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Organic Tomatoes Versus Canned Beans: How Do Consumers Assess the Environmental Friendliness of Vegetables?

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Abstract

The assessment of a food product's environmental friendliness is highly challenging for consumers because such an assessment requires the consideration of various product characteristics. Furthermore, products often show conflicting features. This study uses a choice task and a questionnaire to examine how consumers judge the environmental friendliness of several vegetables. The consumers' assessment is compared with life cycle assessment (LCA) results, which represent the overall environmental impact of a product throughout its lifespan. In contrast to the LCA, consumers consider transportation distance rather than transportation mode and perceive organic production as very relevant for the environmental friendliness. Furthermore, consumers assess the environmental impact of packaging and conservation as more important than the LCA results show. Findings also suggest the current product information for vegetables is insufficient for judging their environmental friendliness. Implications for information campaigns and ecological food labeling are discussed.

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Food consumption has been estimated to contribute to 20% to 30% of the total environmental impact in the Western world (Tukker & Jansen, 2006), and food consumption patterns in industrialized countries exceed the recommended greenhouse gas (GHG) emission for sustainable development by a factor of 4 (Carlsson-Kanyama, 1998). GHG emissions from different meals with the same caloric and protein content can vary by a factor of 9, depending only on the ingredients. Thus, with food choices, consumers can substantially contribute to sustainable development. To the best of the authors' knowledge, little research has examined which factors consumers pay attention to when choosing environment-friendly (EF) food products. The present study, therefore, aimed to investigate how consumers choose the most EF alternative. Moreover, this study examined whether laypeople's assessments differ from life cycle assessment (LCA) results.

Past research on consumers' perception and behavior related to sustainable food has focused on the consumption of organically produced food (e.g., Grunert & Juhl, 1995; Magnusson, Arvola, Koivisto Hursti, Aberg, & Sjödén, 2003; Squires, Juric, & Cornwell, 2001; Tregear, Dent, & McGregor, 1994; Wandel & Bugge, 1997). However, the EF assessment of a product requires the consideration of additional product features such as transportation, conservation, and packaging (Jungbluth, 2000). Ideally, an EF food product is domestically produced rather than imported from abroad; furthermore, it is organically grown, seasonal, fresh (rather than frozen), and unwrapped (Tanner, Kaiser, & Kast, 2004; Tanner & Kast, 2003).

Tanner and Kast (2003) considered all these dimensions and found EF food purchases were facilitated when consumers had the knowledge to distinguish between EF and environmentally harmful products. Thus, if consumers judge the EF of food products correctly, they may be better able to choose green food products.

However, the EF assessment of a food product is challenging for consumers. First, the environmental impact of a food product is not directly observable and, therefore, has to be deduced in a rather complex procedure (Tanner & Jungbluth, 2003). Second, food products rarely fulfill all ecological requirements and frequently show conflicting features (e.g., a regional vegetable that stems from greenhouse production or a field-grown alternative that is imported from overseas). Thus, consumers have to weigh these characteristics and make tradeoffs to reach an appropriate EF decision.

Making tradeoffs is one of the most difficult challenges in decision making because different objectives have to be pursued simultaneously, and each objective has its own basis of comparison (Hammond, Keeney, & Raiffa, 2002). Decision difficulty is substantially increased when attribute values show negative correlations between different alternatives (Hastie & Dawes, 2001). Few studies have examined how consumers judge the EF of food products if they are faced with such conflicting product features (e.g., Tanner, 2008; Tanner & Jungbluth, 2003).

LCAs of products use a multiattribute assessment method. All environmental impacts are measured and weighted according to their environmental importance. Such an elaborate assessment method is difficult for consumers because working memory capacity limits the amount of information they can process within a reasonable time frame (Bettman, Johnson, & Payne, 1991). It was, therefore, assumed that laypeople use few information cues and that consumers' EF assessments accordingly differ from LCA results. So far, no study has directly compared consumers' EF assessments of food products to LCA results. Such a comparison seems worthwhile, as it could reveal consumers' misconceptions about the environmental impact of food characteristics. This would provide useful information for campaigns or education material addressing EF food choice.

In sum, the present research aimed to determine what consumers believe to be relevant for the EF of food characteristics and to find out whether consumers are able to correctly assess the EF of food products. Consumers' EF assessment of various product features was compared to LCA results to determine whether the assessments differed, and if so, in what respect. Furthermore, the authors tried to investigate how consumers evaluate the EF of various vegetable products. For this purpose, participants repeatedly chose which they believed was the most EF alternative between pairs of vegetable products. Consumers' EF assessments of vegetables and the LCA results were then compared.

Method

Sample

For the sample, 375 addresses in and around Zurich (three urban districts and three municipalities) were randomly selected from the telephone book. The selected households first received a letter informing them about the study. To avoid self-selection bias, they were informed that the study only aimed to investigate people's evaluation of food items; the subject of EF was not mentioned. The selected households were then contacted by phone, and the person responsible for the household shopping was asked to participate.

A total of 79 persons participated, of whom 70% were women. As the primary shoppers were asked to take part in the experiment, women were overrepresented.

The mean age of the participants was 49 years (SD = 16), ranging from 19 to 82 years, and the mean household size was 2.4 people (SD = 1.4); both demographics are in line with the Swiss census data (BFS, 2009). The majority of the participants (49.4%) had attended upper secondary vocational school or business school, and 26.6% had a college or university degree. A smaller fraction indicated upper secondary school (8.9%), lower secondary school (7.6%), or other (7.6%) as their highest education level. Compared with Swiss census data (BFS, 2009), the sample's education level was slightly higher.

Procedure

The study took place in a university laboratory. Participants were seated in cubicles with laptop computers and introduced to the task and, if necessary, to handling the computer. Participants then completed a choice task and a questionnaire on EF criteria and demographic variables. They progressed through the slides at their own pace, with no time limit. After participants had completed the computer-based choice task and questionnaire, the experimenter debriefed, thanked, and paid them CHF 50 (approximately US$45).

Because answering questions about EF dimensions could affect the subsequent choice task and vice versa, half of the participants were asked about the EF dimensions before the choice task. The other half started with the choice task and answered the questions about the EF dimensions afterwards.

Materials

Choice task. Overall, 10 vegetable products, consisting of green beans, tomatoes,[1] and potatoes in different varieties were presented in the way they are offered for sale in Swiss grocery stores. The products were selected according to the following criteria: (a) All products should be offered by one of the main retailers in Switzerland and, therefore, be known to the general public, (b) all EF-relevant product features (such as Swiss origin, European, and imported from overseas) should be represented, and (c) there should be LCA data of each product available in the life cycle inventory database.

Each vegetable product was shown by means of a photo and a short description, which corresponded to the information provided in the shops. Before the choice task started, each vegetable product was presented individually so the participants were familiar with the products.

Figure 1. Example slide of the choice task
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During the choice task, pairs of vegetable products were repeatedly shown and the participants were asked to choose the one that is more EF during the winter season. All 45 possible pairs were displayed on a computer screen (see Figure 1 for an example). The order of pairs and screen side of the stimuli (right/left) was set in an optimal order to avoid regular repetitions (Ross, 1934).

Questionnaire. Similar to the choice task, the questionnaire on EF criteria and demographic variables was computer based. In an open-ended question, the participants were asked which EF criteria they believed to be relevant for food products. The participants could mention as many criteria as they wanted. They then assessed the EF of 19 given criteria, such as greenhouse production or air transport from overseas, which could be rated on a 7-point Likert-type scale (higher scores indicated more EF).[2] Since not all criteria given were EF-relevant, the scale midpoint was labeled as *neutral*. Finally, participants provided information about their demographics (gender, age, education, and household size).

LCA. To compare consumers' assessments with an objective evaluation, the environmental impact of the product criteria and the vegetable products presented were estimated using an LCA. An LCA is a holistic method that assesses

the overall environmental burden of a product across its life cycle. A product is followed through all stages (cradle to grave), from raw material extraction through production and use to its disposal (Baumann & Tillmann, 2004). Accordingly, an LCA of food products calculates the environmental impact associated with production, packaging, conservation, and transportation (Jungbluth, 2000; Jungbluth, Tietje, & Scholz, 2000).

The use of natural resources as well as pollutant emissions is described in quantitative terms (Baumann & Tillmann, 2004). These resources and emissions are then related to various environmental impacts, which can be put on the same scale through weighting.

The first LCAs were conducted in the United States and Europe in the late 1960s and early 1970s and mainly focused on packaging and waste management (see, Baumann & Tillmann, 2004; Russell, Ekvall, & Baumann, 2005). However, as it transpired, similar LCA studies yielded different conclusions, partly because of the use of different methodologies. Thus, researchers strove for harmonization and developed LCA standards (ISO 14040 series) in the 1990s. At the same time, the application of LCA diversified, not only focusing on packaging but also on food products, building materials, chemicals, and cars. The concept also spread beyond North America and Europe. Today, there are several different types of LCA applications, each with its particular methodological requirements.

For the present study, the most recent version of the Swiss method Ecological Scarcity (UBP 06–Umweltbelastungspunkte 06) was used. This ecofactor calculation aggregates manifold environmental impacts (use of resources and emissions into the air, soil, and water) according to politically defined scarcity (Frischknecht, Steiner, Braunschweig, Egli, & Hildesheimer, 2006). The ecological performance, therefore, refers to the current political agenda and is based on Swiss environmental legislation. The one-score-impact assessment allows for a comparison between different products and characteristics (Jungbluth et al., 2000). The scale is open ended; higher scores indicate higher environmental impact.

Data Analysis

Data analysis was conducted with SPSS (version 17.0, SPSS Inc.) and SYSTAT (version 12, SYSTAT Software Inc., Chicago, IL). Consumers rated the EF criteria with regard to the products' environmental *friendliness* because this term is more prevalent in the media and advertising than environmental *harmfulness*. To enable comparison with LCA results, which indicate negative environmental impacts, the EF ratings of the consumers were recoded so higher

scores indicated more environmental harm. As these ratings were not normally distributed, $D(79) > .15$, $p < .001$, the medians and 95% confidence intervals of the medians are reported next to the mean values. The medians and confidence intervals were calculated with the bootstrap method (Efron & Tibshirani, 1993; Johnson, 2001). For this procedure, 1,000 samples were drawn with replacement with size $n = 79$ from the data set. For further analysis of the EF criteria, nonparametric tests were used.

A multidimensional scaling analysis was performed (MDS PROXSCAL) to explore the extent the perceived EF of products differed in the consumers' view. MDS is a method that represents (dis)similarity between pairs of objects as distances in a low-dimensional space (Borg & Groenen, 2005). Thus, the data and its structure can be explored visually. In the present study, the preferences for each of the 45 pairs were aggregated in percentages and transformed into dissimilarity data by measuring their deviation from 50%. If 50% of the participants chose either product, it was assumed that in their view the products were very similar.

Following this assumption, the more each aggregated percentage of choice deviated from 50%, the more distinctly consumers perceived these two products. Overall, the multidimensional structures of the matrix consisted of 45 dissimilarities (choices) between the 10 products. To indicate how well the configuration matched the data, stress was computed as a measure of goodness of fit (ranging from 0.00 to 1.00). Smaller stress means a better fit, and a value of zero would mean perfect fit (Borg & Groenen, 2005; Kruskal, 1964).

Results

Manipulation Check

Mann–Whitney U tests were applied to analyze whether task order affected the respondents' assessment of EF criteria. With the exception of the EF assessment of plastic packaging, no significant difference was found between the group that started with the choice task and the group that started with the EF rating of provided criteria (all U values < 774.50 and all p values > .05). Participants who carried out the choice task first assessed plastic packaging as less environmentally harmful (median = 4) than those who rated the EF criteria first (median = 5), $U = 450.50$, $p = .001$ (the Bonferroni correction for multiple comparisons was applied, $\alpha = .05/19 = .003$). Because this was the only criterion that differed significantly and because the divided sample size would have been too small for meaningful results, the sample was aggregated for all further analyses.

Spontaneously Mentioned EF Criteria

The open-ended question on perceived EF criteria showed most participants spontaneously mentioned production method as a relevant criterion (78%). A majority (66%) also believed provenance is important for the EF of food products. Season (19%) and packaging (19%) were mentioned less frequently. Finally, 8% of the consumers named conservation methods, degree of processing, and health aspects (such as naturalness, freshness, and ingredients).

A closer look at the category of production method revealed participants mainly named organic production (41%) and/or related aspects, such as use of chemicals (20%) or use of fertilizers (9%). Open-field production was mentioned by 5% of the consumers, and only 4% named greenhouse production as EF relevant. Many participants remained unspecific and mentioned energy and water use (16%) or production method in general (8%).

In the category of transportation, most consumers referred to the product's provenance (30%) and/or the transportation distance (24%). Transportation mode was mentioned by only 3% of the participants, whereas 14% remained unspecific and just mentioned transportation in general.

In sum, when asked about EF criteria, most consumers spontaneously thought about production methods and mainly referred to organic production. A majority also mentioned transportation as EF relevant and, in doing so, mostly considered provenance and transportation distance.

Evaluation of the EF Criteria Presented

Participants were then asked to rate the environmental impact of the 19 EF criteria presented. Table 1 shows that participants rated water scarcity as most environmentally harmful, followed by air transportation, genetic modification, and transportation by truck or ship. Consumers rated organic production and consideration of biodiversity as most EF.

In the further analyses, only criteria used in the LCA were included. Items assessed by laypeople alone, such as genetic modification, are, therefore, omitted here.

Figure 2 shows the LCA results and consumers' EF assessments of product criteria. In both the consumers' assessment and the LCA results, air transportation appeared as the most important determinant of EF. To simplify the comparison, the extreme points of the consumers' ratings and the LCA outcomes were scaled equally, using the air transportation ratings as the calibration point.

According to the LCA, all product characteristics contributed to some extent to the environmental impacts of a vegetable product. However, compared to

Table 1. Mean Scores, Medians, and 95% CI for the Medians of Perceived Environmental Harmfulness for Each Criterion Provided

EF Criterion	*M*	*Median*	95% Confidence Interval (95% CI)
Water scarcity	6.77	7.0	7.0-7.0
Air transport	6.42	7.0	7.0-7.0
Genetic modification	6.13	7.0	6.0-7.0
Truck or ship transport	6.05	6.0	6.0-7.0
Metal packaging	5.46	5.0	5.0-6.0
Impairment of biodiversity	5.35	6.0	5.0-6.0
Deep-frozen	4.86	5.0	5.0-5.0
Plastic packaging	4.81	5.0	4.0-5.0
Greenhouse production	4.57	5.0	4.0-5.0
Preserved (e.g., dried or heated)	4.04	4.0	4.0-4.0
Glass packaging	3.70	4.0	3.0-4.0
Healthiness	3.49	4.0	4.0-4.0
Unchilled storage	2.96	3.0	2.0-3.0
Fair trade	2.68	2.0	2.0-3.0
Open-field or integrated[a] production	2.47	2.0	2.0-3.0
Regional production	2.38	2.0	2.0-2.0
Unpacked	2.22	2.0	2.0-2.0
Biodiversity consideration	1.77	1.0	1.0-2.0
Organic production	1.61	1.0	1.0-2.0

Note: EF = environmental friendliness. EF assessment was done on a 7-point Likert-type scale and recoded (1 = *not environmentally harmful at all* to 7 = *very environmentally harmful*).
[a]Integrated production denotes an agricultural practice that limits use of chemical fertilizer and pesticides (Tanner & Jungbluth, 2003).

air transportation, the LCA assessed all other criteria as considerably less environmentally harmful. According to the LCA results, greenhouse production was the second most harmful dimension, followed by refrigeration. With the exception of glass packaging, packaging was less EF relevant in the LCA results.

In contrast to the LCA, consumers rated truck or ship transportation as similarly harmful to air transportation. Greenhouse production, the second most harmful criterion according to the LCA, ranked only sixth in the consumers' assessment after air, truck, or ship transportation, metal and plastic packaging, and refrigeration. Relative to the perceived environmental impact of air transportation, consumers rated metal and plastic packaging as more environmentally harmful than did the LCA. In contrast to the LCA, consumers rated glass packaging as the most EF packaging material.

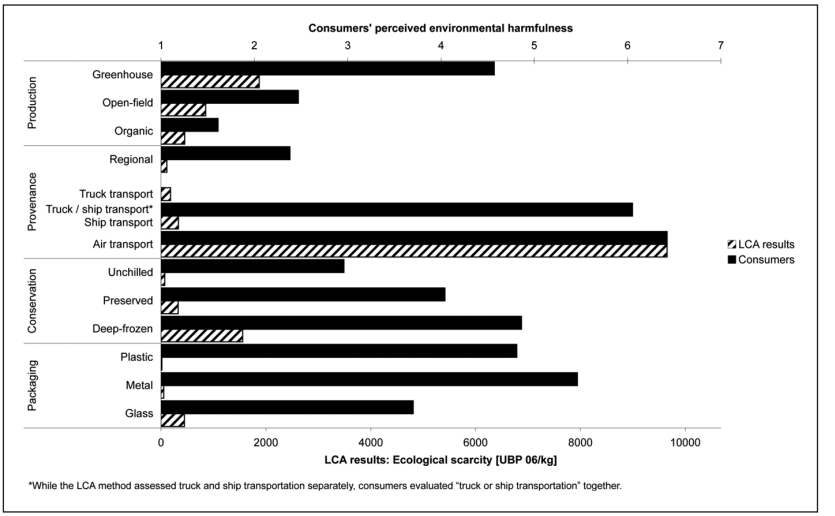

Figure 2. LCA results[3] versus consumers' EF assessments of product characteristics
Note: LCA = life cycle assessment; EF = environmental friendliness.

Consumers' EF Assessment of All Products in the Choice Task

To explore consumers' EF assessment of different vegetable products, a choice task was conducted. The aggregated choice preferences were analyzed with an MDS. PROXSCAL displayed a one-dimensional solution (Figure 3, y-axis), implying that consumers' choice preferences were based on just one dimension. Stress-I was .15, indicating an acceptable fit between the configuration and the data (Borg & Groenen, 2005; Kruskal, 1964).

Organic Swiss potatoes ranked at the lower end, indicating they were perceived as the least environmentally harmful option of all vegetable products presented. In second position were conventional Swiss potatoes. Hence, consumers perceived potatoes as the most EF vegetable overall.

Potatoes were followed by regional green beans and Swiss tomatoes, both from greenhouse production. All four products that explicitly indicated Swiss origin in their descriptions were ranked at the lower end and thus perceived as EF.

These products were followed by frozen beans, tomatoes from Morocco, canned beans, and open-field beans from Egypt. Tomatoes from the Netherlands and dried beans from China were located at the upper end of the scale. This indicated that the participants perceived these two products as the most environmentally harmful compared to the other vegetable products.

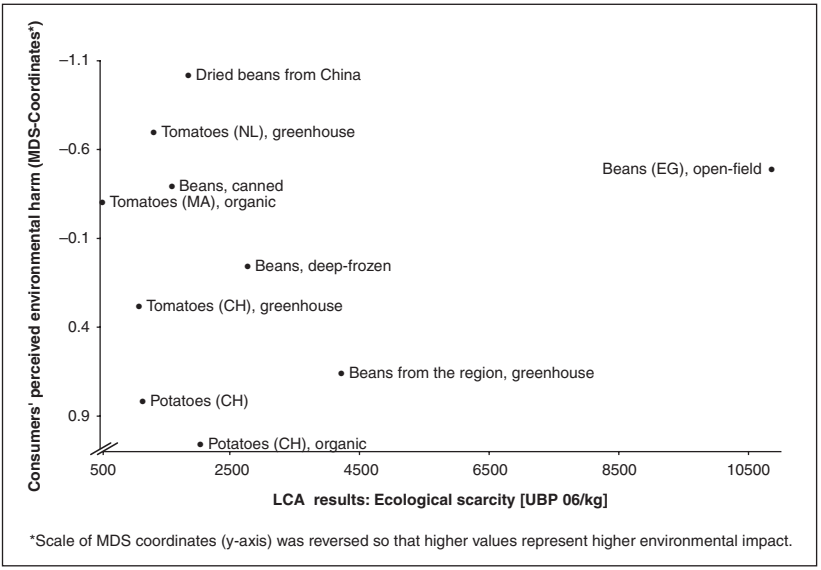

Figure 3. LCA results[3] versus consumers' perceived environmental harm of each vegetable
Note: LCA = life cycle assessment.

If the outcomes of the MDS are compared with the LCA results (Figure 3, x-axis), it appears consumers' assessment of vegetable products differed from the LCA results. All vegetable products were rather evenly distributed in terms of environmental impact in the average consumer's mind. In the LCA results, however, there was a major difference between the environmental harmfulness of Egyptian beans and the other products.

Consumers seemed to overestimate the environmental harm caused by Chinese dried beans and greenhouse tomatoes from the Netherlands. Compared to the LCA, consumers also rated the environmental harm from canned beans as relatively high. Consumers appeared to estimate the environmental harmfulness of Egyptian and regional greenhouse beans to be lower, compared to the LCA.

Assessments Within the Vegetable Categories

For a more elaborate comparison between LCA results and consumers' EF assessments, product rankings by consumers and the LCA are now compared within the vegetable categories.

Green beans. In the choice task, consumers seemed to consider provenance as important because regional beans from greenhouse production ranked lowest in the consumers' perspective, whereas dried Chinese beans ranked highest. Beans from Egypt, however, were perceived as moderately environmentally harmful.

As green beans are out of season in winter, the conserved alternatives were considered the most EF options in the LCA. Canned, dried, and refrigerated beans were assessed as similarly EF. Producing regional beans in a greenhouse is very energy intense, due to the heating required. The LCA assessed this product as not ideal with regard to the environment. Because Egyptian open-field beans were imported by airplane, they ranked highest in terms of environmental impact.

A comparison between LCA results and consumers' assessments of green beans revealed considerable differences. Chinese dried beans as well as the canned alternatives had the best LCA results, but consumers rated these products as among the worst. The regional beans were viewed as environmentally suboptimal by LCA, whereas consumers assessed this product as the best option for the environment.

Tomatoes. Consumers rated Swiss tomatoes from greenhouse production as more EF than the organic alternatives from Morocco. Due to the warmer climate in Morocco, tomatoes are field-grown, and energy-intense greenhouse heating can be avoided. Therefore, in the LCA, the Moroccan tomatoes were considered more EF than the Swiss alternatives. The tomatoes from the Netherlands included intensive greenhouse production as well as transportation from abroad; accordingly, they ranked as the least EF tomato product both among consumers and in the LCA.

Potatoes. Consumers ranked organic potatoes as more EF than the conventional ones. However, due to the use of copper as an insecticide in place of chemical insecticides, the LCA assessed the organic potatoes as less EF than conventional ones.

In sum, the product rankings within the vegetable categories suggest that consumers mainly used two criteria to estimate EF, namely, transportation distance and production method (preferring organic production). The LCA method, however, considered a multiplicity of EF criteria, particularly transportation mode and heated greenhouse production.

Discussion

This study aimed to investigate what consumers believed to be EF-relevant product features. In addition to asking participants directly to assess the EF

of several criteria, the participants' EF assessment was studied by letting them choose the environmentally friendlier alternative between several pairs of vegetable products. Consumers' assessments of EF criteria and EF assessments of vegetable products were then compared to the LCA results to see whether they differed.

Overall, the consumers' EF assessments and the LCA results differed substantially. In contrast to the LCA method, consumers mainly considered transport distance rather than means of transportation. Furthermore, consumers seemed to overestimate both the environmental benefit of organic production and the environmental harm of packaging and conservation. These findings are discussed in more detail in the next sections.

Transportation

Overall, consumers seemed to be aware of the environmental impact of transportation in general. However, they appeared to consider transportation *distance* rather than *means* of transportation. This conclusion appears to be supported by three different findings. First, respondents spontaneously mentioned transportation when thinking of EF-relevant criteria and thereby mainly named transportation distance or country of origin.

Second, respondents rated transportation from abroad as very environmentally harmful in the list with the 19 criteria. Unlike the LCA results, however, consumers perceived air transportation as being similarly environmentally harmful to truck or ship transportation.

Third, in the choice task, the four products that consumers assumed to be most EF were all labeled as *Swiss* in origin. These findings suggest consumers tend to rate domestic products as more EF than imported products or products with unspecified provenance. This is even the case when the domestic products were produced in a heated greenhouse.

Consumers' EF evaluations of the foreign vegetable products allow two alternative explanations. The finding that the participants assessed the Egyptian beans as less environmentally harmful than the dried Chinese alternatives, contrary to the LCA results, can be used as an example for these possible explanations. First, it is possible consumers had difficulties inferring transportation mode from the available information. Consumers might, therefore, have assumed both bean products were imported by the same means of transportation. The consumers' EF assessments would thus differ from LCA results because the consumers were unsure about how a product was transported. A second possible explanation for this finding might be that consumers had other nonenvironmental reservations concerning the Chinese provenance,

for instance, associations with social or political problems. The consumers might have generalized these reservations to their EF assessment of this product.

Overall, consumers' EF assessment of food products seemed to be excessively influenced by the products' provenance. This finding is supported by past research, which found that country of origin has a strong influence on consumers' product evaluation. Consumers generally seem to rate domestic products more favorably and tend to believe products from less developed countries are lower in quality and performance (see Verlegh & Steenkamp, 1999).

Production Method

The results indicate organic production seems to dominate consumers' minds when they think of EF food characteristics. A majority of the respondents spontaneously mentioned organic production, which was, furthermore, rated as the most EF product characteristic. This finding was somewhat expected since organic products are visibly labeled in Switzerland, and retailers and farmers actively promote these products as the EF alternative. This salience of organic labels probably strengthened consumers' association with EF. Consumers could, therefore, easily recall organic production in this context, which might have led them to believe that organic production is of high EF importance.

Other EF Criteria

The ratings of the different EF criteria in the questionnaire showed that consumers seemed to attribute more environmental harm to packaging and conservation than was done in the LCA. This difference in the assessments is supported by the fact that respondents perceived canned beans as rather environmentally harmful in the choice task, while, according to the LCA results, canned beans are fairly benign to the environment.

Consumers' overestimation of the EF relevance of packaging is in line with the results of Van Dam (1996), who concluded that consumers judge the EF of food products mainly on the basis of postconsumption treatment of the packaging waste. This overrating of packaging might be due to media coverage and campaigns that, for example, promote recycling behavior. This media presence might have raised consumers' awareness of the environmental impact of packaging. In the context of EF, it was, therefore, easily brought to mind and, similar to organic production, overestimated in terms of EF importance. Furthermore, both packaging and conservation are cues that consumers can easily identify. This could, therefore, influence their EF assessment.

Consumers also rated genetic modification as very environmentally harmful. Its impact on the environment has not yet been considered by LCA methods. There are, however, indications that some forms of genetic modification could actually increase the EF of a product (see Batista & Oliveira, 2009). Introduction of insect resistance, for instance, could reduce use of pesticides. However, the generally low public acceptance of genetic modification (e.g., Gaskell et al., 2000; Magnusson & Koivisto Hursti, 2002; Siegrist, 2003) might have influenced the EF assessment of this criterion.

Water scarcity, which consumers rated as most environmentally harmful, has received only limited attention in the LCA, mainly due to a lack of methodological basis (Koehler, 2008). Currently, LCA experts are trying to develop a method for assessing the environmental impacts of freshwater consumption (e.g., Milà i Canals et al., 2009; Pfister, Koehler, & Hellweg, 2009). Fair trade was rated as relatively EF among consumers, and LCA experts have also shown an increasing interest in the inclusion of social aspects in the LCA. However, the development of the so-called social LCA (SLCA) is still in its infancy and faces issues such as which impacts should be included and how to measure them (Hunkeler & Rebitzer, 2005; Jørgensen, Le Bocq, Nazarkina, & Hauschild, 2008). Consumers rated healthiness as being somewhat positive for the environment. According to the LCA, however, healthiness from consumption has no direct relationship with EF.

Limitations

This study faced several limitations. First, comparisons between the LCA results and the consumers' scores were difficult because the two consisted of different assessment scales. The LCA scale on the environmental impact of product criteria was open ended, whereas consumers rated perceived environmental harmfulness on a predetermined 7-point scale. The decision at which point to calibrate the LCA results and consumers' extreme values was arbitrary because it was unknown whether the highest perceived environmental impact by consumers corresponded to the maximum LCA rating. The LCA results and the consumers' EF assessment, therefore, should be compared with caution. Nevertheless, the authors believe this study offers some insights into how consumers differ from LCA results in EF assessments of product criteria. For instance, the finding that consumers seem to perceive little difference between different transportation modes, in contrast to the LCA, is unaffected by this limitation.

Consumers' environmental product assessment on a rating scale might yield different results than a choice task. However, the authors decided on a choice

task, as previous studies demonstrated that consumers' assessments depend on whether products are evaluated individually or jointly (Hsee, 1996; Tanner, 2008). This joint evaluation also seemed to be a more realistic test of consumer choice, as Swiss grocery stores usually offer a wide variety of products.

LCA methods are also reported to have a few limitations (e.g., Ayres, 1995; Finnveden, 2000). Nevertheless, LCA is the only tool available for comparing the environmental impact of products over their entire life cycle (Finnveden, 2000).

This study solely focused on consumers' environmental food assessment and aimed to determine whether consumers are able to assess the EF of food products. However, a realistic shopping situation was not investigated. Thus, the present findings report only on how consumers would choose vegetable products if they were willing to behave in an EF way. In real shopping situations, other criteria such as taste, price, or healthiness might play a more important role (e.g., Steptoe, Pollard, & Wardle, 1995; Van Birgelen, Semeijn, & Keicher, 2009).

Implications and Suggestions for Further Research

Past research indicated most consumers mainly include taste and cost aspects in food decision making (e.g., Lennernäs et al., 1997; Magnusson, Arvola, Koivisto Hursti, Aberg, & Sjödén, 2001; Wandel & Bugge, 1997). EF, however, does not seem to be the most important purchase criterion. As discussed, consumers associate EF with organic production, which usually is more costly. EF might, therefore, be perceived to conflict with consumers' usual purchasing criteria. However, the LCA results indicate that from the EF perspective it is most important to avoid air transportation, heated greenhouse production, and refrigeration. All these requirements can be met by the consumption of seasonal and domestic vegetables. As this consumption pattern is not associated with higher costs, consumers might be more willing to contribute to such a sustainable consumption pattern. The environmental benefits of the consumption of seasonal and domestic vegetables should, therefore, be highlighted in information campaigns.

Consumers also seem to associate locally produced food with higher quality, particularly in terms of freshness and taste (Chambers, Lobb, Butler, Harvey, & Traill, 2007). Support of local producers and farmers might serve as an additional motivation to consume domestic food. Such additional nonenvironmental benefits should be emphasized when this behavior is promoted. As consumers might not be aware of which vegetables are currently seasonal, this should be tackled through a labeling scheme. However, there would still be the problem that consumers place value on the variety and year-round choice that imported foods provide (Chambers et al., 2007).

To develop EF consumption patterns, consumers need to be able to identify EF products. The results, however, reveal that consumers seem to lack the knowledge required for an adequate EF assessment. The identification of such knowledge gaps is useful for education material. Only if consumers' misconceptions are identified can they be tackled through information campaigns. It seems consumers are aware of the environmental benefit of organic production and the environmental harm caused by the production and disposal of packaging material. Educational information should, therefore, highlight the environmental harm of air transportation and greenhouse production because consumers seem to be oblivious to these EF criteria. As the transport mode of products is usually not indicated, some sort of labeling to indicate the means of transportation, at least for those products that are imported by airplane, would help consumers to avoid such environmentally harmful products.

However, since EF food assessment is too complex for consumers, it seems insufficient to merely inform them about all the EF-relevant dimensions. A simple communication tool, as suggested in the domain of nutrition labels, would be more beneficial to facilitate EF food consumption. Similar to nutritional value information, such a communication tool would have to be easy to understand and interpret. For example, a three-level ecolabel system, adapting the design of a traffic light system, could inform consumers about positive as well as negative environmental outcomes associated with the product. Accordingly, a red label would indicate that the overall environmental impact of this product is assessed as worse than average, a yellow-labeled product would be ecologically average, and a green label would denote an EF product. Such differentiated information about environmental consequences has been shown to influence product preference of consumers with both intermediate and strong environmental concerns (Grankvist, Dahlstrand, & Biel, 2004). However, a labeling scheme that indicates not only environmentally benign products would have to be implemented by legislation, as it is unlikely producers and retailers would voluntarily label their products as environmentally harmful.

Furthermore, such a labeling scheme would require a useful and meaningful tool to describe the environmental impact of products. Thus, LCAs should be further improved and account for freshwater-use-related environmental impacts (Koehler, 2008). As the EF of vegetables (and fruits) is subject to seasonal changes, consumers would need to be informed about the reasons why the EF of the same product varies over the year.

The results indicate that consumers tend to view organic production as very EF relevant. The ecological impact of organic labels could be increased by strengthening their regulations, such as prohibition of air transport or limitations on greenhouse heating. Thus, consumers could still use organic labels as EF-relevant cues and thereby contribute to more EF food purchase.

A suggestion for further research would be to determine whether additional product information or labels (as for transportation mode) would improve consumers' EF assessment. It also seems worthwhile to investigate whether the findings can be generalized to other food products with high environmental impact, such as dairy or meat products.

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Notes

1. *Vegetable* is a purely culinary term. Botanically, tomatoes are berries and, therefore, fruits. However, since tomatoes are usually served as part of a salad or a main course, they are culinarily classified as vegetables.
2. More information about the materials used, including the questionnaire, can be requested from the corresponding author.
3. The life cycle assessment (LCA) data were calculated by Niels Jungbluth, ESU-services.

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