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The nutritional and toxicological value of organic vegetables

Consumer perception versus scientific evidence

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Abstract

Purpose – The present study aims to explore and compare consumer perception and scientific evidence related to food quality and food safety aspects of organic versus conventional vegetables.

Design/methodology/approach – Primary data on consumer perception were gathered in 2006-2007 through a consumer survey with Flemish adults ($n = 529$) and compared with scientific evidence from literature. Consumers of organic and conventional vegetables were selected by means of a convenience sampling procedure. Subjects were asked to complete a self-administered questionnaire concerning the perception of the nutritional and toxicological value of organic relative to conventional vegetables. Data processing and analysis included descriptive analysis (frequency distributions), data reduction (Cronbach's alpha test, factor analysis), bivariate analysis (correlations, *t*-test, ANOVA) and multivariate analysis (stepwise multiple regression).

Findings – It was found that organic vegetables are perceived as containing less contaminants and more nutrients, and as such, being healthier and safer compared to conventional vegetables. However, not enough evidence is currently available in the literature to support or refute such a perception, indicating a certain mismatch between consumer perception and scientific evidence. The gap between perception and evidence is larger among older consumers with children. The perception is stronger when the consumption frequency is higher, but is independent of gender, place of residence (rural or urban), education and income level. Also non-users, on average, perceive that organic vegetables have a nutritional and toxicological advantage over conventional vegetables.

Research limitations/implications – A non-probability convenience sampling method was applied which limits generalisation of the findings beyond the sample characteristics.

Originality/value – This paper is original in comparing consumer perception and scientific facts related to both nutritional and safety aspects of organic versus conventional vegetables.

Keywords Consumers, Perception, Organic foods, Vegetables, Safety, Belgium

Paper type Research paper

Introduction

The health benefits of an adequate consumption of vegetables and fruit and the role of this food group in preventing a variety of diseases such as cardiovascular diseases, certain cancers and obesity, has been recognised for quite some time now (Steinmetz and Potter, 1996; Ness and Powles, 1997; Hu, 2003; Bes-Rastrollo *et al.*, 2006). In relation

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to other foods, vegetables and fruits are important sources of vitamins, minerals, trace elements, dietary fibre and a large variety of beneficial phytochemicals. Although these plant foods are perceived as healthy by the majority of consumers, the dietary recommendation of eating at least five portions of fruits and vegetables a day is often not met by an important share of the population in many countries (WHO, 2003; Pomerleau *et al.*, 2004).

Besides nutrients, fruit and vegetables may also contain less favourable substances like environmental contaminants (e.g. nitrates, pesticide residues) and pathogenic micro-organisms (and their metabolites).

Growing consumer concerns about the quality and safety of foods due to the presence of these harmful contaminants are considered to be one of the major motives for the increased demand for organic foods (Magkos *et al.*, 2003a). The popularity of organic foods is reflected in the growth of the organic foods market in Belgium and other European countries (Abando and Rohner-Thielen, 2007; Samborski *et al.*, 2007). When comparing the market share of organic product groups in the Belgian market, it seems that vegetables have the second largest share after eggs. The present study is focused on vegetables.

The way in which consumers perceive organic-products has been investigated in a number of studies, and has been reviewed for example in Bonti-Ankomah and Yiridoe (2006). However, until now no study on consumer perception of organic food in general, or organic vegetables in particular, has yet been undertaken in Belgium.

Based on existing consumer science literature, organic foods are mainly perceived as healthier and safer compared to conventional foods. From a scientific point of view however, there is currently not enough evidence to unconditionally recommend organic foods over conventionally produced foods (Williamson, 2007; Hoefkens *et al.*, 2008). In response to a potential mismatch between consumer perceptions and scientific facts, the objective of this paper is to explore Flemish consumer's (subjective) perception of organic vegetables, relative to conventional vegetables, and to compare these findings with current scientific (objective) knowledge and consensus. This investigation and comparison generate new insights for further research and communication for both organic and conventional vegetables.

Methodology

Study design and subjects

A quantitative survey was conducted in Flanders, Belgium, during the period of December 2006-February 2007 by means of structured questionnaires. The present study was part of a large-scale research project about comparing organic food and farming with the conventional alternative (Van Huylenbroeck *et al.*, 2007). The population for the consumer survey consisted of adults (age range 18-84) to make sure that the respondents were at least now and then responsible for food purchase. In addition to the overall population, we targeted specifically people who are a member of the Flemish organisation VELT that promotes an ecological lifestyle. This choice was informed by our interest in comparing heavy users of organic vegetables (whom we expected to recruit from the VELT members) versus medium and low users of organic food (whom we expected to recruit from the general population). In total 529 respondents, including 281 women (53.1 per cent) and 248 men (46.9 per cent), were personally contacted and asked to complete a self-administered anonymous questionnaire. About half of this sample ($n = 266$) are member of VELT, thus people who can be considered to be more

highly involved in organic food. It should be noted that these subjects have been excluded from descriptive analyses as reported further in this paper when talking about "Flemish consumers". The reason is that the non-members are considered to be more representative for the overall (Flemish) population.

A non-probability convenience sampling procedure was applied with a view to obtain a representative distribution of socio-demographic characteristics. The distribution of the characteristics such as gender, age, place of residence (rural versus urban based on urbanisation degree, respectively below and above 300 inhabitants/km^2) (Lauwers *et al.*, 2004), presence and age of children, education and income cover a wide range and are shown in Table I (in per cent). Concerning the age, a small over-sampling of older respondents occurred due to the fact that respondents had to be responsible for food purchasing. The over-representation of higher educated respondents and the higher proportion of respondents with adult children and with a relatively higher income is probably due to the convenient character of the sampling. Therefore, it is not advisable to generalise the findings beyond the sample characteristics.

	%
Gender	
Male	46.9
Female	53.1
Age (years)	
18-25	8.9
26-40	22.3
41-50	32.1
26.7	
65 +	10
Mean (standard deviation)	46.7 (14.1)
Children in the household	
Yes	76.4
No	23.6
Education	
<18 years	5.9
18 years	34.2
>18 years	59.9
Family income (€/month)	
<1,000	2.8
1,000-1,500	10
1,500-2,500	12.7
2,500-3,000	16.1
>3,000	27.4
No answer	15.5
Urbanisation degree of residence	
Urban (>300 inh/km2)	70.5
Rural (≤300 inh/km2)	28.0
No answer	1.5

Table I.
Sample characteristics

Note: $n = 529$

Questionnaire

The questionnaire's purpose was to assess consumers' perception of organic vegetables relative to conventional vegetables with regard to food quality attributes in general, and food safety in particular. Using several statements and answer categories on a seven-point interval scale ranging from "totally not agree" over "neutral" to "totally agree", respondents were asked to evaluate the potential added value of organic vegetables on seven attributes:

(1) nutritional value (in general);
(2) health;
(3) safety;
(4) level of contamination (both in general and more specific in terms;
(5) pesticide residues;
(6) pathogenic micro-organisms; and
(7) mycotoxins (see Table II).

Based on the mean scores for the individual attributes, a general added value score was computed.

Finally, to identify consumer segments, respondents were also questioned about their consumption behaviour and socio-demographic characteristics including gender, age, place of residence, education, family income and household composition.

Statistical analyses

The questionnaire was pretested and refined before starting the survey. Statistical analyses were carried out with the software program SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Significance was assessed at $\alpha = 0.05$.

Consumer perception measures are summarized in table format as mean scores and standard deviations on a seven-point scale. In addition, frequency distributions are provided in recoded categories ((slightly) negative perception, neutral (slightly) positive perception). Cronbach alpha was used to estimate the proportion of variance that is consistent in a set of scores. Following factor analysis and reliability testing, a composite measure of perception related to organic vegetables was computed. Independent samples *t*-tests and ANOVA *F*-tests with Duncan post hoc comparison of mean scores were applied for detection of differences in consumer beliefs and perception between different socio-demographic and user groups (non user, light user, medium user, heavy user of organic fruit and vegetables). Stepwise linear regression was used to determine the predictive value of the nutritional value and safety attributes for the health perception.

Results

Sample characteristics

An interesting criterion used to subdivide the study population is the claimed share of organic in total claimed vegetable consumption. Respondents with a zero contribution are referred to as non-users. The contribution of organic vegetables for light, medium and heavy users is respectively defined at $\leq$ 20 per cent, 20-80 per cent and $>$ 80 per cent. Based on these definitions, about half of the sample are classified as medium users (47 per cent), whereas less than 10 per cent are non-users (9 per cent). Light users

Table II. Consumers' perception of organic versus conventional vegetables mean score and standard deviation (SD) on seven-point scale

Item: organic vertables compred to conventional vegetables are/contain …	Totally disagree/ disagree	Slightly disagree	Neutral	Slightly agree	Agree/totally agree	Mean	SD
General beliefs							
Healthier	2.8	4.0	9.5	12.3	71.5	5.94	1.38
Better controlled	4.3	7.9	21.2	17.4	49.1	5.22	1.50
Nutrient content belief							
More nutrients (e.g. vitamins and minerals	11.3	8.7	18.3	14.9	46.7	5.01	1.79
Contaminant content beliefs							
Less contaminants (e.g. pesticides and nitrates)	1.7	3.6	6.4	12.9	75.4	6.07	1.25
No synthetic pesticide residues	6.8	7.4	11.5	14.2	60.1	5.48	1.64
Less harmful micro-organisms[a]	6.8	14.4	25.9	15.7	37.2	4.85	1.62
Less mycotoxins[a]	7.4	11.0	28.7	14.0	38.9	4.87	1.62

Notes: Figures are percentages; $n = 529$; Categories "totally disagree" and "disagree", and "agree" and "totally agree", from the initial seven-point scale have been merged for clarity of presentation; statistical analyses as reported in the text have been performed with the original seven-point date. [a]Item asked in the negative (or more harmful micro-organisms/mycotoxins); inverse coded for inclusion in composite construct

and heavy users are almost equally represented, respectively 21 and 23 per cent. The socio-demographic profile of the sample is represented in Table I.

General perception of organic versus conventional vegetables

The results of the consumer perception survey on organic versus conventional vegetables are reported in Table II. The mean perception scores on all the attributes are around five on a seven-point scale and differ significantly between organic and conventional vegetables. This indicates that, in general, consumers perceive organic vegetables positively, and more positively than conventional vegetables. Compared to conventional vegetables, they believe that the nutritional and toxicological value of organic vegetables is better. It is apparent from Table II that the highest mean perception scores (in favour of organic vegetables) correspond to the perceived contaminant content ($\mu = 6.07$) and healthiness ($\mu = 5.94$). A relatively less positive perception is attached to the attributes of microbiological contamination, i.e. less mycotoxins ($\mu = 4.87$) and less harmful microorganisms ($\mu = 4.85$). With respect to the pesticide residue level and the nutrient content in general, the respondents attributed a mean score of 5.48 and 5.01 respectively. Finally, respondents (slightly) agree that organic vegetables are more controlled than their conventional alternative.

In order to explore similarities and differences in beliefs and perceptions related to organic vegetables, data were reduced through factor analysis. A principal components factor analysis with varimax rotation of the seven items revealed only one meaningful factor. The Cronbach alpha coefficient for these items was 0.73, denoting good and acceptable internal consistency reliability (Nunnally, 1978). For further analysis, a composite construct score was computed, hereafter referred to as "perceived added value of organic" relative to conventional vegetables. In case of significant differences in this composite measure, the mean scores for the individual items were also compared between the groups.

Socio-demographic differences in perception of organic versus conventional vegetables

Perceived added value of organic increased with increasing age ($r = 0.288; p < 0.01$). Significant differences were observed between the age category 18-25 years and the category above 25 years ($p < 0.001$), with the latter reporting higher perceived added value of organic. Additionally, in the above 25 age group the perception differed significantly between the subgroups 26-40 years and 51 + years ($p = 0.002$), again with the older age group reporting more positively. On each individual item level, a consistent difference was found between the youngest age group (18-25 years) and the other groups. Respondents with children reported a more positive perception of organic vegetables compared to conventional vegetables ($p < 0.001$). Specifically, the presence of children positively affected the perception on the attributes of pesticide residue level, contaminant content, nutrient content and healthiness ($p < 0.05$). When comparing consumer perception between different income classes, a significantly higher agreement ($p = 0.004$) was observed for respondents with a family income between €1,000-1,500/month compared with respondents having an income between €2,500-3,000/month. However, no correlation was found between perception and income level ($p > 0.01$). Gender, place of residence and education level had no significant impact on the overall perception of organic having nutritional and toxicological advantages over conventional

vegetables. When considering the mean perception scores for each item and socio-demographic group, consistently the attributes of healthiness and contaminant content were indicated as the main positive attributes of organic vegetables (see Table III).

Organic versus conventional vegetables: differences in perception according to consumption level

As could be expected, heavy users (> 80 per cent of vegetable consumption is organic) on average hold the strongest favourable beliefs about organic compared to conventional vegetables ($p < 0.001$). Compared to the other user groups, heavy users perceive organic vegetables as being significantly healthier ($\mu = 6.66$) and better controlled ($\mu = 5.87$), and containing more nutrients ($\mu = 5.87$), less contaminants ($\mu = 6.55$), no synthetic pesticide residues ($\mu = 6.31$), less harmful micro-organisms ($\mu = 5.18$) and less mycotoxins ($\mu = 5.26$) ($p < 0.05$). The mean scores indicate that the attributes of healthiness and contamination level are the major arguments in favour of organic vegetables (see Table IV). Medium users (organic's claimed share between 20 and 80 per cent) perceive organic vegetables more positively than light users (≤ 20 per cent) ($p < 0.001$), who in turn have a slightly better perception than non users ($p > 0.05$). Less expected is that also non-users on average believe in the nutritional and toxicological benefits of organic vegetables compared to the conventional alternative. This can be explained by the fact that non-users have other than food content related arguments for not buying organic foods. Preferences of consumer groups and underlying arguments as determined in a choice experiment are described in another paper (Mondelaers *et al.*, 2009). When comparing medium users with light users on individual item level, the mean perception scores for all attributes are significantly higher for the first group ($p < 0.05$) except with respect to perceived contamination with harmful microorganisms where no significant difference was found ($p = 0.123$). Also medium, light and non-users assigned the highest score to the attributes of healthiness and contaminant level (see Table IV).

Another grouping variable considered here is the membership in the Flemish organisation VELT that promotes an ecological lifestyle. The mean perception scores for the seven-item construct as well as for the individual items are, as could be expected, significantly higher for the members in comparison with non-members ("Flemish population") ($p < 0.05$). Regardless of the membership, the items concerning contaminant concentration and healthiness are again the major arguments in favour of organic vegetables (see Table IV). When comparing the members with the heavy user group of non-members, no significant differences are found in the overall perception. However, the perception of the healthiness and mycotoxin level differ significantly between both groups, with a higher score for the members.

Perceived healthiness of organic vegetables in function of other attributes

The comparison of consumers' health perception of organic and conventional vegetables with the perception of nutritional and toxicological aspects resulted in significant correlations ($p < 0.01$). In other words, consumers who considered organic vegetables to be healthier than the conventional variant also perceived organic vegetables as containing/being (in decreasing order of correlation): less contaminants ($r = 0.572$), more nutrients ($r = 0.538$), no pesticide residues ($r = 0.435$), safer

Table III.
Socio-demographic difference in consumers' perception of organic versus conventional vegetables

Sample characteristics	Item: Healthier Mean	SD	More nutrients Mean	SD	Less contaminants Mean	SD	No synthetic pesticide residues Mean	SD	Less harmful micro-organisms Mean	SD	Less mycotoxins Mean	SD	Better controlled Mean	SD	Overall added value Mean	SD
Gender																
Male	5.95	1.39	4.99	1.83	6.13	1.18	5.46	1.68	4.82	1.64	4.88	1.63	5.29	1.43	5.36	1.00
Female	5.94	1.38	5.02	1.75	6.02	1.30	5.49	1.60	4.87	1.61	4.86	1.62	5.15	1.56	5.31	1.03
Age (years)																
18-25	4.66*	1.55	3.64*	1.54	5.23*	1.18	4.64*	1.54	4.36*	1.52	4.13*	1.24	4.60*	1.41	4.43*	0.77
26-40	5.69**	1.61	5.02**	1.79	5.94**	1.25	5.05*	1.79	4.68*,**	1.51	4.80**	1.41	5.13**	1.45	5.21**	1.00
41-50	6.09***	1.21	5.09**	1.67	6.14**	1.20	5.58**	1.52	4.88*,**	1.49	4.91**	1.63	5.22**	1.46	5.40**,***	0.98
51-65	6.30***	1.07	5.14**	1.80	6.28**	1.22	5.82**	1.57	4.99**	1.83	5.06**	1.76	5.45**	1.44	5.55***	0.96
65 +	6.23***	1.22	5.57**	1.82	6.32**	1.24	5.94**	1.47	5.19**	1.69	5.06**	1.82	5.34**	1.84	5.62**	1.00
Children in the household																
Yes	6.11††	1.27	5.12††	1.78	6.17††	1.23	5.65††	1.55	4.92††	1.63	4.93††	1.66	5.28††	1.50	5.44††	0.98
No	5.42†	1.61	4.66†	1.76	5.74†	1.25	4.92†	1.78	4.63†	1.58	4.67†	1.49	5.02†	1.49	5.00†	1.06
Education																
<18	6.39**	1.05	5.74*	1.44	6.06	1.63	6.03	1.52	4.87	1.69	5.32	1.72	5.55	1.55	5.61	1.02
≤ 18	6.08*,**	1.30	5.31*,**	1.71	6.06	1.31	5.51	1.56	4.78	1.59	4.85	1.68	5.23	1.54	5.40	1.02
>18	5.82*	1.44	4.76*	1.82	6.08	1.17	5.40	1.68	4.89	1.64	4.84	1.58	5.18	1.48	5.27	1.00
Family income (€/month)																
$<1{,}000$	6.33**	1.11	5.40*,**	1.88	6.00	1.31	5.60*,**	1.84	4.73*	2.15	4.73	1.75	4.80*	2.08	5.33*,**	1.11
1,000-1,500	6.26**	1.24	5.68**	1.37	6.15	1.46	5.92**	1.21	5.49**	1.51	4.94	1.74	5.72**	1.63	5.68**	1.00
1,500-2,000	5.97**	1.36	4.96*,**	1.75	4.96*,**	1.21	5.60*,**	1.72	4.63*	1.67	4.96	1.54	5.31*,**	1.41	5.34*,**	1.11
2,000-2,500	6.00*,**	1.40	5.01*,**	1.74	6.22	1.14	5.82*,**	1.34	4.91*,**	1.61	4.87	1.71	5.43*,**	1.33	5.49*,**	0.92
2,500-3,000	5.91*,**	1.42	5.02*,**	1.70	5.76	1.39	5.09*	1.82	4.54*	1.67	4.85	1.56	5.12*,**	1.36	5.20*	0.91
$>3{,}000$	6.02*,**	1.25	4.90*,**	1.87	6.26	1.09	5.48*,**	1.61	4.84*,**	1.57	4.84	1.65	5.19*,**	1.51	5.33*,**	0.96
No answer	5.49*	1.62	4.72*	1.96	5.78	1.28	5.11*	1.77	4.90*,**	1.53	4.85	1.57	4.83*	1.58	5.10*	1.15
Residence																
Urban	6.00	1.33	5.02	1.80	6.12	1.20	5.50	1.60	4.87	1.66	4.87	1.66	5.29	1.50	5.37	1.02
Rural	5.81	1.47	4.96	1.77	5.98	1.29	5.47	1.72	4.80	1.56	4.87	1.56	5.09	1.53	5.27	1.01

Notes: *,**,*** indicate significantly different means using ANOVA *F*-tests with Duncan post hoc test on a seven-point scale (1 = totally disagree; 7 = totally agree); †,††indicate significantly different means using independent samples *t*-tests on a seven-point scale (1 = totally disagree; 7 = totally agree); $n = 529$

Table IV.
Consumers' perception of organic versus conventional vegetables in function of consumption behaviour and VELT membership

	Item															
	Healthier		More nutrients		Less contaminants		No synthetic pesticide residues		Less harmful micro-organisms		Less mycotoxins		Better controlled		Overall added value	
Sample characteristics	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
User group																
Nonuser	4.96*	1.88	4.34*	1.85	5.47*	1.59	4.66*	1.90	4.28*	1.51	4.45*	1.49	4.833*,**	1.66	4.70*	0.98
Light user	5.27*	1.55	4.20*	1.83	5.58*	1.34	4.95*	1.72	4.63*,**	1.48	4.48*	1.58	4.72*	1.38	4.83*	0.95
Medium user	6.09**	1.16	5.08**	1.67	6.17**	1.14	5.47**	1.58	4.90**,***	1.58	4.94**	1.53	5.20**	1.49	5.37**	0.92
Heavy user	6.66***	0.82	5.87***	1.53	6.55***	1.12	6.31***	1.12	5.18***	1.80	5.26**	1.81	5.87***	1.35	5.99***	0.87
VELT member																
Yes	6.56††	0.83	5.65††	1.57	6.53††	0.87	5.98††	1.35	5.10††	1.73	5.20††	1.66	5.59††	1.38	5.80††	0.85
No	5.32†	1.55	4.36†	1.76	5.61†	1.39	4.97†	1.74	4.60†	1.47	4.53†	1.52	4.84†	1.53	4.86†	0.94

Notes: *,**,***indicate significantly different means using ANOVA *F*-tests with Duncan *post hoc* test on a seven-point scale (1 = totally disagree; 7 = totally agree); †,††indicate significantly different means using independent samples *t*-tests on a seven-point scale (1 = totally disagree; 7 = totally agree); $n = 529$

($r = 0.387$), less mycotoxins ($r = 0.216$) and less harmful micro-organisms ($r = 0.120$). Despite being significant at $p < 0.01$, the correlation coefficients (r) range between 0.120 and 0.572, indicating that the relationships between the health attribute and remaining attributes are rather weak.

Stepwise multiple regression analysis was performed to develop equations involving food quality and food safety attributes that most contributed to the health perception of organic vegetables. The final model and results are shown in Table V. The lower contaminant level was the first variable entered into the equation for predicting the health perception of organic. The second, third and fourth variable entered, were the higher nutrient content, the zero pesticide residue content and the lower mycotoxin level respectively. The variables "better controlled" and "less harmful micro-organisms" did not meet the significance level requirement for entry into the model ($p < 0.05$). Although the absence of pesticide residues in organic increased the *R*-square of the equation, it was obvious that the pesticide residue level did not add to the predictive value of the model.

The correlation and stepwise regression analyses indicate that the contaminant and nutrient content are the two major drivers for consumers to believe in the health advantage of organic over conventional vegetables. In addition, it appears that other than food related arguments contribute to consumers' health perception of organic vegetables, as only 48.6 per cent of the total variation in health perception is explained by the proposed model of four variables.

Discussion – facts versus perception

Toxicological advantage of organic vegetables versus conventional vegetables

The statements:

(1) "Organic vegetables contain less contaminants . . . "

(2) "Organic vegetables contain no synthetic pesticide residues".

All foods, regardless of the production method, need to be ensured that they are sufficiently safe to be consumed. The question is whether the consumption of conventionally grown food provides any greater safety-related risks to consumers than organic food. Given the prohibition to use synthetic pesticides and synthetic fertilizers (containing nitrogen) in an organic farming system, it is reasonable to assume that organically grown food will in general contain lower amounts of pesticide residues and of nitrate levels.

Although in the international public literature, few data on pesticide residues in organic foods are available, scientific literature indicates that conventionally grown

Variables entered	Correlation	Estimation	Standardised beta	*t*-value	*p*-value
(Constant)		0.97		3.967	<0.001
Less contaminants	0.572	0.428	0.387	10.698	<0.001
More nutrients	0.538	0.281	0.363	10.775	<0.001
No synthetic pesticide residues	0.435	0.103	0.121	3.341	0.001
Less mycotoxins	0.216	0.083	0.097	3.056	0.02

Notes: Variables not entered in the model: better controlled ($r = 0.387$), less micro-organisms ($r = 0.120$). Model goodness-of-fit: $R^2 = 48.6$ per cent; $n = 529$

Table V.
Stepwise linear regression: explanatory variables for perceived health of organic vegetables

foods are more likely to contain (single and multiple) pesticide residues than organic foods. Furthermore, the residue levels in organic foods are consistently lower compared to conventional foods (Slanina, 1995; Woese *et al.*, 1995; Woese *et al.*, 1997; Bitaud, 2000; Baker *et al.*, 2002). However, these findings do not mean that organic and conventional foods necessarily contain (detectable) amounts of pesticide residues (Fjelkner-Modig *et al.*, 2000; Hajslova *et al.*, 2005). Given these data, it can be concluded that consumers' beliefs about the absence of residues of synthetic pesticides is to a large extent supported by scientific evidence. On the basis of the Flemish survey sample, a majority of the respondents (62 per cent) also agreed with the idea.

Another relatively consistent finding is that organic vegetables tend to have lower nitrate levels (Woese *et al.*, 1995; Woese *et al.*, 1997; Bourn and Prescott, 2002). The use of lower amounts and less available sources of nitrogen in organic farming (e.g. compost) is likely to be the underlying reason. For some vegetables with a lower nitrate accumulating capacity like seed and bulb vegetables, the fertilisation practices appear to have less influence on the nitrate content. Consequently, lower and equal amounts of nitrate between organic and conventional vegetables are reported in literature (Woese *et al.*, 1997).

Less evidence exists concerning the relative content of heavy metals (e.g. cadmium, arsenic) between organic and conventional products. From the limited data available, no major differences are observed. Given equal possibilities for heavy metals to be absorbed in plant foods of organic and conventional production, no significant differences are expected. Cadmium could be an exception due to the use of sewage sludge in conventional farming, which could eventually lead to higher cadmium levels in conventional vegetables. However, no differences were detected for cadmium in the comparative studies evaluated for the two forms of cultivation (Woese *et al.*, 1997; Jorhem and Slanina, 2000; Malmauret *et al.*, 2002; Magkos *et al.*, 2006).

Taking these facts into consideration in combination with the possibility that consumers have their own interpretation of the term "contaminant", it is quite understandable that consumers perceive organic vegetables as being less contaminated compared to conventional vegetables ($\mu = 6.07$). Additionally, it appears from the correlation and stepwise regression analyses that the contaminant content (relatively to the other attributes) is consumers' most important food content-related motive for believing in the health advantage of organic vegetables ($r^2 = 0.327$).

The statements:

(3) "Organic vegetables contain less harmful micro-organisms . . ."

(4) "Organic vegetables contain less mycotoxins . . ."

The question of whether the consumption of organically grown vegetables causes any greater microbiological risk to consumers than conventional vegetables remains unclear. Several studies indicate higher bacterial contamination in organically versus conventionally grown crops, while others show no difference (Avery, 1998; Johannessen *et al.*, 2004; Mukherjee *et al.*, 2004). Some authors have suggested that, given the use of animal manure and the prohibition of fungicides and some food additives in organic production practices, organically produced foods may have an increased risk of microbiological contamination (Stephenson, 1997; Avery, 1998). However, other research found that most pathogens were destroyed due to the high

temperature during the composting period (Amlinger, 1993; Food Standards Agency (FSA), 2000).

Scientific evidence is currently insufficient to state that organically grown food is more prone to microbial or mycotoxin contamination than conventionally grown food. Although science is inconclusive in this matter, consumers' perception on both the statements of harmful micro-organisms and mycotoxins is in favour of organic vegetables with a mean perception score of about 5 ("slightly agree") on a seven-point scale. In this case where science is more undecided, consumers are also less convinced. Specifically, 28.7 per cent (micro-organisms) and 25.9 per cent (mycotoxins) of the sample are also undecided (responding neutral on the seven-point scale). The proportion of consumers scoring neutral is clearly lower for the other attributes, with the exception of the attribute "better-controlled" (21.2 per cent).

Statement:

(5) "Organic vegetables are better controlled . . . "

A mean perception score of 5.22 was obtained for the statement that organic vegetables are better-controlled than conventional vegetables. This indicates that consumers in general perceive organic vegetables to be more subject to quality and safety controls compared to conventional vegetables. From a scientific point of view however, it is not possible to draw a valid conclusion on that statement as no qualitative and quantitative data is available on the relative frequency and intensity of quality and safety controls of organic versus conventional vegetables.

Nutritional and health benefits of organic vegetables versus conventional vegetables

Statements:

(6) "Organic vegetables contain more nutrients . . . "

(7) "Organic vegetables are healthier . . . "

The results of the consumer survey suggest that consumers believe that organic vegetables are healthier than conventional vegetables, partly owing to their perceived nutrient content (e.g. vitamins and minerals). With the possible exception of vitamin C content, there is not enough scientific evidence that organic and conventional vegetables differ in nutritional value (Woese *et al.*, 1997; Magkos *et al.*, 2003b; Rembialkowska, 2007, Williamson, 2007). A large number of inconsistent results are observed from comparative studies in the literature. As it is the case for microbiological contamination, consumers overestimate the nutrient content of organic relative to conventional vegetables. About 60 per cent of the respondents score 5 ("slightly agree") or more ("totally agree") on the seven-point scale. Besides the nutrient content, another important motive for consumers to believe in the health benefits of organic vegetables is the lower contamination level of organic compared to conventional vegetables. From the correlation and regression analysis, it is apparent that consumers have a higher credence in the health benefit of less contaminants than of more nutrients. This finding should come as no surprise, given that unfavourable communication related to food health issues weigh more heavily in consumers' food consumption decisions than favourable news (Robenstein and Thurman, 1996; Kinnucan *et al.*, 1997) (see Table VI).

Table VI.
Summary table

Item	Scientific evidence	Consumer perception
Healthier	Inconclusive	Organic > conventional
More nutrients	Inconclusive	Organic > conventional
Less contaminants	Mostly in favour of organic	Organic > conventional
No synthetic pesticide residues	Organic > conventional	Organic > conventional
Less harmful micro-organisms	Inconclusive, but mostly in favour of conventional	Organic > conventional
Less mycotoxins	Inconclusive, but mostly in favour of conventional	Organic > conventional
Better controlled	Inconclusive	Organic > conventional

Conclusion

Important gaps have been observed between consumer perception and current scientific evidence concerning the nutritional and toxicological value of organic vegetables compared to conventional vegetables. Although current scientific literature cannot state that organically produced vegetables are superior to conventionally produced alternatives, consumers on average belief that organic vegetables are better. In other words, consumers in general seem to overestimate the nutritional and toxicological benefits of organic vegetables, with the exception of synthetic pesticide residues. The gap between facts and consumers' perceptions appear to be the largest for the health character, nutritional value and microbiological safety of vegetables, especially among older consumers with children. The contaminant and nutrient content of organic vegetables are the two major drivers, among considered attributes, for consumers to believe in the health advantage of organic over conventional vegetables. The mismatch is also stronger when the consumption frequency is higher, but is independent of gender, place of residence, education and income level. Where science is more undecided, consumers' perception of organic versus conventional vegetables may be based on stereotypes, image transfer and emotion instead of factual knowledge and personal experience. In the future, more research is needed to strengthen scientific evidence about relative benefits and risks of organic compared to conventional vegetable consumption, as such that consumers can make decisions based on correct and objective information. Future research is also needed to verify the results of the present study that is based on a relatively small sample size and non-probability convenience sampling method, with larger and statistically representative consumer samples. An important basis for further research is now provided as new insights into basic beliefs and perceptions of a sample of Flemish consumers concerning organic versus conventional vegetables are generated here.

Managerial implications from this study mainly pertain to product positioning and communication strategies. The present study indicates that organic vegetables benefit from favourable consumer perceptions, some of which cannot be backed up scientifically. From the perspective of the organic vegetable sector, it seems dangerous to exploit propositions that are not fully scientifically backed up in their product positioning and communication strategies. A recommendation from this study would be to capitalise rather on emotional value than providing rational argumentation for the choice of organic vegetables. An opposite strategy could obviously be recommended to the conventional vegetable industry. Given the inconclusiveness of

current scientific evidence, it is recommended from a public and health policy point of view, to further aim at stimulating vegetable consumption in general without differentiating between the eventual organic or conventional origin of the produce.

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