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# Consumer reaction to information on the labels of genetically modified food

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## ABSTRACT

**OBJECTIVE:** To analyze consumer opinion on genetically modified foods and the information included on the label.

**METHODS:** A systematic review of the scientific literature on genetically modified food labeling was conducted consulting bibliographic databases (Medline – via PubMed –, EMBASE, ISI-Web of knowledge, Cochrane Library Plus, FSTA, LILACS, CINAHL and AGRICOLA) using the descriptors “organisms, genetically modified” and “food labeling”. The search covered the first available date, up to June 2012, selecting relevant articles written in English, Portuguese or Spanish.

**RESULTS:** Forty articles were selected after applying the inclusion and exclusion criteria. All of them should have conducted a population-based intervention focused on consumer awareness of genetically modified foods and their need or not, to include this on the label. The consumers expressed a preference for non-genetically modified products, and added that they were prepared to pay more for this but, ultimately, the product bought was that with the best price, in a market which welcomes new technologies. In 18 of the articles, the population was in favor of obligatory labelling, and in six, in favor of this being voluntary; seven studies showed the consumer knew little about genetically modified food, and in three, the population underestimated the quantity they consumed. Price was an influencing factor in all cases.

**CONCLUSIONS:** Label should be homogeneous and clarify the degree of tolerance of genetically modified products in humans, in comparison with those non-genetically modified. Label should also present the content or not of genetically modified products and how these commodities are produced and should be accompanied by the certifying entity and contact information. Consumers express their preference for non-genetically modified products and they even notice that they are willing to pay more for it, but eventually they buy the item with the best price, in a market that welcomes new technologies.

**DESCRIPTORS:** Food Labeling. Food, Genetically Modified. Health Knowledge, Attitudes, Practice. Food Security. Health Promotion.

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## INTRODUCTION

Biotechnology can be found in many everyday products: biofuels, vaccines, drugs, cereals, wine, dairy products, and others. The animal world also participates in this technology, with the generation of cloned organisms, chosen for their productive and reproductive characteristics, and consumption of genetically modified (GM) grains (corn and soya, among others) all over the world.<sup>13,16,17,22,27,35,38,42,44,45,48-51,54,57,62</sup> It is difficult not to encounter or consume transgenic products in the market, whether we are aware of this or not. The introduction of all these advances in genetic engineering has been accompanied by the corresponding patents.<sup>13,16,17,22,27,35,38,42,44,45,48-51,54,57,62</sup> However, it may be that the promises of GM technology (farming in extreme conditions, increasing nutritional value, sustained increase in harvests, decreasing need for pesticides, reducing world hunger, among others) exist more in the minds of GM supporters than in the commercial supply.<sup>13,16,22,27,35,38,42,44,45,48-51,54</sup>

Opinions and decisions on GM are divided: they have come to be consumed and accepted in the United States over the last decade, as well as in the rest of America, Australia and South Africa. However, Europe is, partly, resisting the introduction of GM foods into shopping lists.<sup>16,27,42,45</sup> The citizen should be informed about the options available in the market by product labeling.<sup>13,16,38,45</sup>

In the United States, GM foods are allowed to be sold without being identified as such on the labeling and, in Europe, it is also not necessary if the GM content in the total product is < 0.9%.<sup>a</sup> Correct labeling should be viewed not only as a consumers right, but also as an important way of controlling and providing information on the risk of consuming the product.<sup>13,16,38,45</sup> It is easier to conduct epidemiological studies to detect any increases in illness of allergies due to consumption of GM food, and other food, if they are correctly labelled.<sup>45</sup> Tracing has been proven to be an effective tool in appropriate control of the source of food,<sup>b,c</sup> as has been shown in cases of food poisoning.

The objective of this study was to analyze users' opinions of genetically modified foods and of the information on the label.

## METHODS

A critical and systematic analysis was made of studies found in a bibliographical review of the scientific literature.

The data used were obtained by direct and internet consultation of the scientific literature from the following databases: Medline, via PubMed; EMBASE; Web of Knowledge, Institute for Scientific Information (ISI); The Cochrane Library Plus; Food Science and Technology Abstracts (FSTA); Latin American and Caribbean Health Sciences Literature (LILACS); The Cumulative Index to Nursing and Allied Health Literature (CINAHL); AGRICOLA.

Articles which had been published in Spanish, English and Portuguese, in various countries and by different institutions or individual investigators were collected for the entire period for which each primary source had an index.

Medical Subject Headings (MeSH), developed by the National Library of Medicine, were used to search for the documents. Subheadings were not used, nor was it necessary to use tags. Using the Thesaurus, the following descriptors were deemed adequate «organisms, genetically modified» and «food labeling», using these as the major topic in such databases as allowed this (Medline and EMBASE). This guaranteed the greatest search sensitivity and, therefore, the achievement of the most relevant and pertinent articles, eliminating 'noise' (articles not related to the principal topic of the search) from the results. The filter (limit): Humans, was used.

The search equation was developed for use in the Medline, via PubMed database, using Boolean connectors, and later adapted to the other databases mentioned above.

The search range was from the first available date, according to the characteristics of each database, until June 2012 (the time of the most recent update).

As a secondary search, to reduce potential publication bias, the bibliography of each article selected in the principal search was examined, aiming to identify studies that had not been detected in the review.

The final selection of articles was conducted according to their fulfilling the following inclusion criteria: having undergone peer review, being relevant, the entire text being available and being written in English, Spanish or Portuguese.

Exclusion criteria were: not containing information on the label, not having been studied in a population and the label not containing information on GM organisms and their products, despite being food products.

<sup>a</sup> Regulation (EC) no. 1831/2003 of the European Parliament and Council of 22 September 2003 concerning the traceability and labeling of genetically modified organisms and the traceability of food and feed products produced from GMOs, and the Directive 2001/18/EC. EU Official Journal, no. L 268, 18 October 2003.

<sup>b</sup> Regulation (EC) no. 852/2004 of the European Parliament and Council on the hygiene of foodstuffs. EU Official Journal, no. L 139, 29 April 2004.

<sup>c</sup> Corrigendum to Regulation (EC) no. 852/2004 of European Parliament and Council of 29 April 2004 on the hygiene of foodstuffs. EU Official Journal, no. L 226, 25 June 2004.

The articles were independently evaluated by two of the authors of this review (S-P and S-V) to determine relevance. The STrengthening the Reporting of OBservational studies in Epidemiology (STROBE)<sup>d</sup> questionnaire was used as an aid in evaluating the quality of the articles. The score for agreement between these authors (Kappa index) had to be > 0.80 (very strong agreement) to make selection of the articles for the review valid. As long as they met this criterion, possible disagreements were resolved by consulting a third author (W-B) and consensus then being achieved between the authors.

The accuracy of the data was monitored using double entry, which enabled errors to be noted and corrected through consulting the original again.

The studies were grouped according to the variable studied, aiming to systemize and facilitate understanding of the results, codifying the following data: authors and year of publication, intervention conducted, study population, location, year in which it took place and the main conclusions drawn.

None of the articles were rejected for methodological reasons. There were no restrictions concerning gender or age of the patients or type of sample.

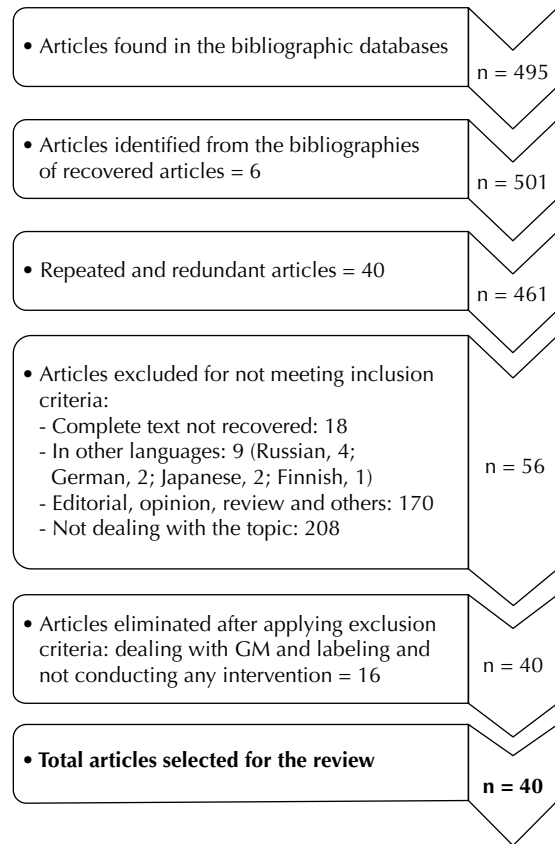
## RESULTS

A total of 495 articles were found, of which 372 (75.1%) were from the Institute for Scientific Information (ISI) database, 62 from Web Of Knowledge, (12.3%), from Medline, 31 (6.3%), and 16 from EMBASE (3.2%), from CINAHL, 12 (2.4%), from AGRICOLA and 3 (0.6%) from LILACS. Forty articles were selected after applying the inclusion and exclusion criteria<sup>1-6,8-12,15,18,20,21,23-26,28-34,36,40,41,43,46,47,52,53,56,58-61,63</sup> (Figure).

It was not necessary to measure agreement between the authors, as agreement on the studies' relevance was 100%. All of the selected articles were above the median of the items proposed by STROBE for observational studies.

In addition to redundant articles, appearing in different databases, we also found studies dealing with the same intervention in various publications. In such cases, the most recently published article covering data from the entire intervention was selected.<sup>23,46,53,61</sup>

In some articles, depending on the study population, various interventions were included. Thus, four interventions in Bredahl,<sup>8</sup> three in Huffman et al,<sup>23</sup> Knight et al<sup>26</sup> y Miles et al,<sup>36</sup> and two in articles by Brown,<sup>9</sup> Lü,<sup>29</sup> McGarry Wolf et al,<sup>34</sup> Nayga et al,<sup>41</sup> Shehata,<sup>53</sup>



**Figure.** Diagram of the selection of articles on GM and labeling.

Tenbült et al.<sup>59</sup> and Zhong et al<sup>63</sup> are considered. The rest of the articles had evidence of one intervention each. In total, there were 56 interventions in the 40 selected articles (Table).

The most used intervention method for obtaining data was the personal interview, 30.3%<sup>2,4,6,10,12,18,24,26,28,29,32,34,41,52,53</sup> of the 56 interventions; followed by group work, 30.3%<sup>9,15,23,29,30,40,43,58,59</sup> questionnaires, 12.5%<sup>3,25,36,47,56</sup> telephone surveys, 12.5%<sup>1,5,21,41,53,60,63</sup> mail surveys, 7.1%<sup>11,20,31,46</sup> point of sale data, 3.6%<sup>13,16,26,33,38,45</sup> internet survey, 1.8%<sup>61</sup> and investigation of journals, 1.8%.<sup>63</sup>

The population investigated provided heterogeneous data, ranging from very concrete data on age, sex and levels of culture and income,<sup>15,23,41,52,53</sup> to merely providing data on the number of participants: 12 studies (30.0%)<sup>3,5,10,24-26,31,34,41,53,61,63</sup>

The intervention with the largest number of participants<sup>46</sup> was n = 2,387 and that with the lowest number had<sup>26</sup> n = 17. In one of the interventions, it was noted that the population was selected according to sex (only women).<sup>30</sup>

<sup>d</sup>STROBE Statement: collaborative initiative of epidemiologists, methodologists, statisticians, researchers and journal editors involved in the conduct and dissemination of observational studies[cited 2014 Feb 8]. Available from: <http://www.strobe-statement.org/>

Of the 40 studies selected, 44.6% of interventions took place in Europe, 33.9% in America, 14.3% in Asia, 5.3% in Oceania and 1.8% in Africa. Whereas in Europe, Asia, Africa and Oceania, the interventions were distributed homogeneously (between one and three interventions) in different countries, in America the interventions centered on the USA (15 of the 19 interventions).

The design was cross-sectional, with the exception of monitoring articles published in journals, which lasted six years,<sup>63</sup> and one of the studies which collected point of sale data and lasted four years.<sup>33</sup>

The most recent interventions (four in total) were performed in 2007 (7.1%),<sup>6,15,47,53</sup> in Germany, Kenya, Japan and Spain.

In 45.0% of the 40 selected articles, the population studied were shown to be clearly in favor of mandatory GM product labeling.<sup>1,3-5,12,24,28,29-30,32,40,46,47,53,56,58,60,63</sup> In 15.0%, they were in favor of voluntary labeling.<sup>9,23,31,43,52,61</sup> Young people were in favor of mandatory labeling, as shown in certain studies conducted in educational institutions.<sup>4,47</sup> Nutrition professionals and consumers agreed that mandatory labeling was necessary.<sup>3</sup>

In the interventions in which participants received information, their wish for mandatory labeling depended on: whether the information received was positive (clearly in favor of GM products), the label did not seem to be important, and whether the information was negative (clearly against GM products) or neutral (technical information without connotations), they expected the labeling to be mandatory.<sup>23,47</sup> Consolidated negative attitudes were difficult to change.<sup>4,36,61</sup> The information received (neutral, positive or negative) was a decisive factor in acceptance or rejection of GM products.

Consumers did not demand labeling nor oppose GM products if they perceived benefits for themselves, for farming or for the environment, and, of course, if no health risk was perceived.<sup>5,9</sup> According to the interviewees, educational material should explain the risks and benefits GM poses to the environment and to human health. They also declare that the actual labeling system does not meet customers' expectations.<sup>20</sup>

The rapid expansion of GM products contrasted with professed lack of knowledge, as was found in 17.5% of the articles.<sup>1,9,28,29,32,53,63</sup> In the interventions, consumers did not conclude that the tolerable level of GM material in the final product, of between 1.0% and 5.0%, made no difference to acceptance.<sup>23,55</sup> Nor did they find differences in accepting products manufactured using GM, but not containing it, and products that did contain GM.<sup>8</sup> The population underestimated the quantity of GN products they consumed.<sup>15,23,56</sup>

## DISCUSSION

As can be seen in the results, the consumer expressed a preference for non-genetically modified products but stated they would buy the article with the best price, in a market that welcomes new technologies. The population was shown to be in favor of mandatory labeling for GM products, although some studies show a preference for voluntary labeling. A lack of knowledge of GM was shown, as was, in some cases, an underestimation of the quantity consumed.

The impact of GM products is difficult, if not impossible, for the consumer to determine. However, it is assumed that their market, and consumption, would be affected if it was marked on the label that they were GM, the products being stigmatized.<sup>52</sup> Reading the selected articles revealed consumer uncertainty at not being able to distinguish easily between GM and non-GM products.<sup>8,11,14,23</sup> This would be solved by one single, standardized label.<sup>15</sup>

The responses to the studies were partly determined by the type of intervention conducted: while the results varied in the personal, telephone and mail results, the desire for mandatory labeling was higher after information was provided. The same occurred in groups, when the information provided to the population was neutral or negative towards the technology. Although mandatory labeling of GM products does not seem economically justifiable in all countries, it is a necessary alternative, offering consumers the information they are demanding.<sup>28,55</sup>

Sociodemographic data (age, sex, education) do not provide conclusive data as, whereas in some articles they appeared to be significant,<sup>46,63</sup> in others they were not.<sup>23</sup>

The higher quantity of interventions performed in the USA, a country in which labeling is voluntary, may be due to these products having been included on the shopping list since this technology began.<sup>6</sup> The most recent interventions did not take place in this country. The lack of population studies since 2007 may be a consequence of this technology being gradually, progressively incorporated and different legislations have adapted themselves to this new order. Tacit acceptance of GM may explain the lack of any more studies<sup>19</sup> and, perhaps, the lack of knowledge concerning GM.

Consumers who stated they paid attention to labels were those who were shown to have the least desire to consume GM products.<sup>1,10,25</sup> They were in favor of specific labels, for the right to knowledge and to making informed decisions.<sup>56,60</sup>

<sup>6</sup> Gruère GP, Carter CA, Farzin YH. Explaining international differences in genetically modified food labeling regulations. In: Annual Meeting of the American Agricultural Economics Association; 2004 Aug 1-4; Denver, Colorado. Paper N° 20341.

**Table.** Characteristics of the studies reviewed on genetically modified products and label information, until June 2012.

Article	Intervention	Population	Location	Year	Main conclusions
Dannenberg et al <sup>15</sup> 2011	Groups	n = 1,04; 84♀, 77♂ Age: 18-26 = 24; 26-40 = 57; 41-65 = 71; 66-75 = 9 University graduates = 41 Income: < 2,500 euros = 124; ≥ 2,500 euros = 36	Germany	2007	To give the respondents confidence it was explained that specific and effective mandatory labeling existed. A single, uniform label was suggested concerning non-GM <sup>e</sup> : (non-GM, 100% GM-free).
Bett et al <sup>6</sup> (2010)	Personal interview	n = 39; 3♀, 36♂ Mean age: industrial workers = 45 years old; Supermarket workers = 36 years old. Education: < sec = 16; ≥ sec = 23	Kenya	2006-2007	The respondents found traceability important, but they preferred not to label due to costs and possible adverse consumer reactions. Los
Kim <sup>25</sup> (2010)	Questionnaire	n = 202	Japan	2003-2004	The more attention the population paid to labels, the lower the desire to consume GM
Todd et al <sup>60</sup> (2009)	Telephone survey	n = 1,002 Age: ≥ 18 years old	Spain	2004	The respondents were in favor of specific labeling for GM, arguing the consumers' right to know and to make decisions.
Veeman et al <sup>61</sup> (2009)	Internet survey	n = 445	Canada	2003	The presence of labeled GM was associated with a high loss of utility, and lack of a label lead to gains in utility. Consumers were safer and more confident in a scene of voluntary labelling than in a situation where labeling was mandatory, or no labeling.
Shehata <sup>53</sup> (2008)	Telephone survey (Hawaii) Personal interview (Japan)	Hawaii n = 538; 229♀, 309♂ Age: < 18 = 23; 18-30 = 93; 31-50 = 165; 56-60 = 122; > 60 = 134 Education: < sec = 264; ≥ sec = 272 Income: < 60,999\$ = 306; ≥ 61,000\$ = 176 Japan n = 493	Hawaii and Japan	2006-2007	Both the Hawaiians and the Japanese surveyed firmly believed that GM fruit should be labelled.
Ramón et al <sup>67</sup> (2008)	Questionnaire before and after information	n = 500; 300♀, 200♂ Mean age: 17.4 years old	Spain	2007	Young Spaniards were strongly in favor of labeling/ they did not think it was a good idea to label conventional foods as GM free. They were moderately receptive to GM, but wanted to be better informed by the label.

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Radas et al <sup>46</sup> (2008)	Mail survey	N = 2,387 (375+2,012) Maine n = 375; 187 ♀, 188 ♂ Mean age: 50 years old White = 334; black = 19; other = 22 Mean income: 64,000\$ Rest of the USA n = 2,012; 1,046 ♀, 996 ♂ Mean age: 50 years old White = 1,509; black = 241; other = 262 Mean income: 55,000\$	Maine and the rest of the USA	2002	The respondents were in favor of labeling GM. GM labels were viewed as more credible than those of non-GM. Including contact information would resolve some of this uncertainty.	
Lusk et al <sup>31</sup> (2008)	Mail survey	n = 501	USA	2004	Those who declared that the government should impose mandatory labeling found that GM was less safe and wanted to buy and consume less GM than those who believed that the no labeling policy was correct.	
Scholder et al <sup>52</sup> (2008)	Personal interview	n = 210; 116 ♀, 94 ♂ Age: 18-44 = 158; > 44 = 52 race: white = 153; other = 57 Education: ≥ sec = 124 Mean income: between 25,000-34,999\$	USA.		Labeling should be voluntary, because if not, there would be stigma towards GM products.	
Batrimou et al <sup>4</sup> (2008)	Personal interview	n = 229; 124 ♀, 105 ♂ Mean age: 21.1 years old	Greece	2004-2005	GM products evoked negative attitudes (some even refusing to try GM foods) and people sa products which were certified by a public agency as more credible.	
Chembezi et al <sup>12</sup> (2008)	E Personal interview	n = 1,887 Mean age: 58 years old	USA	2002	The majority of respondents were in favor of mandatory labeling, although only half were in total agreement. Producers of principle food cultivation (rice, fruit and vegetables) were more in favor of mandatory monitoring.	
Bukenya et al <sup>10</sup> (2007)	Personal interview	n = 310	USA	2003	The more important labeling was to the consumer, the lower their desire to buy GM. The need for labeling was the result of perception, attitude and knowledge of the technology. Consumers were prepared to pay more for non-GM products, if they were labeled.	
Man-ser et al <sup>32</sup> (2007)	Personal interview	n = 940; 461 ♀, 479 ♂ age: 21-30 = 244; 31-50 = 470, > 50 = 226	Taiwan	2004	Labeling GM would be useful for Taiwanese consumers of tofuu, who stated their aversion or acceptant of this product.	

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Huffman et al <sup>13</sup> (2007)	Groups	n = 172; 107♀, 65♂ Mean age: 49.5 years old Mean education: ≥ 2 years of college Mean income: 57,000\$	USA	2001	The type of information provided to participants influenced their desire for GM labeling. No evidence was found that consumers could easily distinguish GM products in a market where labelling was mandatory. This demonstrated to the investigators that voluntary labeling was the best policy, in the US. There was no evidence that consumers called for GM products with 1% GM compared with 5% GM, which supports the proposed policy of a permitted 5% tolerance level, which would be cheaper for producers. Consumers were prepared to pay more to avoid GM products. This quantity did not vary according to the proportion of GM content. The label affects the desire to pay for the product; lower for GM.			
Abdulkadri et al <sup>1</sup> (2007)	Telephone survey	n = 128; 68♀, 60♂	Jamaica	2002	The respondents were strongly in favor of GM labeling and the stronger the opinion that they should be labeled, the lower the desire to buy GM.			
Carlsson et al <sup>11</sup> (2007)	Mail survey	n = 757 Age: 20-75 years old	Sweden	2004	Respondents were prepared to pay more to ensure total prohibition of GM. But when shopping and non-GM products were more expensive this affirmation was not put into practice.			
Februhartanty et al <sup>18</sup> (2007)	Personal interview	n = 400; 186♀, 214♂ Age: 18-29 = 189; 30-39 = 84; 40-49 = 84, 50-59 = 27, ≥ 60 = 16 Education: undergraduate = 131 postgraduate = 269	Indonesia	2003	The vast majority of the respondents stated that information should be provided on the label. The majority said it was an excellent idea to clearly label GM products and it was the task of the regulatory authorities to label.			
Tenbült et al <sup>39</sup> (2007)	Groups. Two studies	Study 1: n = 74; 43♀, 31♂ Mean age: 40.04 years old Study 2: n = 166; 140♀, 26♂ Mean age: 20.77 years old	Holland		It was difficult to classify GM products. Those who classified non GM products did so with more reliable criteria than those who classified GM products (vague perception, non-specific cognitive load regarding GM)			
Gaivoronskaia et al <sup>20</sup> (2006)	Mail survey	n = 488; 287♀, 201♂ Allergic = 251; Non allergic = 237 Age: 18-29 = 86; 30-49 = 212; 50-69 = 148; ≥ 70 = 42 Education: < sec = 273; ≥ sec = 215	Norway	2003	The vast majority of those surveyed (both with and without allergies) stated that a voluntary labeling system was not useful.			

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Nayga et al <sup>41</sup> (2006)	USA : telephone survey South Korea: Personal interview	USA n = 1,201; 673♀, 528♂ Education: ≥ sec = 664 Income: ≥ 50,000\$ = 600 South Korea n = 1,054; 516♀, 538♂ Age: 20-29 = 232; 30-39 = 358; 40-49 = 306; 50-59 = 158 Education: = sec = 495; > sec = 443 Income: < 20 million won = 221; 20-30 million won = 295; 40 million won = 242	USA South Korea	2003	Consumers who considered GM labeling to be necessary were less likely to approve genetic modification.	
Caniere et al <sup>21</sup> (2006)	Telephone survey	n = 256; 198 ♀, 58♂ Age: 20-24 = 6; 25-34 = 53; 35-44 = 43; 45-54 = 46; 55-59 = 16; 60-64 = 16; ≥ 65 = 50	USA	2002	A third of consumers interviewed were opposed to GM and this opposition appeared to be associated with support of mandatory labeling.	
Badrie et al <sup>2</sup> (2006)	Personal interview	n = 113; 66♀, 47♂ Age: 18-21 = 47; 22-33 = 34; 34-45 = 19; 46-60 = 13 Education: prim (1-5 years old) = 2; sec (6-12 years old) = 57; tert (13-16 years old) = 54	Trinidad and Tobago	2003	Half of the respondents felt that labeling GM should be allowed and found warnings, information and advertising on the label to be important.	
Lü <sup>39</sup> (2006)	Two stage intervention: - questionnaire - interview: alone and in group (discussion)	n = 2,006 Age: 16-65 years old	China	2003	All participants were in favor of labeling GM products. Educational level was the determining factor in this review.	
Bánáti et al <sup>3</sup> (2006)	Questionnaire after information	n = 556 256 of these people had a university degree in science and food technology	Hungary		No differences between the views of professionals and consumers were found, and the vast majority of respondents felt that GM labeling was absolutely necessary.	
Lusk et al <sup>30</sup> (2005)	Groups	n = 372 ♀	USA , England and France	2002	European participants considered a GM labeling policy beneficial, also found in the U.S.	
Miles et al <sup>36</sup> (2005)	Questionnaire after information	Italia n = 416; 207♀, 209♂ Mean age: 43.4 years old Norway n = 315; 161♀, 152♂ Mean age: 42.32 years old England n = 402; 202♀, 200♂ Mean age: 43.03 years old	Italy, Norway and England	2001	The participants had a greater desire to develop an effective traceability system to increase confidence and control over GM.	

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Knight et al <sup>26</sup> (2005)	3 stage study: -1 <sup>st</sup> part: interview importers/distributors - 2 <sup>nd</sup> part: interview consumers - 3 <sup>rd</sup> part: Point of sale data	1 <sup>st</sup> part, n = 17 2 <sup>nd</sup> part, n = 474 3 <sup>rd</sup> part, n = 409	1 <sup>st</sup> part Germany, Italy, UK, Holland and Greece 2 <sup>nd</sup> part New Zealand 3 <sup>rd</sup> part New Zealand	1 <sup>st</sup> part: there was no relationship between the countries cultivating GM and desire to import from these countries 2 <sup>nd</sup> part: there was no relationship between the countries cultivating GM and desire to buy these products at the supermarket 3 <sup>rd</sup> part: negative consumer attitudes towards GM concept, did not result in adverse effects on purchasing behavior.
Baumann et al <sup>5</sup> (2005)	Telephone survey	n = 280	Australia	2002-2003  The majority of respondents were in favor of GM labeling.
Marks et al <sup>13</sup> (2004)	Point of sale data		Holland	1997-2001  No significant change was observed in response to GM labeling purchase.
McCarthy Wolf et al <sup>24</sup> (2004)	Two stage personal interview	1 <sup>st</sup> stage: n = 882 2 <sup>nd</sup> stage: n = 324	USA and Ireland	1 <sup>st</sup> part: Irish consumers were in favor of mandatory GM labeling and had lower intention of buying GM. 2 <sup>nd</sup> part: US consumers desire for mandatory GM labeling increased
Loureiro et al <sup>28</sup> (2004)	Personal interview	n = 334; 184 ♀, 150 ♂ Mean age: 50.27 years old Mean education: < sec = 174, ≥ sec = 160	USA	Families on low incomes, those with higher education and those who were very concerned about the possible effects of GM on their children, were willing to pay for mandatory labeling. Mandatory labeling did not appear to be economically sustainable by citizens due to the high costs associated with traceability, testing and segregation.
Irani et al <sup>24</sup> (2004)	Personal interview	n = 342	USA	When the product was identified as containing GM, purchase attitudes toward it were less than when it was labeled as GM-free.
Mucci et al <sup>40</sup> (2003)	Groups	n = 40; 20 ♀, 20 ♂ Age: 20-50 years old	Argentina	No GM labeling was considered dangerous and worrying because of the possibility that the product produce allergies or environmental change: consumers wanted to see GM products labeled.

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Brown et al <sup>19</sup> (2003)	Groups	<p>Intervention 1: RRS n = 150, 106♀, 44♂ Mean age: 43.9 years old Race: white = 140, Afro-American = 10 Education: = sec = 59, &gt; sec = 91 Intervention 2: omega-3 n = 150; 105♀, 45♂ Mean age: 45.6 years old Race: white = 137, Afro-American = 13 Education: = sec = 56, &gt; sec = 94</p>	USA	<p>Voluntary labeling of GM increased consumer confidence. The information on the positive effects of GM did not replace the desire for GM labeling. The "genetically modified" legend was preferred.</p>
Zhong et al <sup>63</sup> (2002)	Telephone survey Investigation in newspapers	n = 480 personas n = 4 papers	China 2002 Review of newspapers from 1995 to 2001	<p>Respondents thought that GM should be labeled, and argued that the fact that the products were labeled would not change their attitude to GM. Stories about GM in newspapers began to appear from 1995, and from 1998 more stories, and therefore more articles against GM began to appear.</p>
Noussair et al <sup>63</sup> (2002)	Groups	n = 112; 60, 52 Mean age: 33 years old	France	<p>The studies indicated that despite the hostility towards GM in Europe, sales were not declining even when the label indicated that it was GM. They wanted lower prices for GM. Consumers were not aware of the label as they did not pay attention to that: standardization of labeling is recommended.</p>
Teisl et al <sup>56</sup> (2002)	Groups	<p>n = 56; 39♀, 17♂ Age: &lt; 50 = 37; ≥ 50 = 18 Education: Low level of education n = 11 Medium/High level of education = 45</p>	USA	<p>The population showed great skepticism towards GM-free logos, which were seen as a marketing strategy. Most said they wanted mandatory labeling, preferring that neutral labels and contact information be included. The provision of information on both sides of the container, simpler in the front and more detailed on the rear was preferred. Another view was that the FDA should be in charge of this labeling program.</p>
Subrahmanyam et al <sup>156</sup> (2000)	Questionnaire after information	<p>n = 417; 213♀, 204♂ Age: 15-19 = 155; 20s = 102; 30s = 63; 40s = 49; 50s = 38; ≥ 60 = 10 Education: &lt; sec = 4, sec = 93, &gt; sec = 320</p>	Singapore	<p>Most participants wanted the GM to be labeled in order to decide whether or not to consume these products.</p>

Continue

Continuation	Groups	Denmark, Germany, Italy, united Kingdom	There were no differences in accepting products containing GM in the final product (yoghurt) compared with those which did not contain it (beer), by which the researchers understood that the interviewees did not understand the difference between GM products and GM itself, and thought there had been a mix up.
Bredhal <sup>18</sup> (2000)	<p>n = 2,031</p> <p>Denmark n = 505</p> <p>Intervention with GM yoghurt n = 250; 150♀, 100♂</p> <p>Mean age: 45.1 years old</p> <p>Intervention with GM beer</p> <p>n = 255; 84♀, 171♂</p> <p>Mean age: 44.0 years old</p> <p>Germany n = 516</p> <p>Intervention with GM yoghurt n = 258; 150♀, 108♂</p> <p>Mean age: 43.2 years old</p> <p>Intervention with GM beer</p> <p>n = 258; 72♀, 186♂</p> <p>Mean age: 44.9 years old</p> <p>United Kingdom n = 499</p> <p>Intervention with GM yoghurt n = 250; 230♀, 20♂</p> <p>Mean age: 39.7 years old</p> <p>Intervention with GM beer</p> <p>n = 249; 67♀, 182♂</p> <p>mean age: 37.7 years old</p> <p>Italy n = 511</p> <p>Intervention with GM yoghurt</p> <p>n = 256; 110♀, 146♂</p> <p>mean age: 39.0 years old</p> <p>Intervention with GM beer</p> <p>n = 255; 102♀, 153♂</p> <p>Mean age: 37.5 years old</p>		

prim: primary; sec: secondary; tert: tertiary

<sup>a</sup> GM: genetically modified

For some consumers, the GM concept was associated with a loss of utility.<sup>55,61</sup> Thus, it did not seem, to them, a good idea to label conventional products as «GM free».<sup>47</sup> It was more credible to label GM products in contrast to non-GM products.<sup>46,58</sup> Including contact information partly resolved uncertainty about GM, even more so when the information was supported by certification by a state agency.<sup>4,18,46,55,58</sup>

The negative perception of GM products, in contrast with non-GM products,<sup>4,24,52</sup> may be due to consumers considering the non-GM products cause fewer environmental problems.<sup>39,40,46</sup> In the case of the article in which reports in newspapers,<sup>63</sup> it was noted that articles on GM products were more abundant and in a negative sense from 1995 onwards. In the US, greater desire for mandatory labeling of GM products began with the appearance of StarLink corn in the food chain.<sup>34</sup>

Distributors and wholesalers of GM products found traceability important, and even supported it, but they prefer not to label because of the costs and possible adverse consumer reaction.<sup>6,26</sup> Nor did these wholesalers and distributors show the desire to cease importation from countries producing GM items.<sup>26</sup>

When consumers accept GM products, they expect more competitive prices<sup>10,11,23,43</sup> and are prepared to pay a little more, a premium, if the label assures them that the product is non-GM.<sup>11,23,28,39,55</sup> Although they state that they prefer non-GM to GM products, evidence from supermarkets shows that consumers pay more attention to price than to containing GM, or otherwise.<sup>11,33</sup>

There is disparity in opinions concerning GM products, based on lack of knowledge of the topic in general (% of tolerance, presence or absence of GM in food, GM concept, among others).

Despite this lack of information, the population does not refrain from expressing their opinion. The information and sources from which the consumer receives it affect the way in which the market perceives GM products. This is directly related to the way in which they want to be informed by the label. Educational materials should present explanations of the risks and benefits GM poses to the environment and to human health.<sup>7,55</sup> The review detected that current labeling of GM products is not effective at informing the consumer.

It would be interesting to continue in the same vein as these articles, investigating the population's opinion and knowledge of these technologies. This allows an evaluation of the evolution of people's interest in what they consume and their understanding of labeling.

Although it is preferable to base a systematic review on studies with adequate follow up periods, as well as limit the review to studies with an appropriate design, guaranteeing scientific evidence of the final conclusions, it was decided to include all of the studies found that were deemed relevant, having studied behavior in relation to labeling and genetically modified food, and having passed the quality evaluation (STROBE).

To conclude, labeling needs to be homogeneous and explain the degree of tolerance of GM products, compared with non-GM, as well as explaining GM content, or otherwise, and the way in which these articles of consumption are manufactured. The label should also include contact data. In practice, consumers express a preference for non-GM products, but buy the article which has the best price in a market which welcomes new technologies.<sup>37,39</sup>

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