# Effects of food-related health concerns and risk perception on the consumption frequency of fresh vegetables

## Efectos de la preocupación en salud asociada a los alimentos y la percepción de riesgo en la frecuencia de consumo de vegetales frescos

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**Abstract**

Consuming fresh vegetables certainly brings health benefits; however, these types of products may also contain biological, chemical and technological elements that can affect people´s health due to lack of food safety. We developed a conceptual model to explain the main relationships between food-related health concerns (FHCs) and risk perceptions (RPs) on consumption frequency of fresh vegetables (CFFV) from a food safety point of view. We applied a structured questionnaire to 1028 consumers in the Central and South Central zones of Chile, where the main agricultural production of the country is concentrated. Through a structural equation model, we determined the moderator effect of RP on the relationship between FHC and CFFV. As a result, CFFV is less if RP is present in the minds of the consumer, impacting the direct effect of FHC on CFFV. Finally, our results suggest that reducing risks associated with the production and commercialization of fresh vegetables can improve health concerns related to food and the consumption of fresh vegetables. Therefore, the state must improve surveillance systems of fresh vegetables commercialized in local markets.

**Keywords**
Food safety • consumers • structural equation model (SEM) • moderator effect • fresh vegetables

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**Resumen**

Consumir vegetales frescos sin duda trae beneficios a la salud, sin embargo, este tipo de productos también pueden contener elementos biológicos, químicos y tecnológicos que afecten la salud de las personas por falta de inocuidad de los alimentos. Con base en estudios previos, desarrollamos un modelo conceptual para explicar las principales relaciones entre la preocupación en salud ligada a los alimentos (FHC) y la percepción de riesgo (RP) sobre la frecuencia de consumo de hortalizas frescas (CFFV) desde el punto de vista de la inocuidad alimentaria. Se aplicó un cuestionario estructurado a 1028 consumidores en las zonas Centro y Centro Sur de Chile, donde se concentran los principales sistemas de producción agrícola del país. A través de un modelo de ecuaciones estructurales se determinó el efecto moderador de RP sobre la relación entre FHC y CFFV, lo que significa que CFFV es menor si RP está presente en las mentes de las personas. Impactando el efecto directo de FHC en CFFV. Por último, los resultados sugieren que la reducción de los riesgos asociados con la producción y comercialización de hortalizas frescas, mejorará la preocupación por la salud relacionada con los alimentos y el consumo de hortalizas frescas. Por lo tanto, el Estado debe mejorar los sistemas de vigilancia de las hortalizas frescas comercializadas en el mercado local.

**Palabras claves**

Inocuidad alimentaria • Modelo de ecuaciones estructurales (SEM) • efecto moderador • vegetales frescos

## Introduction

Different studies report the importance of vegetable consumption to avoid non-communicable diseases (10, 22). Nevertheless, these types of products may also contain risky elements that can affect human health. These risks in fresh vegetables are associated to three different sources: a) Biological hazards such as *E. Coli* and listeriosis; b) Chemical hazards, *e.g.* excessive pesticide residues and c) Potential risks associated with technology such as gene modification, irradiation and nanomaterials (8, 46, 52). However, risk perception (RP) toward fresh vegetables by the consumer is low, at least until they suffer an adverse health incident related to them (48). However, people with high food-related health concerns attempt to avoid incidents associated to food consumption (17, 41). In this context, food risk perception and food related health concerns are concepts associated to food safety. According to authors such as Grunert (2005) and the World Health Organization (WHO) (2014), food safety is the probability of not contracting a disease as consequence of consuming a certain food, and it is considered a public health concern around the world. Different incidents associated to the lack of food safety have been reported in many countries during the last thirty years, and fresh vegetables do not escape these incidents. More recently, in the scientific literature there are examples such as fenugreek sprouts imported from Egypt which were contaminated with *E. coli*, affecting the French and German populations during 2011; maize contaminated with aflatoxins affected southern Europe in 2013; Listeriosis in

frozen vegetables affected populations in the EU and the USA in 2016 (13). All these examples associated to vegetables show food risks which can cause health problems. This given, the relationship between food risk, health concern and frequency of vegetable consumption from the perspective of food safety has not yet been analyzed in-depth in the literature. In addition, the lack of food safety is perceived in different ways by consumers from developed and developing countries. In developed countries, consumers are concerned about the risk associated with food (44). Meanwhile in developing countries, these health problems generate less concern in the population; and therefore exists a major propensity to consume fresh vegetables lacking safety controls (4, 5, 7). Our research attempts to explain the main relationship between food-related health concerns (FHC) and risk perceptions (RP) on the consumption frequency of fresh vegetables (CFFV) in Chile as a study case for Latin America. The following sections discuss the conceptual model and the research hypotheses, continuing with the methodology and our findings. Finally, we present the discussion, conclusions and implications for future research.

## Conceptual model and development of the hypotheses

### Vegetable consumption frequency

Vegetables are basic components of a balanced diet, and their consumption have health benefits to the population. These benefits are associated to the reduction of non-comunicable deseases such as cancer, cardiovascular complications and nutritional deficiencies. For these reasons, the WHO (2017) recommends consuming at least 400 grams of fruit and vegetables per day. However, in many countries (such as USA, New Zealand, Chile and others), the consumption is only half the WHO-recommended level (21, 34). There are different factors that influence the vegetable consumption frequency. Some of these factors are psychological, and others have to do affordability, economy and socio-demographics (5, 9, 36, 39). However, there still exists a gap in research regarding vegetable consumption frequency from a food safety perspective.

### Food-related health concerns, risk perception and vegetable consumption

People's health concerns are associated with their health-related behavior (40). According to Sun (2008), the relationship between health concern about developing diseases and attitudes toward healthy eating is mediated by food choice motives. In that sense, consumers choose fresh vegetables for consumption in attempt to have a balanced diet and engage in healthy eating. These behaviors reduce the population's health concerns about contracting a diet-associated disease. This is because of the perception that the main benefits of consuming fresh vegetables are to reduce the incidence of obesity and cardiovascular diseases, and that they supply vitamins, minerals, fiber, antioxidants, among other nutrients needed to maintain good health (24, 34, 40, 49). Therefore, assuming food-related health concerns as a latent dimension are a good proxy for determining consumption frequency of fresh vegetables, we hypothesized that:

$H_1$. Food-related health concerns influence the consumption frequency of fresh vegetables.

To examine food risk from the consumer's point of view, it is necessary to address the concept of their risk perception about food. From the perspective of cognitive theory, the risk

perception is the consumer concern caused by the uncertain effects on their health generated by insalubrious foods (6). All types of contamination in vegetables from chemical, biological and/or technological sources represent a food risk to the population.

Recent studies show that risky events associated to contaminated vegetables represent a public health concern. For example, the necessity of reducing the consumer exposure to active pesticides in vegetables (44); contamination with heavy metals and pathogens (1, 35). It is important to highlight that if risky events associated with vegetables that affect society are publically reported, RP will increase. This implies that the consumer reacts by reducing or postponing the vegetable consumption until the food alert is lifted. Likewise, they may prefer to purchase labeled, branded or quality assured vegetables (5). Therefore, based on this information, we hypothesized that:

$H_2$. Food-related health concerns are related to risk perception

$H_3$. Risk perceptions directly influence the consumption frequency of fresh vegetables.

According to Sun (2008), consumer health concerns are related with diet. Consumer demand for healthy food products has increased in the last decade. Some examples are the proliferation of functional foods, the rise in demand for organic produce among others (3, 47). Therefore, consumer health concerns could influence a higher consumption of fresh vegetables. But, food risk could likewise generate a contrary effect, since the consumption frequency of fresh vegetables, depends on the level of consumers' RP towards different hazards such as the presence of pesticide, microorganisms and technological alterations (27, 30). Based on these antecedents, we hypothesized that:

$H_4$ Food-related health concerns indirectly influence fresh vegetable consumption frequency through RP.

$H_5$. Risk perception as a moderator latent variable affects the relationship between food-related health concerns and the consumption frequency of fresh vegetables.

Based on the hypothesis proposed, our conceptual model is presented in figure 1 (page 293).

## Materials and methods

### Sample and procedures

Two of the most important zones for vegetable production in Chile were chosen. These zones included the cities of Santiago, Talca and Temuco, corresponding to the central and south central regions of the country. Data were compiled through convenience sampling of 1,200 vegetable buyers, over the age of 18 (400 fresh vegetable buyers in each city), using face to face surveys administered from September to November 2012. The measuring instrument was applied in public places close to stores, banks and supermarkets. Previously, a pre-test of 10% of the sample was carried out to detect biases in comprehension.

The questionnaire was structured to investigate consumer opinion about the following items: risk perception toward fresh vegetables they consumed; health concerns associated with fresh vegetables; frequency of vegetable consumption and socio-demographic characteristics. Following Byrne (2010), outliers were detected and deleted in order to continue with the analysis. Finally, the sample used in the study was 1,028 cases. Table 1 (page 294) shows the socio-demographic data from the surveyed sample.

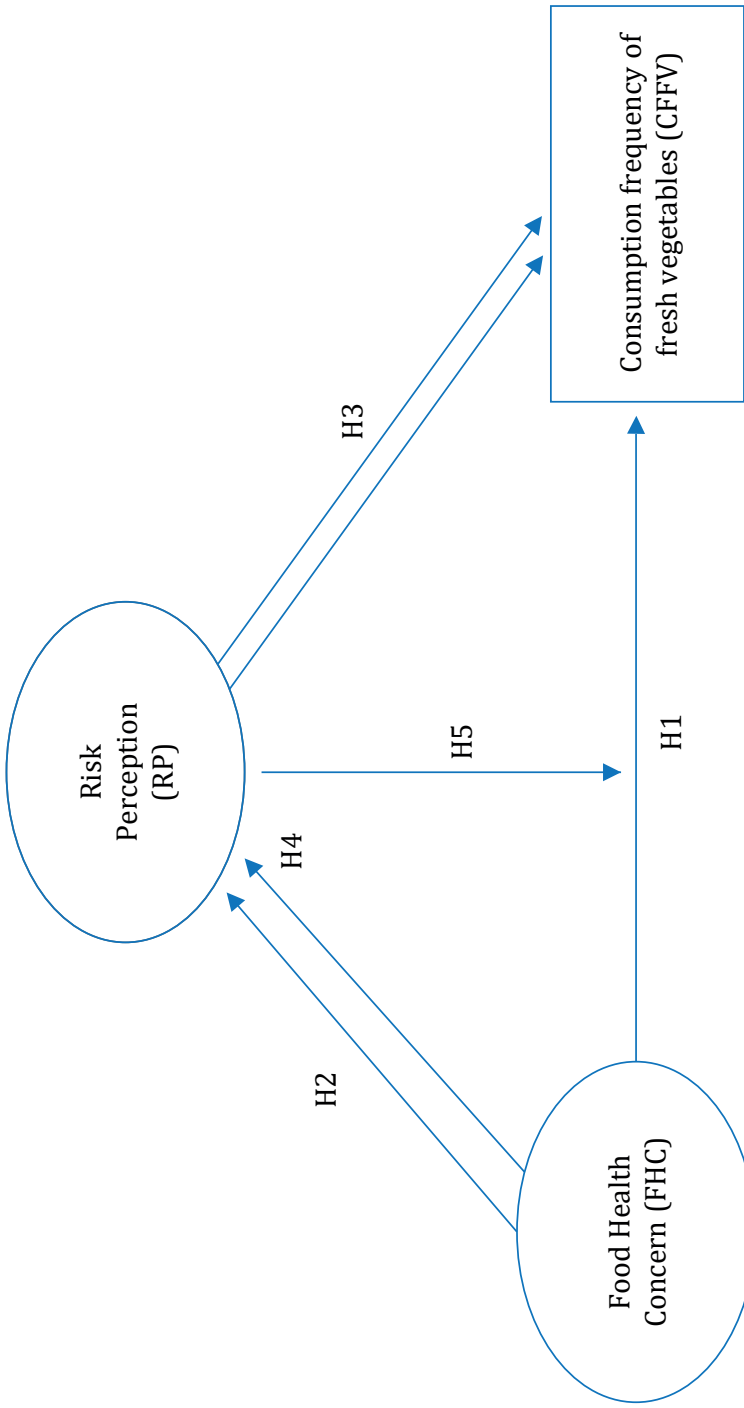



**Figure 1**. Conceptual model of factors that affect the frequency of fresh vegetable consumption in consumers, from a food safety point of view.

**Figura 1**. Modelo conceptual de los factores que afectan la frecuencia de consumo de vegetales frescos en los consumidores, desde un punto de vista de la inocuidad alimentaria.

**Table 1**. Socio-demographic statistics.
**Tabla 1.** Estadística socio-demográfica.

| **Items** | **Values** |
|---|---|
| *Sample size* | 1028 |
| *Gender (%)* | |
| Male | 30.5 |
| Female | 69.5 |
| *Age (mean ± st. dev.)* | 38.9 ± 3.53 |
| *Education (%)* | |
| Elementary | 5.9 |
| High School | 32.5 |
| Incomplete technical college | 2.5 |
| Complete technical college or incomplete university | 48.2 |
| Complete university or more | 10.9 |
| *Income (%)* | |
| More than US$3.700<br>US$1.401 to US$3.700<br>US$1.121 to US$1.400<br>US$500-US$1.120<br>Less than US$500 | 13.0<br>43.3<br>26.7<br>12.5<br>4.5 |
| *Frequency of vegetable consumption (%)* | |
| Occasionally | 5.1 |
| Once a week | 8.9 |
| Three times a week | 37.5 |
| Daily | 48.6 |
| *Main fresh vegetable consumed (%)* | |
| Lettuce | 50.6 |
| Tomato | 22.6 |
| Other | 26.8 |
| *Places for buying fresh vegetables (%)* | |
| Municipal markets | 29.6 |
| Greengrocers | 32.3 |
| Food distribution centers | 7.6 |
| Supermarkets | 30.5 |
| *Self-declared food safety knowledge (%)* | |
| Low food safety knowledge | 32.2 |
| Medium food safety knowledge | 52.7 |
| High food safety knowledge | 15.1 |

**Data collection instrument**

The measuring instrument was structured with observed variables and measurement scales used in previous studies. A 5-point importance scale was used to measure each indicator (1 to express the lowest level and 5 to indicate the highest level), except for the frequency of vegetable consumption and socio-economic variables. The measurement of risk perception toward vegetables consumed was based on previous literature on food products, and the statements were adapted from measures contained in Brewer and Prestat (2002), Tucker *et al.* (2006) and Yeung and Morris (2006). The measurement of opinion about health concerns associated with food was adapted from Gil *et al.* (2000); Sánchez and Gil (2000). In the analysis, an observable variable was included as a dependent variable named vegetable consumption frequency (15, 24), which received the effects from all the constructs. Table 2 (page 296) presents the observable variables (indicators) which defined each construct (latent variables).

**Statistical analysis**

Data were analyzed by the structural equation model (SEM), which represented the relationships between the constructs of food-related health concerns (FHC) and risk perception (RP) and the observed variable consumer frequency of fresh vegetables (CFFV). The steps involved in the analysis were: a) Measurement modeling through confirmatory factor analysis (CFA); b) Construct validity; c) Structural modeling to test the causal relationship; d) Mediation test through direct and indirect effects obtained by the Sobel and Bootstrapping test and e) Moderation test through techniques for constructs proposed by Zainudin (2012). To evaluate the model's goodness of fit, various indicators were used: Chi-square to df ratio ($\chi^2$/df < 5.0); comparative fit index (CFI close to 0.9 or 1.0), goodness fit index (GFI close to 0.9 or 1.0) and normed fit index (NFI close to 0.9 or 1.0) and the robustness of the mean squared error approximation (RMSEA) with values lower than 0.08 (20, 26). The analysis was performed with AMOS 20 and IBM SPSS 20.

## Results

**Descriptive analysis**

This study was carried out with the participation of fresh vegetable buyers, over 18 years old. Most of the interviewees were women who had either completed or not completed higher education. In terms of household income, the highest proportion of interviewees received monthly income between US$1.401 and US$3.700. The majority of the consumers surveyed declared that they ate fresh vegetables daily. The most consumed fresh vegetable was lettuce, followed by tomatoes. Of the sample, 61.9% bought their produce at traditional markets, such as municipal markets, greengrocers and food distribution centers. Most interviewees reported a medium level of food safety knowledge (more details in table 1, page 294).

**Measurement and structural model**

The first step carried out was to validate the scales through confirmatory factor analysis (CFA). Results of the CFA showed good fit of the datasets $\chi 2$ = 82.727, df = 30, $\chi 2$/df = 2.76, p=0.000, RMSEA = 0.041, CFI = 0.984, GFI = 0.984, NFI = 0.976 (table 2, page 296).

**Table 2**. Measurement model, reliability and validity of the scales used in the analysis.
**Tabla 2**. Modelo de medida, confiabilidad y validez de las escalas utilizadas en el análisis.

| Construct | Observed variable | Mean | SD | β(t-value) | AV | CR | Cronbach-α | Measurment Model |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | $\chi2$ = 82.727 |
| Risk perception (RP) | *What is the risk perception level on the fresh vegetables consumed?* | | | | 0.50 | 0.85 | 0.85 | |
| | Pesticide presence | 2.97 | 1.52 | 0.81 (15.97) | | | | df = 30 |
| | Polluted irrigation water | 3.03 | 1.43 | 0.88 (15.82) | | | | |
| | Microorganism contamination | 3.20 | 1.39 | 0.78 (15.68) | | | | $\chi2$ /df = 2.76 |
| | Faulty Food-Handling in restaurants | 3.20 | 1.45 | 0.61 (13.94) | | | | |
| | Irradiation UV | 2.40 | 1.38 | 0.57 (16.82) | | | | p = 0.000 |
| | Genetically modified organisms | 2.74 | 1.45 | 0.53a | | | | |
| | | | | | | | | RMSEA = 0.041 |
| Food-related Health concerns (FHC) | I have a healthy diet | 3.72 | 1.14 | 0.57a | 0.39 | 0.71 | 0.71 | CFI = 0.984 |
| | I eat fruits and vegetables frequently | 4.18 | 0.94 | 0.54 (12.13) | | | | |
| | I am worried about my diet and its effects on my health | 4.17 | 0.97 | 0.76 (14.18) | | | | GFI = 0.984 |
| | I am interested in food related information | 4.05 | 1.01 | 0.59 (12.77) | | | | |
| | | | | | | | | NFI = 0.976 |
| | *Frequency of vegetable consumption* | 3.30 | 0.83 | n.i. | | | | |

In addition, the scales used in the analysis satisfied the composite reliability test (above 0.7); average variance extracted values (close to 0.5) and the internal consistency (Cronbach's α above 0.7), showing good indicators of reliability and validity. Therefore, the measurement model presented adequate internal validity.

Once the scales were validated, the structural model was tested through Maximum Likelihood (figure 2, page 298). The structural model had a good fit of the dataset, and indices were within acceptable limits, but exceeded the minimum values recommended in the literature $\chi2 = 94.326$, df = 35, $\chi2/df = 2.69$, p=0.000, RMSEA = 0.041, CFI = 0.984, GFI = 0.984, NFI = 0.975. All direct proposed relationships were significant. In terms of hypotheses with direct relationships, it was found that the construct FHC was positively associated with CFFV ($H_1$) ($\beta$ = 0.57, $t$ =8.74, $p$ = 0.000). Furthermore, FHC was positively associated with RP ($H_2$) ($\beta$ = 0.22, $t$ =4.87, $p$ = 0.000), and RP was positively associated with CFFV ($H_3$) ($\beta$ = 0.09, $t$ =2.83, $p$ = 0.05). Therefore, our results confirm that CFFV was determined mainly by FHC, and to a lesser extent by cosumers' RP of toward fresh vegetables.

**Mediation analysis**

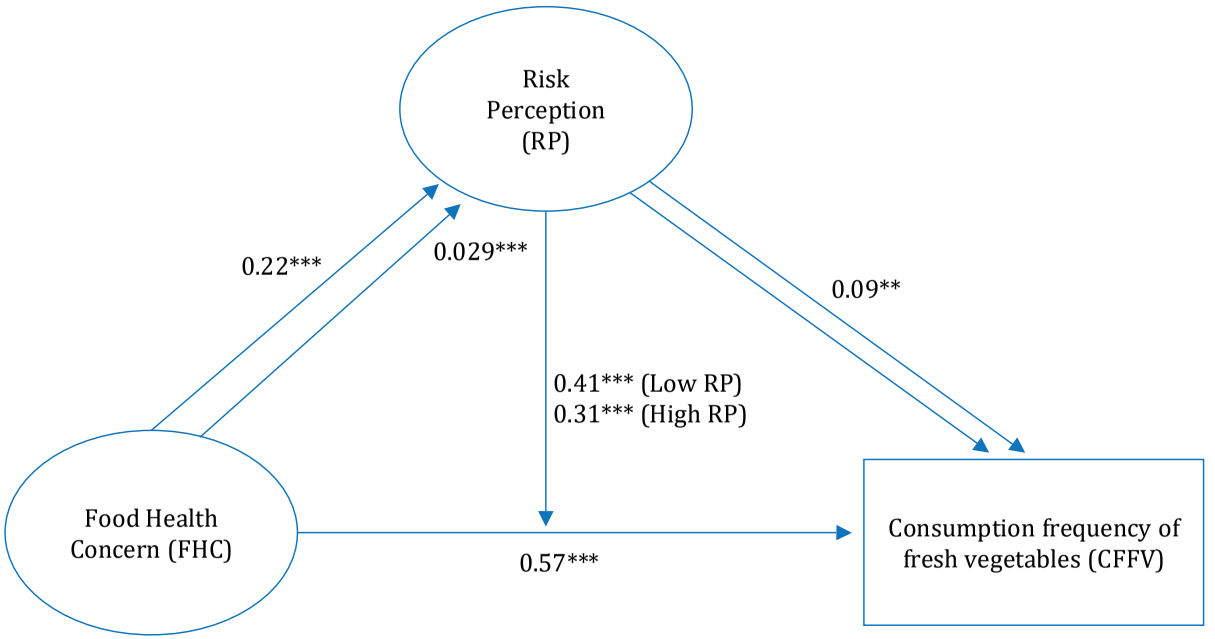
Regarding mediation analysis, we highlight that the construct RP mediated the effect between FHC and CFFV ($H_4$)($\beta$ = 0.029, $p$ = 0.000) (figures 1, page 293 and 2, page 298). Table 3 (page 299) shows the indirect effect model for the mediator. Significant $p$ values of the Sobel test indicated that independent variable FHC predicted CFFV to a lesser but significant extent, through RP (mediator), confirming $H_4$. The bootstrap method also revealed that the mediating effect of RP, between FHC and CFFV, did not lie within zero for the predicted confidence interval. Therefore, the mediated effect was significantly different from zero at $p$ = 0.000.

**Moderation analysis**

Moderation analysis was carried out using RP as a latent variable moderator of the relationship between FHC and CFFV. Following the steps for AMOS, proposed by Zainudin (2012), it can be confirmed that RP acts as a moderator of the proposed relationship. This is because the difference of the $\chi2$ value and degree of freedoms between the constrained and unconstrained models are greater than 3.84 (table 4, page 299). Therefore, the proposed hypothesis ($H_5$) is supported. This means that the moderator effect of RP on FHC and CFFV for the standardized estimate path decreased from the general model ($H_1$ = 0.57) to 0.41 for the Low RP group and 0.31 for the High RP Group.

## Discussion

The majority of the interviewees expressed that they consume fresh vegetables daily (mainly lettuce and tomatoes), which is beneficial for consumers from the perspective of health concerns (14, 31). Consequently, the results obtained in our research contribute to the knowledge about CFFV and what is determined by FHC and RP from perspective of food safety. According to our results, the CFA and structural equation model suggest that there is an interaction between the constructs FHC, RP, and the dependent variable CFFV. The results show that the main construct that determines the frequency of vegetable consumption is mainly FHC and, to a lesser extent, the consumer's RP. Our first hypothesis (H1) confirms that FHC directly and significantly influences CFFV.




The significance of the mediation and moderation variable is: *$p$ = 0.05; **$p$ = 0.01; ***$p$ = 0.001. $\chi 2$ = 94.326, df = 35, $\chi 2$/df = 2.69, p=0.000, RMSEA = 0.041, CFI = 0.984, GFI = 0.984, NFI = 0.975

Significancia estadística de la variable de mediación y moderación: *p = 0,05; **p = 0,01; ***p = 0,001. $\chi 2$ = 94,326, df = 35, $\chi 2$/df = 2,69, p=0,000, RMSEA = 0,041, CFI = 0,984, GFI = 0,984, NFI = 0,975

**Figure 2**. Structural model representing the relationships between risk perception, food-related health concerns and consumption frequency of fresh vegetables. (Ovals represent latent variables or factors, while rectangles represent observed variables. One-headed arrows represent predictive values between factors and observed variables).

**Figura 2.** Modelo estructural que representa la relación entre percepción de riesgo, preocupación en salud asociada a los alimentos y frecuencia de consumo de vegetales frescos. (Óvalos representan variables latentes o factores, mientras que el rectángulo representa la variable observada. Flechas de una cabeza representan valores predictivos entre factores y variable observada).

**Table 3**. Indirect effect among food-related health concerns (FHC) and consumption frequency of fresh vegetables (CFFV) through risk perception (RP).

**Tabla 3**. Efecto indirecto entre la preocupación en salud ligada a los alimentos (FHC) y la frecuencia de consumo de hortalizas frescas (CFFV), a través de la percepción de riesgo (RP).

| Mediation confidence interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Independent variable | Mediator | Dependent variable | Value | Se | Lower | Upper | Z values | p-value |
| FHC | RP | CFFV | 0.029 | 0.0073 | 0.0148 | 0.0432 | 4.0024 | 0.000 |

**Table 4**. The moderation test for Low and High Risk Perception of fresh vegetable buyers.

**Tabla 4**. Prueba de moderación para una Alta y Baja Percepción de Riesgo de los compradores de vegetales frescos.

| Groups | $\chi^2$ constrained model | DF constrained model | $\chi^2$ unconstrained model | DF unconstrained model | $\Delta\chi^2$ | Result on Moderation (H5) | Standard estimate path |
|---|---|---|---|---|---|---|---|
| Low RP | 27.026 | 5 | 7.134 | 4 | 19.892 | *** | 0.41 |
| High RP | 19.329 | 5 | 2.513 | 4 | 16.816 | *** | 0.31 |

This finding is in line with Lee *et al*. (2013) who found that health concerns have a significant impact on behavioral intentions. In addition, FHC is a relevant dimension for consumers at the moment of purchasing vegetables, due to their health benefits (24, 34, 40, 49).

Furthermore, people concerned about their health and healthy eating habits can for example, opt for the consumption of functional foods (16) and/or organic products as a way to reduce the chemical and technological risks associated with food (2, 3). Another finding of this study is the confirmation of the second hypothesis (H2), which concludes that FHC is significantly related to RP. This finding is supported by the previous study about organic foods of Naspetti and Zanoli (2006), who noted that the risk perception is influenced by a generalized health concerns. In addition, it is important to highlight that RP influences CFFV in a minimum, but significant (H3). This finding is based on the logic that a consumer is not thinking about RP at the time of purchase. However, this RP is not triggered until the consumer is faced with an event that affects their health. In this context, Kaptan *et al* (2018) noted that technologies applied to food production tend to potentially be associated with higher levels of RP, linked to perceptions that the food itself is unnatural. Notwithstanding, for some risks that involve biological irreversibility, moral or ethical concerns may be more important determinants of consumer responses than risk or benefit.

The tests of hypotheses of mediation (H4) and moderator effects (H5) of RP on the relationship the between FHC and CFFV are significant. However, the moderator effect of RP on the relationship between FHC and CFFV is higher than RP mediator effects. This means that the RP construct reduces the direct effect of FHC on CFFV when people consider vegetables a higher latent hazard. Therefore, our findings add evidence that consumers show concern about the RP construct for fresh vegetables despite of all their associated benefits. But RP is a dimension or construct present in the minds of consumers, which makes them question the healthiness of fresh vegetables, which can make people reduce or stop buying vegetables. However, RP as a dimension depends mainly on the personal and indirect food safety experience each person (42). For example, Abass *et al.* (2017) found that RP shown by consumers about urban-grown vegetables was low, even after a decade of vegetable contamination risks in Ghana.

Contrarily, as developing countries achieve higher levels of development, RP should grow following the trends observed in developed countries (23). This means that food safety issues are positioning themselves in developing countries, since some consumers seem to be aware of potential health implications when buying and consuming uncertified fresh vegetables. Hence, from a consumer´s point of view, it is necessary to tackle hygiene problems of traditional markets (28, 45). One mitigation option is to certify fresh vegetables as a food risk-reduction strategy; and a food safety labels can be used as a tool for this purpose (4, 54). However, according to Milne (2012), it is essential for the population itself to demand safer products and defend their own right to know how fresh vegetables are produced, stored and commercialized in domestic markets. Consumers do not wonder about whether pesticides comply or not with their withholding period or about whether products have water

quality certification or good storage conditions, among other risk factors related to fresh vegetables (5). Therefore, it is imperative for the Chilean government to improve surveillance systems on fresh vegetable producers in order to ensure the quality of the produce destined for domestic markets.

As for the limitations of the study, it is worth noting that the sample is not representative of Chile´s population distribution. However, the sample is made up of consumers who are in charge of buying vegetables for the household, as acknowledged by the higher proportion of female interviewees, a situation similar to developed countries (38, 47).

## Conclusions

We found that the frequency of vegetable consumption is mainly determined by consumers´ food-related health concerns; and, to a lesser extent, by consumers´ risk perception. However, risk perception is a latent variable which reduces the direct effect of food-related health concerns on the consumption frequency of fresh vegetables through its moderator effect. Therefore, all stakeholders involved (fresh vegetable supply chain agents, government institutions and the private sector) must be aware of the risk associated with fresh vegetables, in order to avoid exposing consumer to potential health risks.

Besides keeping these risks controlled, governments, especially in developing countries must continue with promotional campaigns about vegetable and fruit consumption to prevent chronic diseases associated with poor eating habits and to improve the population's physical condition. In terms of food safety, as a public health policy, the state should strengthen the surveillance of vegetable production systems to reduce the long-term risk associated with traditional markets. Governments should also invest resources in GAPs training for vegetable producers, as well as in quality assurance systems for commercial agents dealing with domestic markets.

## References


1. Abass, K.; Ganle, J. K.; Afriyie, K. 2017. 'The germs are not harmful': health risk perceptions among consumers of peri-urban grown vegetables in Kumasi, Ghana. GeoJournal. 82(6): 1213-1227.
2. Adasme-Berrios, C.; Jara-Rojas, R.; Rodriguez, M.; Diaz-Tobar, B. 2011. Dimension that typify the potential consume of organic foods in the Maule Region, Chile. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 43(2): 59-69.
3. Adasme-Berríos, C.; Sánchez, M.; Jara-Rojas, R.; Engler, A.; Rodríguez, M.; Mora, M. 2015. Who are the potential consumers of organic fruits and vegetables in Central Chile? A CHAID approach. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 47(1): 193-208.
4. Adasme-Berríos, C.; Sanchez, M.; Mora, M.; Schnettler, B.; Lobos, G.; Díaz, J. 2016. Segmentation of consumer preference for food safety label on vegetables. British Food Journal. 118(10): 2550-2566.
5. Adasme-Berríos, C.; Sanchez, M.; Mora, M.; Díaz, J.; Schnettler, B.; Lobos, G. 2019. The gender role on moderator effect of food safety label between perceived quality and risk on fresh vegetables. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 51(1): 93-109.
6. Barrena, R.; Sánchez, M.; Gil, J. M.; Gracia, A.; Rivera, L. 2003. La certificación como estrategia para la recuperacion de la confianza del consumidor en la adquisicion de la carne de ternera. Economía agraria y recursos naturales (Agricultural and Resource Economics). 3(1): 7-29.
7. Behrens, J. H.; Barcellos, M. N.; Frewer, L. J.; Nunes, T. P.; Franco, B. D. G. M.; Destro, M. T.; Landgraf, M. 2010. Consumer purchase habits and views on food safety: A Brazilian study. Food Control. 21(7): 963-969.
8. Berger, C. N.; Sodha, S. V.; Shaw, R. K.; Griffin, P. M.; Pink, D.; Hand, P.; Frankel, G. 2010. Fresh fruit and vegetables as vehicles for the transmission of human pathogens. Environmental Microbiology. 12(9): 2385-2397.
9. Bihan, H.; Castetbon, K.; Mejean, C.; Peneau, S.; Pelabon, L.; Jellouli, F.; Le Clesiau, H; Hercberg, S. 2010. Sociodemographic factors and attitudes toward food affordability and health are associated with fruit and vegetable consumption in a low-income French population. The Journal of Nutrition. 140(4): 823-830.
10. Boeing, H.; Bechthold, A.; Bub, A.; Ellinger, S.; Haller, D.; Kroke, A.; Leschik-Bonnet, E.; Müller, M. J.; Oberritter, H.; Schulze, M.; Stehle, P.; Watzl, B. 2012. Critical review: Vegetables and fruit in the prevention of chronic diseases. European Journal of Nutrition. 51(6): 637- 663.
11. Brewer, M. S.; Prestat, C. J. 2002. Consumer attitudes toward food safety issues. Journal of Food Safety. 22(2): 67-83.
12. Byrne, B. M. 2010. 2° ed. Structural equation modeling with AMOS: Basic concepts, applications, and programming. Routledge. 396 p.
13. Chammem, N.; Issaoui, M.; De Almeida, A.; Delgado, A. M. 2018. Food crises and food safety incidents in European Union, United States, and Maghreb Area: current risk communication strategies and new approaches. Journal of AOAC International. 101(4): 923-938.
14. Cooper, A. J.; Sharp, S. J.; Lentjes, M. A.; Luben, R. N.; Khaw, K. T.; Wareham, N. J.; Forouhi, N. G. 2012. A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. Diabetes care. 35(6): 1293-1300.

15. Dauchet, L.; Ferrieres, J.; Arveiler, D.; Yarnell, J. W.; Gey, F.; Ducimetiere, P.; Ruidavets, J. P.; Haas, B.; Evans, A.; Bingham, A.; Amouyel, P.; Amouyel, P. 2004. Frequency of fruit and vegetable consumption and coronary heart disease in France and Northern Ireland: the PRIME study. British journal of nutrition. 92(6): 963-972.
16. Escudero, L.; Monasterio, R.; Lipinski, V.; Filippini, M.; Wuilloud, R. 2012. Selenized garlic: a future prospect or already a current functional food? Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 44(1): 301-318.
17. Fung, F.; Wang, H. S.; Menon, S. 2018. Food safety in the 21st century. Biomedical journal. 41: 88-95.
18. Gil, J. M.; Gracia, A.; Sánchez, M. 2000. Market segmentation and willingness to pay for organic products in Spain. International Food and Agribusiness Management Review. 3: 207-226.
19. Grunert, K. G. 2005. Food quality and safety: consumer perception and demand. European Review of Agricultural Economics. 32(3): 369-391.
20. Hair, J.; Anderson, R.; Tatham, R.; Black, W. 1999. 5° ed. Análisis Multivariante. Prentice Hall International Inc. 832 p.
21. Hall, J. N.; Moore, S.; Harper, S. B.; Lynch, J. W. 2009. Global variability in fruit and vegetable Consumption. American Journal of Preventive Medicine. 36(5): 402-409.
22. Hartley, L.; Igbinedion, E.; Holmes, J.; Flowers, N.; Thorogood, M.; Clarke, A.; Stranges, S.; Hooper, L.; Rees, K. 2013. Increased consumption of fruit and vegetables for the primary prevention of cardiovascular diseases. The Cochrane Database of Systematic Reviews. 6(6): CD009874.
23. Havelaar, A. H.; Brul, S.; de Jong, A.; de Jonge, R.; Zwietering, M. H.; ter Kuile, B. H. 2010. Future challenges to microbial food safety. International Journal of Food Microbiology 139(SUPPL. 1): S79-S94.
24. He, F. J.; Nowson, C.; Lucas, M.; MacGregor, G. 2007. Increased consumption of fruit and vegetables is related to a reduced risk of coronary heart disease: meta-analysis of cohort studies. Journal of Human Hypertension. 21: 717-728.
25. Kaptan, G.; Fischer, A. R.; Frewer, L. J. 2018. Extrapolating understanding of food risk perceptions to emerging food safety cases. Journal of Risk Research. 21(8): 996-1018.
26. Kline, R. B. 2011. Principles and practice of structural equation modeling. Guilford press. 427 p.
27. Lagerkvist, C. J.; Hess, S.; Okello, J.; Hansson, H.; Karanja, N. 2013. Food health risk perceptions among consumers, farmers, and traders of leafy vegetables in Nairobi. Food Policy. 38(1): 92-104.
28. Lagerkvist, C. J.; Okello, J. J.; Karanja, N. 2015. Consumers' mental model of food safety for fresh vegetables in Nairobi a field experiment using the Zaltman Metaphor Elicitation Technique. British Food Journal. 117(1): 22-36.
29. Lee, S. M.; Jin, N.; Kim, H. S. 2013. Relationships among knowledge of healthy food, health concern, and behavioral intention: evidence from the United States and South Korea. Journal of Quality Assurance in Hospitality & Tourism. 14(4): 344-363.
30. Lemos, J.; Sampedro, M. C.; Ariño, A. de; Ortiz, A.; Barrio, R. J. 2016. Risk assessment of exposure to pesticides through dietary intake of vegetables typical of the Mediterranean diet in the Basque Country. Journal of Food Composition and Analysis. 14: 35-41.
31. Liu, R. H. 2003. Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. The American journal of clinical nutrition. 78(3): 517S-520S.
32. Milne, R. 2012. Arbiters of waste: Date labels, the consumer and knowing good, safe food. Sociological Review. 60(2): 84-101.
33. Naspetti, S.; Zanoli, R. 2009. Organic food quality and safety perception throughout Europe. Journal of Food Products Marketing. 15(3): 249-266.

34. Ortega, D. L.; Wang, H. H.; Olynk, N. J.; Wu, L.; Bai, J. 2012. Chinese consumers' demand for food safety attributes: A push for government and industry regulations. American Journal of Agricultural Economics. 94(2): 489-495.
35. Rahmdel, S.; Rezaei, M.; Ekhlasi, J.; Zarei, S. H.; Akhlaghi, M.; Abdollahzadeh, S. M.; Sefidkar, R.; Mazloomi, S. M. 2018. Heavy metals (Pb, Cd, Cu, Zn, Ni, Co) in leafy vegetables collected from production sites: their potential health risk to the general population in Shiraz, Iran. Environmental monitoring and assessment. 190(11): 650.
36. Saghafian, F.; Malmir, H.; Saneei, P.; Keshteli, A. H.; Hosseinzadeh-Attar, M. J.; Afshar, H.; Siassi, F.; Esmaillzadeh, A.; Adibi, P. 2018. Consumption of fruit and vegetables in relation with psychological disorders in Iranian adults. European Journal of Nutrition. 57(6): 2295- 2306.
37. Sánchez, M.; Gil, J. M. 2000. Segmentación del consumidor respecto al alimento ecológico: diferencias interregionales. Revista de Estudios Regionales. 56: 171-188.
38. Schnettler, B.; Pihán, R.; Valdevenito, A.; Miranda, H.; Lobos, G.; Grunert, K. G. 2015. Acceptance of a vegetable with designation of origin in two cities in southern Chile. Revista de La Facultad de Ciencias Agrarias. 47(1): 173-191.
39. Schnettler, B.; Sánchez, M.; Miranda, H.; Orellana, L.; Sepúlveda, J.; Mora, M.; Lobos, G.; Hueche, C. 2017. "Country of origin" effect and ethnocentrism in food purchase in Southern Chile. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 49(2): 243-267.
10. Slavin, J.; Lloyd, B. 2012. Health benefits of fruits and vegetables. Advances in Nutrition, 3(4): 506-516.
41. Sun, Y. 2008. Health concern, food choice motives, and attitudes toward healthy eating: the mediating role of food choice motives. Appetite. 51(1): 42-49.
42. Tonsor, G. T.; Schroeder, T. C.; Pennings, J. M. E. 2009. Factors impacting food safety risk perceptions. Journal of Agricultural Economics. 60(3): 625-644.
43. Tucker, M.; Whaley, S. R.; Sharp, J. S. 2006. Consumer perceptions of food-related risks. International Journal of Food Science and Technology. 41(2): 135-146.
44. Valcke, M.; Bourgault, M. H.; Rochette, L.; Normandin, L.; Samuel, O.; Belleville, D.; Blanchet, C.; Phaneuf, D. 2017. Human health risk assessment on the consumption of fruits and vegetables containing residual pesticides: a cancer and non-cancer risk/benefit perspective. Environment international. 108: 63-74.
45. Valdes Salazar, R. 2018. Measuring market integration and pricing efficiency along regional maize-tortilla chains of Mexico. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina. 50(2): 279-292.
46. Van Boxstael, S.; Habib, I.; Jacxsens, L.; De Vocht, M.; Baert, L.; Van de Perre, E.; Rajkovic, A.; Lopez-Galvez, F.; Sampers, I.; Spanoghe, P.; De Meulenaer, B.; Uyttendaele, M. 2013. Food safety issues in fresh produce: Bacterial pathogens, viruses and pesticide residues indicated as major concerns by stakeholders in the fresh produce chain. Food Control. 32(1): 190-197.
47. Van Vliet, M.; Adasme-Berríos, C.; Schnettler, B. 2015. Acceptance of functional food among chilean consumers: apple leather. Aula Medica. 32(4): 1616-1623.
48. Verbeke, W.; Frewer, L. J.; Scholderer, J.; De Brabander, H. F. 2007. Why consumers behave as they do with respect to food safety and risk information. Analytica Chimica Acta. 586(1-2 SPEC. ISS.): 2-7.
49. Wang, S.; Melnyk, J. P.; Tsao, R.; Marcone, M. F. 2011. How natural dietary antioxidants in fruits, vegetables and legumes promote vascular health. Food Research International. 44(1): 14-22.
50. World Health Organization. 2014. Advancing Food Safety Initiatives: Strategic Plan for Food Safety Including Foodborne Zoonoses 2013-2022. Available in: [https://www.who.int/foodsafety/strategic-plan/en/] [Consulta 15 Diciembre 2018].

51. World Health Organization. 2017. Promoting fruit and vegetable consumption around the world. Available in: [http://www.who.int/dietphysicalactivity/fruit/en.html.] [Consulta 11 Agosto 2017].
52. Yeung, R.; Morris, J. 2001. Food safety risk. British Food Journal. 103(3): 170-187.
53. Yeung, R.; Morris, J. 2006. An empirical study of the impact of consumer perceived risk on purchase likelihood: a modelling approach. International Journal of Consumer Studies. 30(3): 294-305.
54. Yeung, R.; Yee, W. 2012. Food safety concern. British Food Journal. 114(1): 40-53.
55. Zainudin, A. 2012. Structural Equation Modeling using Amos Graphic. Penerbit Universiti Teknologi MARA. 167p.

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