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Consumers' images regarding genomics as a tomato breeding technology: "maybe it can provide a more tasty tomato"

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Abstract Methods of production are becoming more important to consumers in their decisions about whether or not to buy or consume a certain product. This decision making process is influenced, among other things, by the images consumers have with regard to the product and its method of production. In this research, consumer images regarding plant breeding technologies were ascertained by means of focus group discussions. Thirty-five respondents, divided into four homogenous groups, were given descriptions of three plant breeding techniques and challenged to provide and discuss their images of these technologies. The discussions resulted in images about genetic modification, genomics, and conventional breeding. It was interesting to see that elaboration of the descriptions changed the consumers' images, especially regarding the positioning of genomics in relation to the other two technologies. Whereas initially consumers' images placed genomics close to genetic modification, further discussion and clarification resulted in a re-positioning of genomics closer to conventional breeding.

Keywords Conventional breeding · Genetic modification · Genomics · Homogenous focus groups · Image · Method of production

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Introduction

In addition to the sensory qualities of a tomato and of course the price, the method of production is becoming an increasingly important factor in consumer decision making (Deliza et al. 2003; Grunert et al. 2003), and the acceptability of the production method can be a major determinant of consumer preference (Verbeke and Viaene 1999). In contrast to the sensory qualities of a tomato, which can easily be experienced, properties such as the acceptability of the production method are more difficult for consumers to assess. To make such an assessment, consumers require insights into the production process itself and its implications. Most consumers lack the knowledge and often the motivation that would be required for such detailed and in-depth assessment. This inability, however, does not necessarily mean that consumers would refrain from making a judgment on the tomato's performance on credence qualities. Rather, they would tend to base their judgment on much more intuitive and peripheral assessments than on deliberate and elaborated ones.

The distinction between intuitive and deliberate assessment of information by consumers has important implications for many aspects of consumers' decision making, such as advertising effectiveness (Scholten 1996), trust (Yang et al. 2006), and image formation (Poiesz 1989). This research focuses on the image formation of consumers regarding the production method and especially on the outcome of intuitive assessments of the production method.

Since some methods of production are new to consumers, information is not always available, not easily understood, and not well contextualized yet, and quite often generates ambivalent feelings in consumers (Wagner and Kronberger 2001). Different sources of information often make contradictory statements, and this adds to the feeling of uncertainty (Jonas and Beckmann 1998). In such situations, consumers often use images, because images are first impressions, often intuitive, and can be seen as spontaneous categorizations or simplification strategies (Hong et al. 2006) in consumers' decision making.

These first intuitive assessments are especially relevant in the case of new technologies; after all, a first impression can only be made once. In this study, we focus on the new food technology of genomics that has yet to make its appearance in the market place. Nowadays, most plant scientists do not consider genomics to be a breeding practice, but rather a toolbox which may be used, for example, to improve selection in either conventional breeding or breeding by way of genetic modification (GM). Since about 2000, most professional tomato breeding has been using genomics techniques, mainly molecular markers. As a consequence, conventional breeding (without genomic tools) is becoming extinct. This study follows the lead of Varshney et al. (2005) and considers genomics as a future breeding practice. This new technology can potentially evoke ambivalence, mainly because of the different perceptions that are at stake. On the one hand it can be seen as close to conventional plant breeding, but on the other it may elicit associations with GM.

The position of genomics, as perceived by consumers, in this continuum between conventional breeding and GM will be elemental for its success. A position close to GM, for example, may be less favorable because of the negative attitudes of most consumers toward GM in food production (Grunert et al. 2003). On the other hand, it may be favorable because GM products may solve environmental problems or result in lower food prices (Grunert et al. 2003). To explore consumers' images regarding genomics and its positioning relative to GM and conventional breeding, focus groups interviews are used where respondents are given the opportunity to give their first impressions and interact with each other, with regard to these breeding practices. The purpose is to asses whether consumers have comparable images regarding genomics on the one hand and GM or conventional breeding on the other.

In the next section, we present information on genomics as this production technology is our primary focus. This is followed by some theoretical background, after which the methodology of the study is presented as well as the results. The results and limitations of this study are then discussed.

Plant breeding practices

The focus on genomics, GM, and conventional breeding is interesting since these breeding practices can be compared with each other. This comparison is even more interesting since genomics has associations with both GM and conventional breeding. In this section, the technologies, as defined in the literature, are presented, starting with conventional breeding and followed by genomics and GM. The definitions used in this research to inform the consumers are also presented.

In the past four decades, conventional breeding has contributed significantly to the improvement of vegetable yields, quality, post-harvest life, and resistance to biotic and abiotic stresses (Dalal et al. 2006). Conventional breeding implies that selected plants are crossed and progenies selected that combine the favorable characteristics of the different plants. Major activities of the conventional breeding approach include screening of germplasm for new traits and creating new crosses to recombine sources of variation in new genotypes (Ishitani et al. 2004).

In this research, conventional breeding was specified and presented to consumers as ''*breeding based on the appearance of different plants. The breeder looks for plants with certain characteristics such as* *'many fruits' or 'round tomatoes'. Subsequently he crossbreeds the plants. The genes of these plants will be mixed. The new plant will have the characteristics of both parents. The characteristics of this new plant cannot be determined in advance. Afterwards, when the plant is grown, it can be determined if the plant has many tomatoes and round tomatoes, and then the selection of the plants can begin''*.

Genomics envisions the complete study of the hereditary material of living beings (Lexicon EncycloBio 2007). Genomics research studies the structure and function of genomes to improve the efficiency and effectiveness of breeding practices, whereas GM alters the structure of the genomes by actively modifying them (Lexicon EncycloBio 2007). Genomic research in plant breeding can be defined as research that is generating new tools, such as functional molecular markers and informatics, as well as new knowledge about statistics and inheritance phenomena that could increase the efficiency and precision of crop improvement (Varshney et al. 2005). Genomics will provide large quantities of data on plants grown as primary material (Pridmore et al. 2000). These data can be used in three ways: firstly, as a powerful tool to identify and characterize plants of commercial interest and as an important aid to rapidly advance breeding programs (Pridmore et al. 2000); secondly, to monitor the response of plants or micro-organism to their environment and as a tool to adapt the growth conditions more closely to their needs (Pridmore et al. 2000); thirdly, for the modification of plants or micro-organism to produce new varieties with improved farming, health, nutrition or processing characteristics by the exploitation of the information by the use of biotechnology (Pridmore et al. 2000).

Genomics was specified as *''breeding based on the DNA of different plants. The breeder looks for plants with certain characteristics such as 'many fruits' or 'round tomatoes'. He determines which genes are responsible for these characteristics. The breeder then will crossbreed the plants with the desired characteristics. This is faster than with conventional breeding. The new plant will have the characteristics of both parents. During a test, it will be determined which specific characteristics are present in the plant. Because of this, the best plants can be selected faster''*.

Genetic modification of food involves deliberate modification of the genetic material of plants or animals (Uzogara 2000). Many foods consumed today are either genetically modified whole foods, or contain ingredients derived from gene modification technology (Uzogara 2000). New food products made from genetically modified crops started appearing in US supermarkets in 1996 (Huffman et al. 2007). The rapid adoption of genetically modified food crops with improved agronomic characteristics in the US, Argentina, and Canada stands in strong contrast to the situation in the EU (Kuiper et al. 2004).

Genetic modification is specified as *''breeding based on the DNA of different plants. With genetic modification, one characteristic will be cut out of the DNA. This characteristic will be added without changing the other characteristics. Only the desired gene will be transferred instead of crossbreeding two plants. To be sure that the new gene will provide the plant with the desired characteristic, several generations of plants will be grown''*.

The focus on genomics, GM, and conventional breeding is interesting since these breeding practices can be compared on two determinants in plant breeding. The first determinant is the degree of human manipulation of DNA, and the second determinant is the degree of focus with regard to the plants. The breeding technologies and their place on the axis are visualized in Table 1.

The first axis on which the plant breeding technologies can be categorized is the degree of human manipulation of the DNA. Traditionally, plants have been crossed by humans to develop better plants with better yield, but this human manipulation cannot be categorized as direct human manipulation of the DNA. Nowadays, it is possible to actively sort the DNA of plants and manipulate the plants in this way. The second axis indicates the degree of focus regarding the plants, where the endpoints are phenotype and genotype. Traditionally, plant physiologists have studied the relationship between crop performance (the phenotype) and the environment, but nowadays crop performance can also be increased by modifying the crop genome (the genotype) through plant breeding and molecular biology (Edmeades et al. 2004).

As can be seen from Table 1, conventional breeding involves no direct human manipulation of the DNA and it is applied at the phenotype level. Genomics is placed to the right of conventional breeding since DNA is not manipulated, but parent

Table 1 Plant breeding technologies

Plant breeding technologies		Plant focus		
		Phenotype		Genotype
Human manipulation of DNA	None	Conventional breeding	←→	Genomics
	Much			↕
				GM

and progeny plants are selected based on the presence of characteristics that can be identified by using DNA techniques. GM is placed on the lower right-hand side of the table since the manipulation involves direct human manipulation of the DNA and it takes place at the genotype level.

Theoretical background

Biotechnology and consumers

Biotechnology has been the object of considerable debate in most European countries in the past decade (Pardo et al. 2002). The application of modern biotechnology to food has raised concern amongst the European public (Barling et al. 1999). The public perception of biotechnology applications has been characterized generally as negative (Pardo et al. 2002; Marris et al. 2001; European Commission 2006; Moses 1999). This negative perception of biotechnology and its applications is not based on objective knowledge, as the knowledge of the public about biotechnology is very limited (Pardo et al. 2002; Gaskell et al. 1999; Hamstra and Smink 1996). Nonetheless, this lack of knowledge and understanding does not appear to prevent attitude formation regarding perceived risks and benefits associated with biotechnology (Frewer et al. 1994). The attitudes formed towards biotechnology are rather negative as mentioned, especially in Europe. This is in contrast to the United States of America where the general public are seemingly untroubled by biotechnology (Gaskell et al. 1999; Lusk and Rozan 2005; Hoban 1997; Durant et al. 1999).

One explanation for the negative attitude towards biotechnology could be people's preference for natural entities over those produced with human intervention (Rozin et al. 2004), but even for products involving human intervention like genetically modified food, a GM product that is perceived as more natural is more likely to be accepted than a GM product that is perceived as less natural (Tenbült et al. 2005). The extent to which GM affects the perceived naturalness of a product partly depends on the kind of product (Tenbült et al. 2005) and on what the concept of ''natural'' means to consumers (Rozin 2005).

The image concept

In their decision making, consumers use images, which are created within their minds, as models of the outside world (Hastie and Pennington 1995). Images, as they are discussed in the literature, range from holistic, general impressions to very elaborate evaluations of products, brands, stores or companies (Poiesz 1989). The image concept as it is employed by Poiesz is defined as a general impression of the relative position of the object among its perceived neighbors. Although images are composed of many dimensions, the general image may have more to do with intangible (intuitive) aspects than with concrete aspects (Solomon et al. 2002). The image concept can be seen as a low elaboration approach since the impressions are general and holistic and no deliberate assessment is necessary.

These holistic impressions can well be used when consumers are confronted with new breeding practices. Because of the newness of these practices, consumers have little information available for a deliberate assessment, but will form images about them. The elaboration level will be low because of this lack of information and the most appropriate form of images to be used, then, is holistic impressions. In this article, the image concept is defined as an iconic representation of the relative position of an object (breeding practice) among its perceived neighbors (other breeding practices).

Materials and methods

Subjects

In this study we used the focus group methodology, because this provides the opportunity to witness the first impressions of consumers and to explore the dynamics of these images through interaction (communication). Four consumer focus group interviews were conducted with a total of 35 participants. All respondents were recruited based on the criterion of being responsible for food shopping, even when they worked outside the home. In the majority of households these are women, because it is still only a minority of men who are responsible for household food purchases. We therefore chose to recruit only women. The study took place in May 2006 in Utrecht, a city in the middle of the Netherlands, and all respondents lived in or near the city.

The four focus groups were homogenous as to age (old / young) and level of education (high / low). In Table 2, the four homogenous focus groups are described. The more highly educated group consists of respondents with academic, higher vocational education, or equivalent schooling. The less educated group consists of respondents with elementary, lower, and middle vocational education, or equivalent schooling. Young respondents ranged in age from 18 years to 48 years and old respondents from 49 years to 79 years. The categorization of the groups is mainly based on the research of Bäckström et al. (2003).

Stimulus material

Three breeding technology descriptions were used during the interviews. The descriptions introduced the breeding practices, if not already known, to the respondents and were used in the discussion. Each description included a visual and textual explanation of the breeding practice. An example of a description can be found in the appendix (Fig. 1). The three visual explanations together formed a poster (see appendix, Fig. 2) which was used in the discussion.

The descriptions were formulated with the help of an expert. The expert is the director of a network comprised of Dutch scientists in the field of plant genomics and the major Dutch companies in plant genomics, breeding, cultivation, and processing.

Table 2 Homogenous focus groups

Homogenous focus groups	
A	Young and less educated
B	Old and highly educated
C	Old and less educated
D	Young and highly educated

Conduct of the interviews

The focus group sessions followed an interview guide that had been prepared with the moderator. The interview guide was built upon several themes starting with an introduction round, a free association task, a discussion about the three breeding practices, and a closure.

During the introduction round, it was pointed out to participants that there were no right or wrong answers to the questions and that they should express their honest thoughts, opinions, and beliefs. The participants were seated around a table to allow interaction, eye contact, and free flow of discussion. Each session lasted approximately 90 min under similar conditions. Coffee and tea were available to the participants.

Data treatment

The interviews were analyzed for themes by means of thematic coding. Thematic coding enables one to look at groups that are derived from the research question and are thus defined a priori (Flick 2002). The underlying assumption is that, in different social groups, differing views can be found (Flick 2002). During each interview, one or two researchers and a reporter wrote down the participants' opinions and impressions. Issues were regarded as important enough for inclusion in the summary when they were mentioned in at least two of the four interview sessions (Brug et al. 1995).

Results

Group discussion

Naturalness is the first image of the plant breeding practices to be presented. Naturalness can be seen as a dichotomous theme. Whereas conventional breeding was seen as natural: *''With conventional [breeding], I had that it is a natural selection (D6)''*, genomics and GM were seen as artificial and unnatural: *''[genomics] does not even come close to conventional breeding … there is nothing natural about it (A2)''*; *''I find it [GM] very unnatural, because they use a gene out of something else that has nothing to do with a tomato (D3)''*. However, respondents saw a difference between the unnaturalness of these last two breeding practices. Genomics was perceived to be more natural than GM: *''[genomics] is a bit more natural [than GM] (C4)''*.

It was interesting to find that in the young and more highly educated group genomics was not seen as unnatural as in the other groups. Genomics was perceived as less natural than conventional breeding, but it was considered rather natural: *''[genomics] is still natural (D1)''*. This was clarified even further when the moderator asked about the differences between genomics and GM: *''the difference between genomics and GM is natural versus unnatural (D1)''*.

The second theme regarding the images of plant breeding practices is the *efficiency* of the different practices. A distinction was made between conventional breeding and genomics with regard to efficiency: *''you are in this way [genomics] able to work effectively, when you only use conventional breeding, a lot of things will be lost, but, in this way, you are able to just hold onto the good ones (D7)''*. In the genomics description it was stated that genomics is faster than conventional breeding. Respondents used that statement to conclude that genomics is more efficient than conventional breeding.

The third theme that emerged from the discussions is oriented towards the possible *consequences* of the new plant breeding practices. Respondents were not concerned about conventional breeding. Possible consequences regarding the breeding practices were not mentioned in the descriptions. Prior knowledge could, however, have had an influence, especially with regard to GM: ''[GM] *sometimes you read something about it (B7)''*.

The fourth and last theme is *sensory* appeal. Respondents indicated that the taste of the tomato is one of its most important characteristics: *''I am only interested in the taste (B9)''*. This characteristic especially emerged during the discussions even though nothing relating to sensory appeal was mentioned in the descriptions presented to them. The discussion led to some differences regarding this theme with respect to the different breeding practices. Respondents believed that tomatoes bred by means of conventional breeding methods would be the tastiest: *''I have the idea that it [the taste] is best with conventional breeding (B8)''*. This did not mean, however, that other breeding practices could not produce tasty tomatoes. More highly educated respondents linked taste to genomics-enabled breeding and did this in a positive way. They believed that tomatoes bred by means of genomics would be tasty: *''If, by genomics, you could get a little bit more taste again, that must be technically possible (B9)''*.

Dynamics in the group discussion

In the discussions, the respondents were challenged to elaborate on their first associations and images regarding genomics and the other breeding practices. The interaction between respondents resulted in a change of images. In the groups with older respondents (irrespective of educational level), respondents changed their images regarding genomics after some elaboration, thereby placing it from close to GM to close to conventional breeding: *''[genomics] is closer to conventional breeding. I only just believed that the two adapted methods [GM and genomics] were closer to each other (B4)''*. The groups with younger respondents (again irrespective of educational level) did not make much change in their initial associations regarding the positioning of genomics. The less educated young group placed genomics close to GM and the more highly educated young group placed it close to conventional breeding. So, eventually, after some elaboration, three out of the four groups believed that genomics is closer to conventional breeding than to genetic modification: *''[genomics] is very close to the conventional method (B5)''*; *''[genomics] it is actually conventional breeding with more insight (D8)''*.

Overall judgment of the breeding practices

In a general sense, respondents preferred conventional breeding above genomics, and both practices above GM: *''Most of us opt for conventional [breeding] (A8)''*. Conventional breeding is preferred because it is seen as a natural breeding practice, has a good sensory appeal, and respondents are not concerned about this breeding practice. Conventional breeding is an accepted breeding practice. Genomics is also acceptable to consumers, but they have more concerns regarding this practice and do not perceive it to be as natural as conventional breeding. Respondents realized, however, that conventional breeding was old-fashioned and slow, implying that genomics may be the solution for conventional breeding and will, in the future, become the preferred technology. The only group where the majority of the respondents had a preference for genomics as plant breeding technology was the young and more highly educated group: *''[genomics] has a head start on conventional [breeding] (D1)''*. GM on the other hand is not acceptable. The non-acceptability of GM was mainly based on the statement that GM takes and uses specific genes to incorporate into plants but that these are not necessarily genes from tomato plants; they could just as easily be bacteria.

Discussion

Consumers' images regarding the tomato breeding practices are built on four themes: naturalness, efficiency, consequence, and sensory appeal. Specific themes can be coupled to specific plant breeding practices. For example, conventional breeding was seen as natural. Genomics and GM were seen as unnatural; however, respondents saw a difference between the unnaturalness of these two breeding practices, with GM as the most unnatural. In the descriptions the participants received, nothing was mentioned about the naturalness of the breeding practices; however, the pictures used in these descriptions could have triggered responses with regard to naturalness. Actual pictures of tomato plants were used in the description of conventional breeding, but not in the descriptions of genomics and GM. For the latter descriptions, DNA-strands were used to explain the breeding practices. In comparing the different plant breeding practices, with the given difference in descriptions of plants versus DNA-strands, respondents may perceive the naturalness of the plant breeding practices in a different way.

The result that probably stands out the most is the fact that more highly educated respondents linked taste to genomics-enabled breeding and did this in a positive way. They believed that tomatoes bred by means of genomics would be tasty. A possible explanation for this could be their level of education. The level of education affects the content of argumentation of respondents (Bäckström et al. 2003) and increases their capacity to think. This may lead to a better understanding of the functioning of genomics and the resulting effect it can have on taste.

It was interesting to see that respondents, in first instance and thus before the further elaboration, perceived genomics and GM as almost the same. Eventually, thus after some elaboration, genomics was not regarded as equivalent to GM by three of the four homogenous groups. The main reason for believing that genomics is closer to conventional breeding is that it is still breeding with tomatoes, thus within the same species. This reason triggered respondents to perceive that genomics is close to conventional breeding and not comparable with GM.

The preference for conventional breeding over genomics and GM may be explained by the preferences consumers have for natural entities above entities produced with human intervention as pointed out by Rozin et al. (2004). Consumers perceive conventional breeding as most natural, followed by genomics and then GM, and this may explain the preference for conventional breeding above genomics and GM. The preference for natural entities may also explain why consumers do not accept GM. The extensive human intervention within this breeding practice may decrease the acceptance of GM.

Previous survey studies (Frewer 1992) have indicated that consumer awareness of biotechnology is low. Although the public debate about GM has been substantial (e.g. Pardo et al. 2002), in this study it became clear that respondents' awareness of biotechnology applications might still be low. Respondents were amazed at the fact that tomatoes could be bred in different ways, using different breeding practices. They knew nothing of the existence of these different breeding possibilities.

The low awareness of biotechnology and its applications triggers the question of how much consumers actually understand about these technologies. The results of this study suggest that such knowledge is limited. Most respondents could not, for example, make a clear distinction between the breeding of tomatoes and the production of tomatoes. Respondents saw these two processes as one.

In spite of limited awareness and understanding of biotechnology and its applications, one daring and preliminary conclusion of this study may be that there has been a slight shift in the public's adverse perception of biotechnology and some of its applications. Biotechnology has always been characterized as negative (e.g. Marris et al. 2001; European Commission 2006), but this study indicates that at least some respondents, namely, those that are younger and more highly educated, see genomics as positive and as the solution and only possibility for the future. However, the negative perception of GM is maintained.

The question remains as to how it is possible that the images changed in this discussion. By way of the focus group discussions, respondents were asked to diligently consider the descriptions and poster provided. The interaction and the deliberations caused a shift in respondents' elaboration. Instead of their images being formed by intuitive assessment, consumers formed deliberate images about the plant breeding practices. This change will probably not occur in the real life situation because consumers are often not motivated or able to elaborate on the images.

This may change, however, when products produced with genomics or GM cause more concerns to consumers. These concerns may be triggered by the media and NGOs acting as providers of information when products bred by GM or genomics appear on the shelves. In this way, consumers may become involved, and consequently will be more motivated to pursue the issue and thereby make use of more information sources and discuss this topic in their own social groups. The question still remains as to whether the introduction of a GM tomato and certainly a tomato bred by genomics will cause such a public debate. It is difficult to say what the dynamics of the process will be after the introduction of tomatoes bred using a technique other than conventional breeding.

Limitations

It is important to keep in mind that the respondents received input for the group discussion. We have to take into account that this input, in this case the descriptions and the poster, may influence consumers' images. The pictures portrayed may be the most important influence. The picture regarding genomics, where a DNA-strand was used to explain the breeding of a tomato, could have had a more than normal influence. The reason for this assumption is that respondents immediately associated DNA, genes, etc, with GM. By showing the DNA-strand in the genomics picture, we may have positioned genomics close to GM. In spite of our attempts to present the respondents with descriptions that were as neutral as possible, afterwards it seemed that it would have been better if all three examples had been identical, as in reality. Nonetheless, most respondents were able to distinguish genomics from GM after they were presented with the opportunity to elaborate on the plant breeding practices.

To prevent a learning effect, resulting in a disproportionately large number of associations for the last received description, we systematically changed the order of the descriptions. The randomization had, however, an order effect with regard to the breeding practices, especially with regard to the degree of human manipulation of the DNA. Respondents who received a GM description before a genomics description were not always, in the first instance, able to make a clear distinction about how much human manipulation of the DNA was involved. Those specific respondents believed that genomics needed more human manipulation of the DNA than GM.

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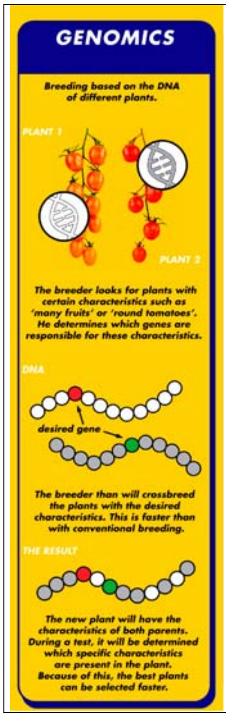
Appendix



- Genomics can be used as a selection-instrument in the breeding of new crops.
- A breeder gets, by means of genomics, insights into all the characteristics of the plant by looking at the genes of the plant.
- Hereby he is able to select only those plants with the desired characteristics.
- After the crossing it is possible, by means of test, to verify whether the new plant has the desired characteristics.
- If the breeder wants a tomato plant which produces many tomatoes and round tomatoes, he is able to look into existing plants to see if these plants possess these characteristics.
- By means of genomics, he can cross in one sequence the plant possessing the genes which cause the plant to produce many fruits with the plant with the genes which produce round tomatoes.
- Because of this crossing he knows for certain that he will get a tomato plant with many and round tomatoes.

Fig. 1 Breeding technology description: genomics

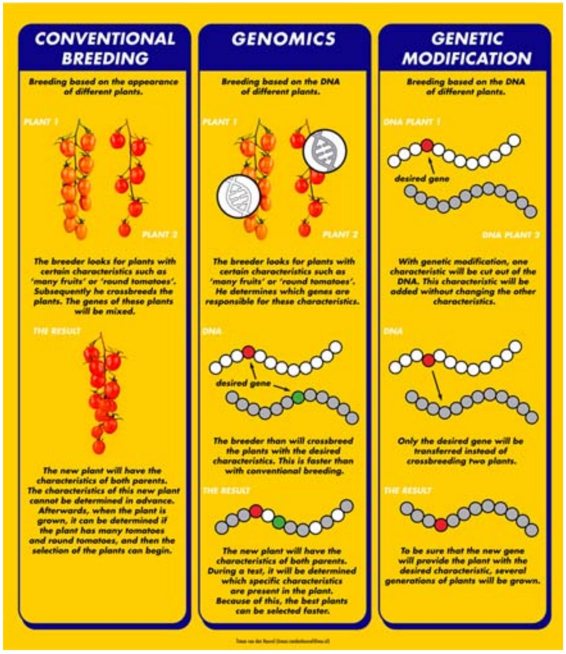


Fig. 2 Poster breeding technologies

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