sciences to Improving Health Properties of FAVs

Two approaches can be adopted to increase the concentration of phytochemicals in FAVs. The first consists of selecting or breeding for new improved cultivars of FAVs (Wink, 1988; Mikkelsen et al., 2002), and the second involves modifying the cultural management of the crop in such a way as to induce or stimulate the accumulation of bioactive compounds (Krumbein et al., 2001). In either approach, it is essential to have a deep understanding of the role of the specific phytochemical we are seeking to enhance. It is also very important, in this respect, to have a comprehensive perspective of the biosynthetic pathway and a good knowledge of the factors affecting its accumulation and availability. With this knowledge, it will be possible to develop an optimal strategy for improving the functional quality of horticultural commodities.

For years, plant breeding has focused on improving yield, appearance and organoleptic properties, stress tolerance and resistance to pests. This has led to a general decline of the nutritional quality of FAVs over the last 50 years (Davis et al., 2004) Breeders are just starting to revisit the germplasm of most horticultural crop plants to evaluate their nutritional quality with the aim of designing new improved FAVs. However, selection and breeding for nutritive attributes is a complex and long-term venture. The content in phytochemicals is influenced by many factors like the genotype, the geographic location, the growing season, the soil type, the plant maturity, and post-harvest handling. All of these must be taken into account to develop FAVs with increased level of phytochemicals. Encouragingly, recent advances in molecular genetics have generated knowledge about the regulation of biosynthetic pathways which has been exploited to improve the content of bioactive compounds in many horticultural commodities. Availability of powerful plant models like *Arabidopsis* and *Solanum lycopersicon* has fostered a comprehensive appreciation of the key reactions in metabolic pathways and provided very precise instruments to modify the phytochemical profiles of FAVs.

Not all FAVs are equal when considering their health functionality and their content of bioactive compounds. Actually, the concentration of a phytochemical can vary by 100% in some commodities. In the case of plant polyphenol contents, the genetic diversity is vast and there is a large pool of species and cultivars to utilize in breeding programs. This is especially true for important berry crops like *Vaccinium*, *Rubus*, *Ribes* and *Fragaria* known for their exceptional antioxidant potential and polyphenol content. Indeed, according to Howard et al. (2003), there is an ample genetic variation among blueberry genotypes to be exploited by breeders. For instance, Kalt et al. (2001) conducted an exhaustive survey of some 250 highbush and lowbush blueberry varieties and clones and found that there was a 1.6 and 1.2 fold difference between the 10^{th} and the 90^{th} percentile of plants, with respect to anthocyanin and total phenolic contents. For their part, Ehlenfeld and Prior (2001), Connor et al. (2002) and Moyer et al. (2002) observed differences in antioxidant capacity of blueberry cultivars spanning from 4.7 to 6.8 fold. In raspberry, Anttonen and Karjalainen (2005) observed a two-fold difference in total phenolics among 17 cultivars; the difference in quercetin and ellagic acid content also varied by a factor of three. In strawberry, Cordenunsi et al. (2002) observed a four-fold increase in anthocyanin and a considerable difference in ellagic acid contents of 45 strawberry cultivars, a difference spanning from 60 $\mu g.g^{-1}$ FW to 311 $\mu g.g^{-1}$ FW. Such a large variability in the concentration of bioactive compounds must be taken into consideration when preparing trials. This points to the need for clinicians to work hand in hand with horticulturists to standardize the starting material at the inception of a nutritional study.

There is significant risk in transposing the results obtained from in vitro studies usually showing very positive effects of FAVs on health to in vivo conditions. The effect of a phytochemical in an isolated cell is much different from its effect in the whole body. Many details are missing about the nature of phytochemicals in food, and their active forms once

absorbed in the body. Moreover, many bioactive phytochemicals remain to be discovered. These compounds are present in very low concentrations in plants and often no standards are available to ascertain their identity which makes characterization especially difficult. Phytochemicals must be extracted and separated before analysis, with a danger of losing the integrity of the molecule and its conjugates. New innovative screening procedures for new molecules must thus be developed. This may include the identification of candidate compounds based on existing knowledge of their properties like chemically reactive functional groups, some known physiological function in humans, and the presence in foods which are widely consumed (Brandt et al., 2004). The advent of improved efficient analytical equipment is opening new possibilities of identifying new molecules with health effects (Hall et al., 2008). Metabolomic is becoming a useful tool to identify new molecules (Steward et al., 2007) and bioactivity-guided fractionation approaches to identification of health effects are being applied more broadly (Neto, 2007).

Many factors are acting simultaneously on the bioavailability of phytochemicals and are confounding the response at target organs or cells. For instance, there is strong interaction between components of the food matrix and phytochemicals which has an influence on their absorption by the body. Moreover, the chemical environment in the gastrointestinal compartments may alter the chemical structure of the bioactive compounds ingested and consequently modify their bioactive properties (McGhie and Walton, 2007). In the case of anthocyanins, there is a paradox between their apparent low bioavailability and the effects they are seemingly causing. There are still many technical limitations to identifying all metabolites of the bioactive molecules in the gastrointestinal tract or all their metabolites after passage through the enterocyte and their entry into the body's circulation. These compounds are often recognized as xenobiotics by the body and are actively conjugated (glucuronated, sulphated, methylated) and actively excreted through the bile or the urine. It is thus essential to determine the target of these compounds with respect to specific diseases and their role in signaling responses. Often, doses used in intervention trial are unrealistic and do not represent the amount of bioactive compounds an individual is likely to be exposed to in a normal diet. In these conditions, considerable aberrations in the metabolism and absorption may be encountered, leading to a general confusion of the responses. It thus becomes important to have a greater understanding of the processes affecting phytochemical fate in the body. It also becomes essential to identify end-points for selection of FAV with improved health benefits. Until recently, antioxidant capacity was used as a target for improvement. For instance, strawberries with higher antioxidant content have been developed (Khanizadeh et al., 2003). But the measurement of antioxidant capacity has yielded variable results and there is no definitive correlation between antioxidant potential of commodities and plasma antioxidant levels nor disease incidence. More emphasis should be placed on the specific bioactive molecules as such. But before this can be done, many questions remain to be answered. What is the identity of the bioactive molecules? How are these molecules absorbed and metabolized by the human body? What is their fate once absorbed in the body? How are they metabolized? Do metabolites of phytochemicals display any activity? How are they transported to target organs or cells? Studies will have to unravel their influence on the antioxidant network of the body. We will need to identify reliable biomarkers and suitable endpoints to assess the efficacy of the bioactive compounds in FAVs.

CONCLUSIONS

We have seen that epidemiological evidence strongly favors the consumption of FAVs to prevent many chronic diseases. On this basis, health organizations are promoting the consumption of FAVs (WHO Technical Report Series 916, 2003) to reduce mortality in populations in both developed and developing countries. However, there is still uncertainty

about the mechanisms by which FAVs confer this effect. Phytochemicals contained in FAVs may have an effect on the body's antioxidant network. However it is now believed that they more likely have a direct effect on specific physiological reactions of the organism leading to a reduction of disease incidence (Halliwell et al., 2005). If we are to recommend the consumption of specific FAVs to improve health and to make claims about their beneficial effects with respect to certain diseases, we will have to develop new targets and objectives for breeding. That is, we must identify the exact phytochemicals involved in the prevention response, and assess the content of these bioactive compounds found in the different cultivars and varieties. Furthermore, we will have to determine the fate of these phytochemicals in the marketing chain and how they are affected by storage and cooking. New rapid and inexpensive analytical tools will have to be developed and standardization protocols of the titer in phytochemicals will be needed if the new designer FAVs are to obtain novel food status and health claims can be legally made. Generally speaking, a new set of quality attributes will have to be developed in horticultural produce and new strategies involving breeding, cultural management and post-harvest storage and processing will have to be conceived to bring to the public these new improved healthy FAVs. This will also require the coordinated action of many scientific disciplines like plant breeding, food chemistry, nutrition, molecular biology, and medicine to work together to unveil the many uncertainties relating to the effect of phytochemicals and human health.

ISAFRUIT is a good example of such coordinated action needed to bring to the consumer the health benefits of a fruit like apple. This European integrated research project covers all aspects of fruit production up to considering consumer preferences with special emphasis on health properties as a determinant of fruit quality. By coordinating the activities of some 200 researchers, this project is probably the most comprehensive initiative currently underway in the world to improve health quality of fruits. ISHS is thus eager to see the outcome of the project. This Society is offering to be a vehicle to disseminate the results of ISAFRUIT activities to the world scientific community. Thus, this could be an opportunity to broaden the scope of this European research project to make it truly international. In this sense, joint activities between ISAFRUIT and ISHS should be organized and ISAFRUIT should contemplate the possibility of taking the leadership role in a Working Group dedicated to health effect of fruits within the Commission on Fruits and Vegetables and Health.

Fig. 3. Standardization protocols of the titer in phytochemicals will be needed if the new designer FAVs are to obtain novel food status and health claims can be legally made.

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