Food Quality and Preference 86 (2020) 104000

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

The relationship between children's and mothers' vegetable liking in Chile, China and the United States

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ARTICLE INFO

Keywords:
Vegetable liking
Hedonic scale
Food variety
Cross-cultural study

ABSTRACT

This study analyzed children's (n = 384), 5 to 12 years old, and their mothers' (n = 321) vegetable liking in three countries (Chile, China and the USA). Liking measures were collected using tasting sessions in which fourteen different vegetables were tasted. Three factors were tested: country (Chile, China, USA), status (mother/child) and products (vegetables). The results showed that mothers gave higher liking vegetable scores than their children when all the participants were analyzed together ($p < 0.05$). However, some differences were found between countries when they were analyzed individually. Specifically, American mothers like vegetables more than their children, while Chinese and Chilean mothers like vegetable the same amount as their children. Moreover, it was observed that Chilean mothers liked a smaller variety of vegetables than their children. The use of the 7-point hedonic scale to rate the vegetables was also analyzed. Children in the three countries and Chilean mothers showed a polarized use of the scale (with mostly extreme like and extreme dislike ratings), while mothers in China and the USA showed a pattern of use of the upper part of the scale. Three preference segments were uncovered for children in Chile and China, and two for US children. The variety of the children's diets, the amount of vegetables eaten at lunch/dinner, and the level of the mothers' satisfaction with their children's vegetable intake were factors used to characterize the different child preference segments according to their level of liking ($p < 0.05$).

1. Introduction

Diets high in vegetables are widely recommended due to their health promoting properties (Slavin & Lloyd, 2012). Vegetables are an important part of the human diet, as they are nutrient dense foods with a low energy content, characterized by their vitamin, minerals, phytochemicals and dietary fiber content. (Rolls, Ello-Martin, Tohill, 2004; Slavin & Lloyd, 2012). Moreover, it has been found that vegetable consumption can reduce the risk of some non-communicable diseases (Joshipura et al., 1999; Boffetta et al., 2010; Cooper et al., 2012). The impact of children's vegetable consumption on health in adulthood has been reported by several studies. Specifically, low vegetable consumption during childhood increases the risks of type 2 diabetes, obesity and some cardiovascular diseases in adulthood (Moller, Taubert, Allen, Clark, Lauer, 1994; Klesges, Klesges, Eck, & Shelton, 1995; Whincup et al., 2002). Despite the health benefits of vegetable consumption, many studies report that children around the world have tended to not reach the recommended amount of vegetable consumption (Currie et al., 2004; CDC, 2014; Yngve et al., 2005; Hall, Moore, Harper, & Lynch, 2009). Many studies have focused on increasing vegetable intake in childhood (Evans, Christian, Cleghorn, Greenwood, & Cade, 2012; Kipping et al., 2014). This is because it has been observed that eating habits established in childhood tend to be reflected in adulthood (Kelder, Perry, Klepp, & Lytle, 1994; Nicklaus, Boggio, Chabanet, & Issanchou, 2005; Beauchamp & Mennella, 2009), and childhood may be a more flexible time to modify food preferences (Birch, 1990; Wardle, 1995). Childhood is also the best time in order to maximize the health benefits associated with vegetable consumption (Cooke et al., 2004).

Many factors are involved in children's vegetable intake, liking has being defined as the first personal determinant of children vegetable intake (Drewnowski, 1997; Gibson, Wardle, & Watts, 1998; Baxter & Thompson, 2002; Cullen et al., 2003). Vegetables, in general, are not sweet, are low in energy content, and many of them are bitter, showing why vegetables preferences need to be learned though experience with food (Beauchamp & Mennella, 2009). Food neophobia, defined as the

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https://doi.org/10.1016/j.foodqual.2020.104000
Received 21 October 2019; Received in revised form 28 April 2020; Accepted 8 June 2020
Available online 16 June 2020
0950-3293/

fear of unknown food, is another important factor that affects children's food intake (Falciglia, Couch, Gribble, Pabst, & Frank, 2000). The evidence shows that a child's food neophobia is a high predictor of low vegetable intake (Cooke, Carnell, & Wardle, 2006). Food neophobia in childhood can be reduced through exposure and learning mechanisms that ensure that a food is safe to eat (Kalat & Rozin, 1973; Birch, 1999) Considering children's environmental factors, family is likely to be the most influential aspect (Cooke et al., 2004; Pearson Biddle & Gorely, 2009; Estay, Lestringant, Pan, Fang, Capitaine, Agosin & Guinard, 2019a). Specifically, it has been reported that parental vegetable consumption is a significant predictor of vegetable intake in children (Gibson et al., 1998; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Cooke et al., 2004). Parents can influence children's vegetable consumptions through different mechanisms, like having vegetables available at home (Hearn et al., 1998; Cullen et al., 2001; Pearson Biddle & Gorely, 2009), being a positive role model of vegetable consumption (Cullen et al., 2001; Pearson Biddle & Gorely, 2009) and using feeding practices that encourage children to try vegetables (Vereecken, Rovner, & Maes, 2010; Sleddens et al., 2014). Moreover, a mother's influence over her child's food preferences starts even before the child can eat solid food (Mennella, Jagnow, & Beauchamp, 2001). During pregnancy, flavors from the mother's diet can transfer to the amniotic fluid, and, during lactation, to the breastmilk (Mennella et al., 2001). In this sense, mothers can be a strong determinant of a child's eating habits regarding vegetable preferences, through exposure, modelling and feeding practices (Cullen et al., 2001; Mennella et al., 2001; Cooke et al., 2004; Fildes, van Jaarsveld, Wardle, & Cooke, 2014). Culture is another fundamental factor in the study of food preferences, as it shapes our experiences with food (Rozin, 2006). In this sense, to have a broader understanding of children's food preferences, it is necessary to consider cultural factors in the analysis (Feunekes, Cees de Graaf, Meyboom, & Van Staveren, 1998; Benton, 2004; Estay, Pan, Zhong, Capitaine & Guinard, 2019b). This allows to factor countries' particularities into the general global pattern of children's vegetable consumption (Hall et al., 2009).

Previously (Estay et al., 2019a), we analyzed and compared the strength of the vegetable liking similarity between children and their social influencers (mothers, siblings and peers) in three different countries. The results of this previous publication showed that culture is a factor that influences the strength of the similarity of vegetable liking between children and their mothers. However, some unresolved questions remain, among them, do mothers like vegetable more, and a greater variety, than their children? How do cultural differences influence mothers' and children's vegetable liking and the relationship between them? Are there characteristics that allow us to characterize different levels of children's vegetable liking (children who like vegetable more versus those who like them less)?

The present study aims to look at some of these inquiries. Specifically, the main objective of this study is to gain a better understanding of children's vegetable liking, through an in-depth examination of the relationship between mothers' and children's vegetables liking in three countries (Chile, China and the United States). By analyzing vegetable liking variety, the use of the hedonic scores by mothers and children, and by characterizing children with different levels of vegetable liking using mother's perception about children's eating habits. The specific objectives of this study were:

1. To analyze mothers' and children's vegetable liking in different countries, using six vegetable samples tasted across countries.
2. To analyze the specific relationship between mothers' and children's vegetable liking within each country, by analyze the effect of 14 different samples tasted in each country, as well as to analyze vegetable liking variety by mothers and children in each country.
3. To analyze the use of the 7-point hedonic scale by mothers and children across countries.
4. To uncover children's preference segments with different levels of vegetable liking and characterize these different levels using eating habit information provided by their mothers.

2. Materials and methods

2.1. Tasting sessions and data collection

A two-part Central Location Test (CLT) was conducted with children and their mothers in Santiago (Chile), Wuxi (China) and in Davis-California (USA). Tasting sessions took place between 11:30 am and 5:30 pm during weekends and lasted around 45 min each. Participants enrolled in the two tasting sessions times according to their convenience (the same or different times each day). Mothers and their children always participated together, sitting separately, but at the same time and in the same room. Participants were asked not to eat during the hour before the tasting sessions. However, the hunger of thirst state of the participants was not assed in this study. During the tasting sessions, 14 different vegetables were tasted in total over two days, with seven samples tasted in each session. Vegetable selection and preparation were chosen individually for each country based on two parameters - familiarity and variety of sensory characteristics. The familiarity was assessed through focus groups with mothers from the three countries (data in preparation for publication) and by checking which vegetables were readily available in the local grocery stores of each city where the study was performed. From this list of possible vegetables and preparations, the group of researchers in the three countries selected 14 samples that covered the widest sensory spectrum possible, of different colors, flavors and textures. Within the 14 individual vegetables for each country, there were 6 common ones (broccoli, cucumber, corn, mushrooms, potatoes and sweet peas). Details of the samples for each country are shown in Table 1. On average, between 5 and 10 children, plus their mothers, participated in each tasting session. During the tasting sessions, participants (children and mothers) rated their degree of liking (overall liking) of the samples using a 7-point hedonic scale. Children used the 7-point hedonic scale with numbers, words and emoji faces, and mothers used the 7-point hedonic scale with numbers and words to evaluate the samples (Estay et al., 2019a). The number 1 on the scale corresponded to "dislike very much" and the number 7 to "like very much". The use of this kind of scale has been reported to be appropriate for the age range involved in the present study (Laureati, Pagliarini, Toschi, & Monteleone, 2015; Guinard, 2001).

Before starting the evaluation, a researcher explained to the children how to perform the evaluation. To be sure that children and mothers understood the instructions, the researcher walked the participants through the whole questionnaire. During the tasting sessions there were 5 trained assistants available to help children during their evaluations The number of trained assistants was increased as was needed in order to count with at least 1 assistant per each child in the age range 5–8 years old, and 1 assistant per 4 children in the range of age 9–12 years old. Mothers were also allowed to help children, when children, especially some of the younger ones, felt more comfortable doing the task with their mothers. In these cases, we required mothers not to interfere with the child's answers. At the end of the second testing session, mothers completed an exit survey providing demographic information, vegetable consumption, and feeding practices (all questions included in the exit survey and their respective percentage by country are presented in table 2 and table 3). Participants tasted the samples in a counterbalanced serial monadic sequence, and the sample order was balanced using a Williams Latin square design (Williams, 1949). The samples were served with blinding codes in 6 oz. containers with lids. In this sense, samples were not visible to participants before they started tasting each individual sample. The data of children and Chinese mothers was collected using paper questionnaires. The data of mothers in Chile and in the USA was collected on tablets, using Qualtrics online survey software (Qualtrics, LLC; Seattle, WA). All

Table 1
Vegetables tasted and their preparation in Chile, China and the Unites States.

Country	Sample	Preparation	Serving Temperature
Chile	Asparagus	Boiled with salt	Room temp
	Avocado	Served raw	Room temp
	Beets	Boiled with salt	Room temp
	Broccoli	Boiled with salt	Room temp
	Cabbage	Served raw and slightly seasoned with salt, lemon juice and sunflower oil	Room temp
	Carrots	Served raw	Room temp
	Corn	Boiled with salt	Room temp
	Cucumber	Served raw and slightly seasoned with salt, lemon juice and sunflower oil	Room temp
	Lettuce	Served raw and slightly seasoned with salt, lemon juice and sunflower oil	Room temp
	Mushrooms	Sautéed with salt sunflower oil	Warm
	Olives	Greek style naturally ripe black olives	Room temp
	Potatoes	Boiled with salt	Warm
	Sweet Peas	Boiled with salt	Room temp
	Tomato	Served raw and slightly seasoned with salt and sunflower oil	Room temp
China	Broccoli	Boiled with salt	Warm
	Bell Pepper	Sautéed with salt and soybean oil	Warm
	Carrots	Sautéed with salt and soybean oil	Warm
	Cauliflower	Sautéed with salt and soybean oil	Warm
	Celery	Sautéed with salt and soybean oil	Warm
	Corn	Boiled with salt	Warm
	Cucumber	Served raw and slightly seasoned with salt, vinegar and soy sauce	Room temp
	Eggplant	Sautéed with salt, soybean oil and water	Warm
	Mushrooms	Sautéed with salt and soybean oil	Warm
	Onions	Sautéed with salt and soybean oil	Warm
	Potatoes	Boiled with salt	Warm
	Spinach	Sautéed with salt and soybean oil	Warm
	Sweet Peas	Boiled with salt	Warm
	Tomato	Sautéed with salt and soybean oil	Warm
USA	Asparagus	Boiled with salt	Warm
	Avocado	Served raw	Room temp
	Bell Pepper	Served raw	Room temp
	Broccoli	Boiled with salt	Warm
	Carrots	Served raw (baby carrots)	Room temp
	Corn	Boiled with salt	Warm
	Cucumber	Served raw and slightly seasoned with salt, lemon and EVOO*	Room temp
	Lettuce	Served raw and slightly seasoned with salt, lemon and EVOO	Room temp
	Mushroom	Sautéed with salt and EVOO	Warm
	Olives	California-style black olives	Room temp
	Potatoes	Boiled with salt	Warm
	Spinach	Served raw and slightly seasoned with salt, lemon and EVOO	Room temp
	Sweet Peas	Boiled with salt	Warm
	Tomatoes	Served raw (cherry tomatoes)	Room temp

* EVOO: Extra Virgin Olive Oil

participants agreed to participate in this study. American participants (mothers and children) signed a consent form. Participants in Chile and in China received the information verbally and agreed to participate. Participants in the three countries received compensation for completing the study. This study was approved for the use of human subjects by the Institutional Review Board of the University of California, Davis (IRB ID: 930546–1).

2.2. Population sample: Children and mothers

The recruitment process was performed in each country through university networks (Catholic University of Chile, University of Jiangnan and University of California-Davis) by email and using flyers, and in primary schools in each city, using emails, personal invitation in classrooms and flyers.

Table 2
Description of mothers' sample in Chile, China and in the US. The information was provided by mothers in their exit surveys.

	Chile	China	US
Mothers' age			
18–35 yrs. old	32.3%	32.3%	12.9%
36–55 yrs. old	67.7%	67.7%	87.1%
Mothers' BMI *			
Underweight	0.8%	12.6%	5.9%
Healthy weight	60.0%	80.3%	58.8%
Overweight	34.6%	7.1%	15.7%
Obese	4.6%	0.0%	19.6%
Mother's occupation			
Housewife	37.7%	8.5%	26.6%
Student	16.2%	0.0%	8.9%
Salaried or hourly position	46.2%	80.0%	50.0%
Self employed	0.0%	8.5%	8.1%
Other	0.0%	3.1%	6.5%
Marital status			
Single, never married	10.8%	0.0%	0.8%
Married or living with a partner	79.2%	96.2%	83.9%
Divorced or separated	7.7%	3.1%	13.7%
Prefer not to answer	2.3%	0.8%	1.6%
Main source of income in the household			
No	63.1%	43.8%	52.4%
Yes	15.4%	3.8%	18.5%
Similar contribution with other family member	21.5%	52.3%	29.0%
Primary shopper of vegetables at home			
Mother	83.1%	43.8%	93.5%
Another person	16.9%	56.2%	6.5%
Main responsible for cooking at home			
Mother	68.5%	43.8%	86.3%
Another person	31.5%	56.2%	13.7%
Breastfeeding (the child that participated in the study)			
Mother who did not breastfeed	1.5%	12.3%	4.6
Mothers who breastfed between 1 and 3 months	6.9%	6.1%	6.3%
Mothers who breastfed between 4 and 6 months	24.6%	18.5%	9.8%
Mothers who breastfed between 7 and 12 months	40.8%	48.5%	25.3%
Mothers who breastfed 13 months or more	26.2%	14.6%	54%

* Mother BMI was calculated based on the weight and height provided by mothers. Considering BMI below to 18.5 as underweight; between 18.5 and 24.9 as healthy weight; between 25 and 29.9 as Overweight; and greater than 30 as Obese.

The child population samples were children born in each of the countries studied (Chile: CL; China: CN; the USA: US), homogenously distributed between the ages of 5 to 12 years old (around 30 children in each age group). Specifically, 130 children participated in Chile (45% female and 55% male), 130 children participated in China (50% female and 50% male), and 124 children participated in the US (45% female and 55% male). Children were eligible to participate in this study if they did not present any allergies to vegetables, were born in each of the countries included, were between 5 and 12 years old, and had a mother willing to participate in the study.

The mother population sample (CL n = 93; CN n = 128; USA n = 100), were the mothers of children eligible to participate in this study who stated they did not have any allergies to vegetables. Mothers were born and raised in each country, with the exception of 4 mothers who participated in Chile (born in Spain, Venezuela and Colombia, all of them had lived in Chile for at least 10 years), and 9 mothers in the USA (born in Japan, Mexico, Denmark, Philippines and Germany, all of them had lived in USA for at least 10 years). The mothers' age range was 18–55 years old (CL: 24–54 yrs. old; CN: 30–50 yrs. old; USA: 18–55 yrs. old). All mothers who participated in this study earned a higher degree diploma (CL: 96.2%, cn:95.4%, and US:100%) or were currently university students (CL:3.8%, CN:4.6%). Mothers who had more than one eligible child were invited to participated with all their children, in Chile 45% of mothers participated with one child, 48%

Table 3
Vegetable consumption and feeding practices. Information provided by mothers in their exit survey*.

	Chile	China	US
a.1 How would you characterize your diet in terms of vegetable intake?			
High	59.2%	33.1%	47.6%
Medium	39.2%	56.9%	49.2%
Low	1.5%	10.0%	3.2%
a.2 How often do you eat vegetables?			
Never	0%	0%	0%
Less than once a day	3.1%	3.8%	36.5%
1–2 times a day	75.4%	88.5%	63.5%
3–4 times a day	16.2%	7.7%	0%
5 or more times a day	5.4%	0%	0%
b.1 How would you characterize your child's diet in terms of vegetable intake?			
High	50.8%	16.9%	33.9%
Medium	36.9%	51.5%	52.4%
Low	12.3%	31.5%	13.7%
b.2 How often does your child eat vegetables?			
Never	0.8%	0%	0%
Less than once a day	11.5%	9.2%	3.2%
1–2 times a day	60.8%	73.8%	60.3%
3–4 times a day	23.1%	16.9%	33.3%
5 or more times a day	3.8%	0.0%	3.2%
b.3 For LUNCH, what percentage of your child's plate are vegetables (on average)?			
0%	0%	0%	1.6%
< 10%	8.5%	10.8%	23.4%
10–25%	26.2%	28.5%	44.4%
25–50%	43.8%	46.9%	26.6%
50–75%	16.9%	11.5%	4.0%
More than 75%	4.6%	2.3%	0.0%
b.4 For DINNER, what percentage of your child's plate are vegetables (on average)?			
0%	2.3%	0%	0.8%
< 10%	14.6%	14.6%	2.4%
10–25%	29.2%	27.7%	34.7%
25–50%	36.9%	40.0%	45.2%
50–75%	10.8%	16.9%	16.1%
More than 75%	6.2%	0.8%	0.8%
b.5 Are you happy with your child's vegetable intake?			
Yes, I am happy with his/her eating habits in terms of vegetables,	60.0%	33.1%	58.1%
No, actually I would like him/her to eat more vegetables	40.0%	66.9%	41.9%
b.6 How varied it the diet of your child?			
He/she is a good eater, but usually eats the same food each day (few variety)	11.5%	28.7%	13.7%
He/she is a picky eater. That is why I give him/her only the few foods that he/she likes	63.8%	17.8%	8.9%
He/she is a picky eater, but I offered her/him a varied diet	3.8%	21.7%	22.6%
He/she is a good eater and has a varied diet	20.8%	31.8%	54.8%
b.7 Do you ask your child to eat everything that you serve to him/her?			
Yes, always	30.8%	32.3%	16.1%
Most of the time	52.3%	57.7%	24.2%
Sometimes	13.1%	10.0%	24.2%
never	3.8%	0.0%	35.5%
b.8 If you offer a food to your child and he/she rejects it, do you offer it again?			
Yes	60.0%	59.2%	66.1%
Sometimes	30.0%	31.5%	25.0%
No	10.0%	9.2%	8.9%
b.9 In general at home, do your children eat the same menu as the rest of the family?			
Yes, in general we eat the same food	92.3%	90.0%	76.2%
No, my children have a different menu that the rest of the family	0%	0.8%	1.6%
Sometimes we eat the same and sometimes we eat differently	7.7%	9.2%	22.2%

* All questions were answered by mothers at the end of the second tasting session. a) questions regarding mothers that participated in this study. b) questions regarding children who participated in the study.

with two children and 7% with three; in China 97% participated with one child and 3% with two; in the USA 61% participated with one child and 39% with two children. More specific information about the mothers who participated in this study is provided in Table 2.

2.3. Data analysis

All statistical analyses were performed using R Studio based on R version 3.3.3. (R Development Core Team 2015). The level of significance was chosen at 5%.

Mothers' and children' hedonic ratings: To analyze children and mothers' vegetable liking in the 3 countries, a mixed model Analysis of Variance (ANOVA) with interactions was run across all overall liking values for the 6 common vegetable samples tasted. The factors included in this model were: country (Chile, China, USA), status (mother/child) and product (broccoli, corn, cucumber, mushrooms, potatoes and sweet peas). Subjects were treated as random effect, nested within the interaction of country and status, repeated across all products. To analyze children and mothers' liking in each country, a second ANOVA model was performed. This second model used was a 2-factor mixed ANOVA with interaction across the overall liking value of each country. The factors included in this second model were: products (the fourteen vegetables samples tasted in each country) and status (mother/child). In this model subjects were also treated as random effect, nested within the interaction subject: status, repeated across all products. For multiple-comparison, Bonferroni post-hoc test was used. Effect size was calculated by using Partial Eta squared (η_p^2).

Use of the 7-point hedonic scale by mothers and children in the three countries: The use of the 7-point hedonic scale by children and mothers in the three countries was analyzed graphically by plotting each vegetable liking score given by each individual participant. Mothers and children were analyzed separately for each of the countries considered in this study. In order to visualize all the hedonic scores given by participants, Jitter function of ggplot package on R was used. This technique adds a small amount of random variation to the location of each dot, so they are not plotted directly on top of each other.

Children's Preference Segments: Agglomerative Hierarchical Clustering (AHC) was conducted on children's overall liking means data by country. AHC was run using Euclidean distances and a Ward.D linkage method, without scaling the data in order to segment children according to their liking level. To verify that the resulting clusters were significantly different from one another in children's hedonic acceptance ratings of the vegetables, 2-factor fixed ANOVA's model with interaction were run across the overall liking ratings. The 2 factors included were: Cluster groups and Products (14 vegetables samples). The number of clusters kept by each country was the maximum number of clusters that showed significant differences between them. In order to characterize children's Preference Segments, the chi-squared test was run for each exit survey question with clusters as factor.

3. Results

3.1. Mothers' and children's hedonic ratings

When mothers and children from the 3 countries were analyzed together over the 6 common vegetable samples tasted we found significant differences in the hedonic ratings among mothers and children ($F_{[1, 699]} = 5.75$, $p < 0.05$, $\eta_p^2 = 0.003$), among countries ($F_{[2, 699]} = 47.44$, $p < 0.05$, $\eta_p^2 = 0.05$), among product ($F_{[5,3863]} = 88.56$, $p < 0.01$, $\eta_p^2 = 0.1$), and significant interactions between country and status (mother/child) ($F_{[2, 699]} = 10.73$, $p < 0.01$, $\eta_p^2 = 0.01$), country and product ($F_{[10, 699]} = 4.27$, $p < 0.001$, $\eta_p^2 = 0.02$), and status and product ($F_{[5, 699]} = 17.6$, $p < 0.001$, $\eta_p^2 = 0.05$). Specifically, the results showed that when all countries were analyzed together, mothers gave higher liking ratings to vegetables than children (Fig. 1), and the vegetable liking scores (of mothers

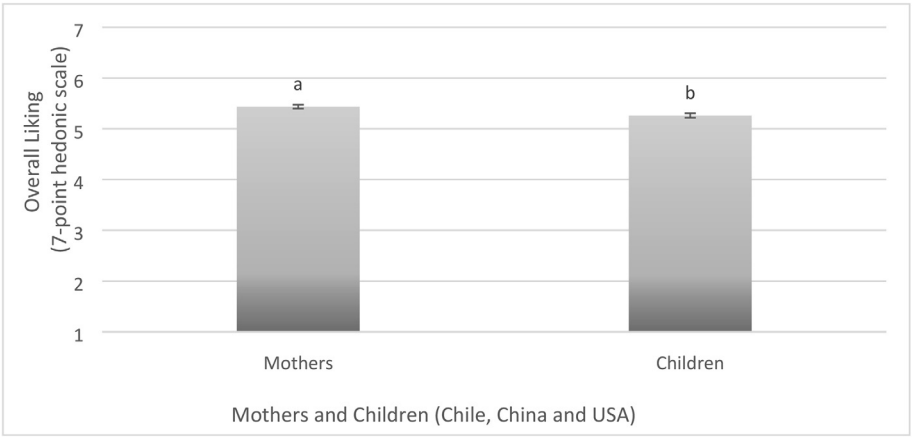

Fig. 1. Mean ratings on the 7-point hedonic scale and standard error of the mean for children (n = 384) and mothers' (n = 321) vegetable liking on the 6 common vegetable samples tasted (broccoli, corn, cucumber, mushrooms, potatoes and sweet peas). Means with different superscripts are significantly different at $p < 0.05$.

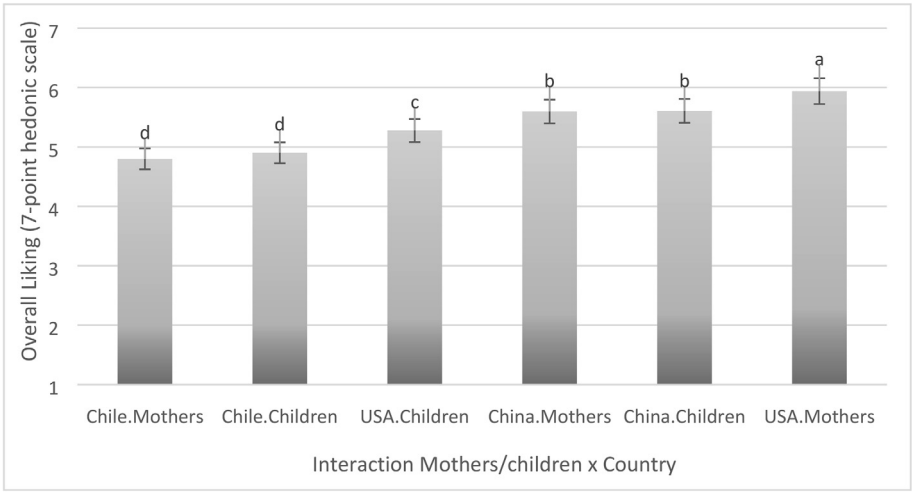

Fig. 2. Mean ratings on the 7-point hedonic scale and standard error of the mean for children's and mothers' vegetable liking, in Chile (CL mothers n = 93; CL children n = 130), China (CN mothers n = 128; CN children n = 130), and in the USA (USA mothers n = 100; USA children n = 124), on the 6 common vegetables samples tasted (broccoli, corn, cucumber, mushrooms, potatoes and sweet peas). Means with different superscripts are significantly different at $p < 0.05$.

Table 4
Mean rating of the 7-point hedonic scale and standard error of the mean (SEM) for children's and their mothers' vegetable liking in Chile (children n = 130, mothers n = 93), China (children n = 130, mothers n = 128) and the USA (children n = 124, mothers n = 100). Within each country, means with different superscripts are significantly different at p < 0.05. Products in bold are the 6 common samples tasted in the 3 countries.

Product	Chile Mothers	SEM	Children	SEM	China Mothers	SEM	Children	SEM	USA Mothers	SEM	Children	SEM
Broccoli	5.326 fgh	0.19	4.98 ghi	0.20	5.16 ijkl	0.12	5.51 efgh	0.15	6.15 abc	0.10	5.57 efgh	0.17
Cucumber	3.97 lm	0.22	5.62 cdef	0.17	5.60 efg	0.11	6.02 bcd	0.13	6.30 a	0.08	5.50 fgh	0.14
Corn	4.67 ij	0.21	5.62 cdef	0.18	6.35 ab	0.08	6.40 a	0.12	6.02 abcd	0.11	6.20 ab	0.13
Mushrooms	5.28 efgh	0.2	2.96*n*	0.21	5.67 def	0.11	4.47 no	0.20	5.43 gh	0.17	3.39 l	0.21
Potatoes	5.33 efg	0.19	6.12 abc	0.12	5.61 efg	0.11	6.12 abc	0.13	6.02 abcd	0.11	5.52 fgh	0.16
Sweet peas	4.57 ijk	0.22	4.12 klm	0.20	5.18 hijkl	0.11	5.12 jkl	0.17	5.71 defg	0.14	5.48 gh	0.16
Asparagus	5.58 def	0.18	3.88 *m*	0.21					6.10 abc	0.08	4.07 k	0.19
Avocado	4.77 hij	0.21	5.92 abcd	0.16					6.08 abcd	0.13	4.70 j	0.19
Beets	3.90 *m*	0.21	4.36 jklm	0.21								
Bell Pepper˙					4.99 klm	0.13	4.22o	0.20	6.20 ab	0.13	4.58 j	0.19
Cabbage												
Cauliflower					5.38 fghij	0.11	6.0 cd	0.12				
Carrots*	4.48 ijkl	0.25	5.79 bcde	0.16	5.38 fghij	0.11	5.58 efg	0.16	5.88 bcdef	0.11	5.90 bcde	0.13
Eggplants					4.15o	0.12	3.78p	0.20				
Celery					5.40 fghij	0.12	5.11 jkl	0.17				
Lettuce									6.11 abc	0.11	5.20 hi	0.16
Olives◆	4.49 ijkl	0.25	5.31 efg	0.21					5.44 gh	0.18	4.91 ij	0.21
Onions					4.73 mn	0.13	4.85 lm	0.18				
Spinach˙					5.27 ghijk	0.12	5.50 efghi	0.14	5.79 cdefg	0.11	4.87 ij	0.17
Tomato*	4.64 ijk	0.23	6.18 ab	0.13	5.82 cde	0.09	5.81 cde	0.15	5.94 abcde	0.14	4.64 j	0.20

. * Carrots and tomatoes in Chile and in the USA were served raw and in China were sautéed.
˙ Spinach and bell peppers in China were sautéed and, in the USA, served raw. ◆Olives in Chile were Greek style naturally ripe black olives and in the USA were California style black olives.

and children analyzed together) were higher in China and the USA, and lower in Chile. Fig. 2 shows the significant interaction between country and status (mother/child) for the 6 common vegetables samples tasted, where it is possible to see that American mothers liked these 6 vegetable samples significantly more than American children, whereas Chilean and Chinese mothers liked these 6 vegetables samples the same as their children.

3.2. Mothers' and children' vegetable liking by country

The ANOVA model run for each country individually over the 14 vegetables showed that mothers and children analyzed together gave different liking scores for the different vegetable in each of the countries included in this study (Chile: $F_{[13, 3391]} = 19.1$, $p < 0.01$, $\eta_p^2 = 0.01$; China: $F_{[13, 3356]} = 46.5$, $p < 0.01$, $\eta_p^2 = 0.15$; US: $F_{[13, 3222]} = 20p < 0.01$, $\eta_p^2 = 0.07$). This result is complemented by the analysis of interaction between product (vegetables) and status (mothers/child) checked for each country. Specifically, in the case of China and the USA, no significant interaction between product and status was found, showing that mother–child pairs in China and in the USA were consistent in their relative preferences for the different vegetables tasted. In the case of Chile, there was a significant interaction between product (vegetables) and status (mother/child) ($F_{[13, 221]} = 6.7$, $p < 0.001$, $\eta_p^2 = 0.06$). Specifically, the interaction between product and status in Chile showed lower mean liking scores by Chilean mothers than their children for 7 of the 14 samples (lettuce, tomatoes, potatoes, avocado, cabbage, corn and olives). Only 2 samples were rated with a higher liking score by Chilean mothers than their children (asparagus and mushrooms), and 5 samples were rated with the same liking score by children and their mothers in Chile (cucumber, carrots, broccoli, beets and sweet peas) (Table 4).

3.2.1. Use of the 7-point hedonic scale by mothers and children in the three countries

Each liking score given by each individual mother and each individual child, for the 14 samples tasted, is graphically shown in Fig. 3. The pattern of the hedonic scores given by children using the 7-point hedonic scale seems to be relatively consistent between children when the three countries were compared. However, the pattern of the hedonic scores given by mothers is different depending on the country analyzed. Specifically, mothers from China and the US showed a pattern of use of the upper part of the scale (higher ratings scores), while Chilean mothers showed a more polarized use of the scale, characterized by the use of extreme like and extreme dislike scores.

3.3. Children's preference segments by country

Cluster analysis was run on children's overall liking scores for each country. In the case of the US, two significant clusters were found, and in the case of Chile and China three significant clusters were found. Below, in detail, are the results of the cluster analysis for each country.

3.3.1. Chilean children

In Chile, three clusters were found using the AHC analysis, with significant differences between them ($F_{[2, 1785]} = 40.49$, $p < 0.001$, $\eta_p^2 = 0.02$). These preference segments will be called Cluster CL.1 (Cluster children Chile 1), Cluster CL.2 (Cluster children Chile 2) and Cluster CL.3 (Cluster children Chile 3). The number of Chilean children in each of the preference segments found and the hedonic rating means for overall liking were n = 31 and mean = 6.41 for CL.1, n = 49 and mean = 5.32 for CL.2, and n = 40, mean 4.13 for CL.3 (Fig. 4). The three preference segments were significantly different in the rating for the different vegetable samples tasted ($F_{[13, 1786]} = 34.52$, $p < 0.001$, $\eta_p^2 = 0.2$). Specifically, in cluster CL.1, all vegetable samples were liked (a mean score of 5 or more). From those, thirteen samples were liked moderately or more, and only one (sweet peas) was liked slightly. In CL.2, 10 vegetable samples were liked, 2 vegetable samples were neither liked or disliked (sweet peas and beets) (a mean score of 4), and 2 samples were disliked (asparagus and mushrooms) (a mean score of 3 or below). In CL.3, 5 vegetables samples were liked (tomato, lettuce, potatoes, avocado, corn) (a mean score of 6 or more), 3 vegetable samples were rated as neither liked or disliked (Cabbage, carrots and cucumber) (a mean score of 4), and 6 vegetable samples were disliked (mushrooms, olives, asparagus, sweet peas, beets & broccoli) (a mean score of 3 or below) (Fig. 4).

Below: Mean rating for each vegetable sample on the 7-point hedonic scale and standard error of the mean of vegetable overall liking of each children's preference segment in Chile. Within each cluster group, mean with different superscripts are significantly different at $p < 0.05$.

3.3.2. Chinese children

In China, three clusters were found using the AHC analysis, with significant differences between them ($F_{[2, 1783]} = 105.24$, $p < 0.001$, $\eta_p^2 = 0.06$). These preference segments will be called Cluster CN.1 (Cluster children China 1), Cluster CN.2 (Cluster children China 2) and Cluster CN.3 (Cluster children China 3). The number of Chinese children in each of these preference segments and the hedonic rating mean for overall liking were n = 49 and mean = 6.18 for CN.1, n = 26 and mean = 5.38 for CN.2, and n = 55, mean = 4.54 for CN.3. (Fig. 5). The three preference segments were significantly different in the rating for the different vegetable samples tasted ($F_{[13, 1784]} = 25.41$, $p < 0.001$, $\eta_p^2 = 0.15$). Specifically, in Cluster CN.1, all vegetable samples were liked (mean score of 5 or more). From those, nine of them were liked moderately or more and 5 of them were liked slightly. In CN.2, ten samples were liked (a mean score of 5 or more), 1 sample was rated as neither liked or disliked (a mean score of 4) and 3 samples were disliked (bell pepper, eggplants and mushrooms) (a mean score of 3 or below). In CN.3, 4 samples were liked (corn, potatoes, cauliflower, cucumber) (a mean score of 5 or below), 8 samples were rated as neither liked or disliked (tomato, spinach, carrots, onions, celery, sweet peas, broccoli, mushrooms) (a mean score of 4), and 2 samples were disliked (bell peppers & eggplants) (a means scores of 3 or below) (Fig. 5).

Below: Mean rating for each vegetable sample on the 7-point hedonic scale and standard error of the mean of vegetable overall liking of each children's preference segment in China. Within each cluster group, mean with different superscripts are significantly different at $p < 0.05$.

3.3.3. American children

In the USA, two clusters were found using the AHC analysis, with significant differences between them ($F_{[1, 1679]} = 203.85$, $p < 0.001$, $\eta_p^2 = 0.11$). These preference segments will be called Cluster US.1 (Cluster children USA 1) and Cluster US.2 (Cluster children USA 2). The number of American children in each of these preference segments and the hedonic rating means for overall liking were n = 49 and mean = 5.81 for US.1, and n = 75 and mean = 4.53 for US.2 (Fig. 6). The two preference segments were significantly different in the rating for the different vegetable samples tasted ($F_{[13, 1679]} = 21.29$, $p < 0.001$, $\eta_p^2 = 0.14$). Specifically, in Cluster US.1, all vegetable samples were liked (mean score of 5 or more). From those, eight of the samples were liked moderately or more and 7 of the samples were liked slightly. In US.2, 7 samples were liked (corn, carrots, cucumber, potatoes, sweet peas, lettuce, broccoli) (a mean score of 5 or more), 4 samples were rated as neither liked or disliked (olives, spinach, red bell pepper & tomatoes) (a mean score of 4), and 3 samples were disliked (bell peppers & eggplants) (a mean score of 3) (Fig. 6).

Below: Mean rating for each vegetable sample on the 7-point hedonic scale and standard error of the mean of vegetable overall liking of each children's preference segment in the USA. Within each cluster group, mean with different superscripts are significantly different at $p < 0.05$.

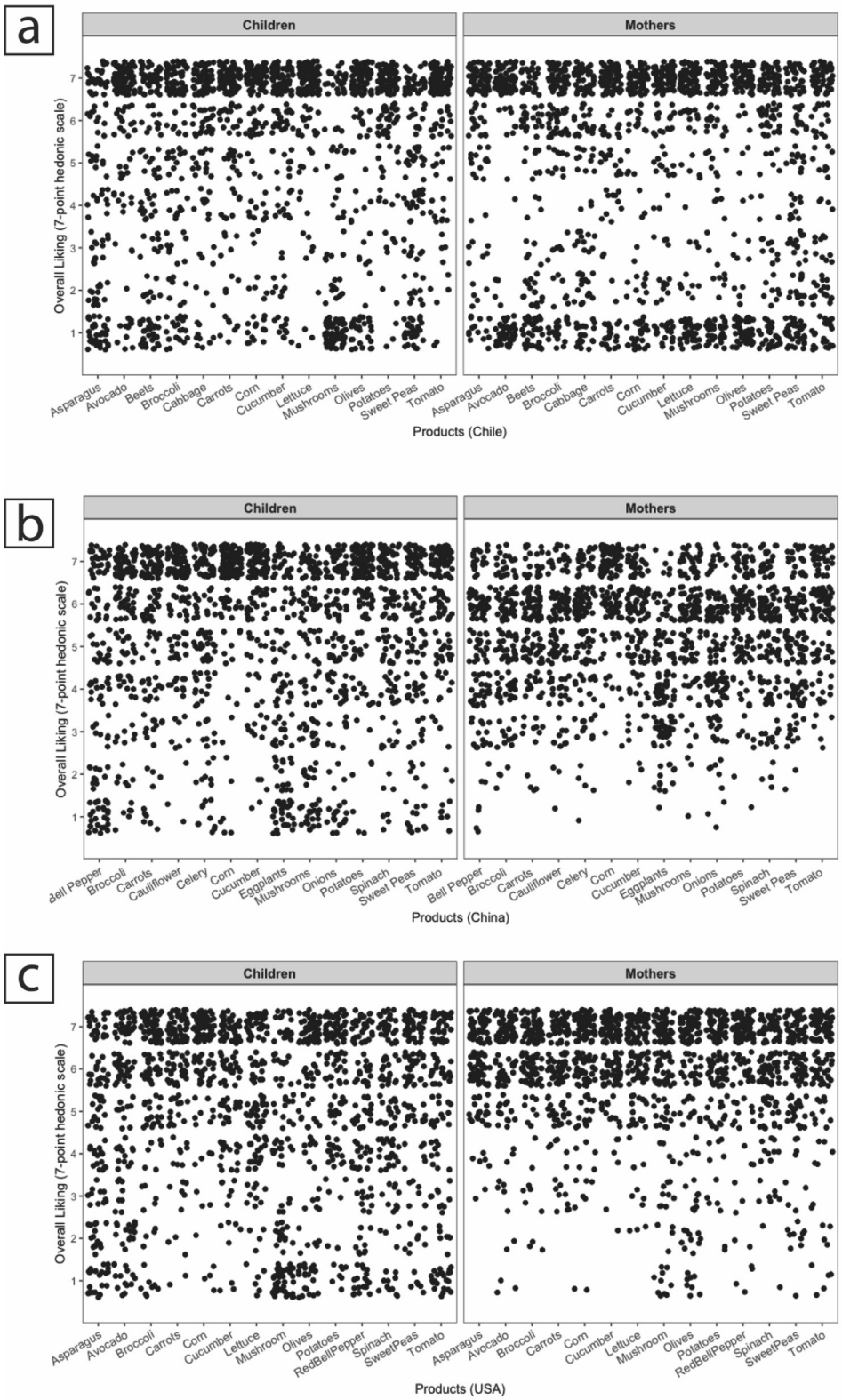

Fig. 3. Individual liking scores on a 7-point hedonic scale given by mothers and children in: a) Chile (mothers n = 93; children n = 130), b) China (CN mothers n = 128; CN children n = 130) and c) the US (US mothers n = 100; US children n = 124). The left side of the graphs shows children's vegetable liking scores and the right side shows mothers' vegetable liking scores. Each point represents an individual liking score given by a single person and for a single vegetable sample tasted.

3.4. Characterization of preference segment using exit survey questions.

Exit survey questions answered by mothers (table 2 and 3) were used to characterize children's preference segments. Questions that were able to differ between preference segments for the three countries are summarize on table 5. The results showed that the question "How varied is the diet of your child?" was able to differentiate children's vegetable liking levels in the three countries. Specifically, CL.1, CN.1

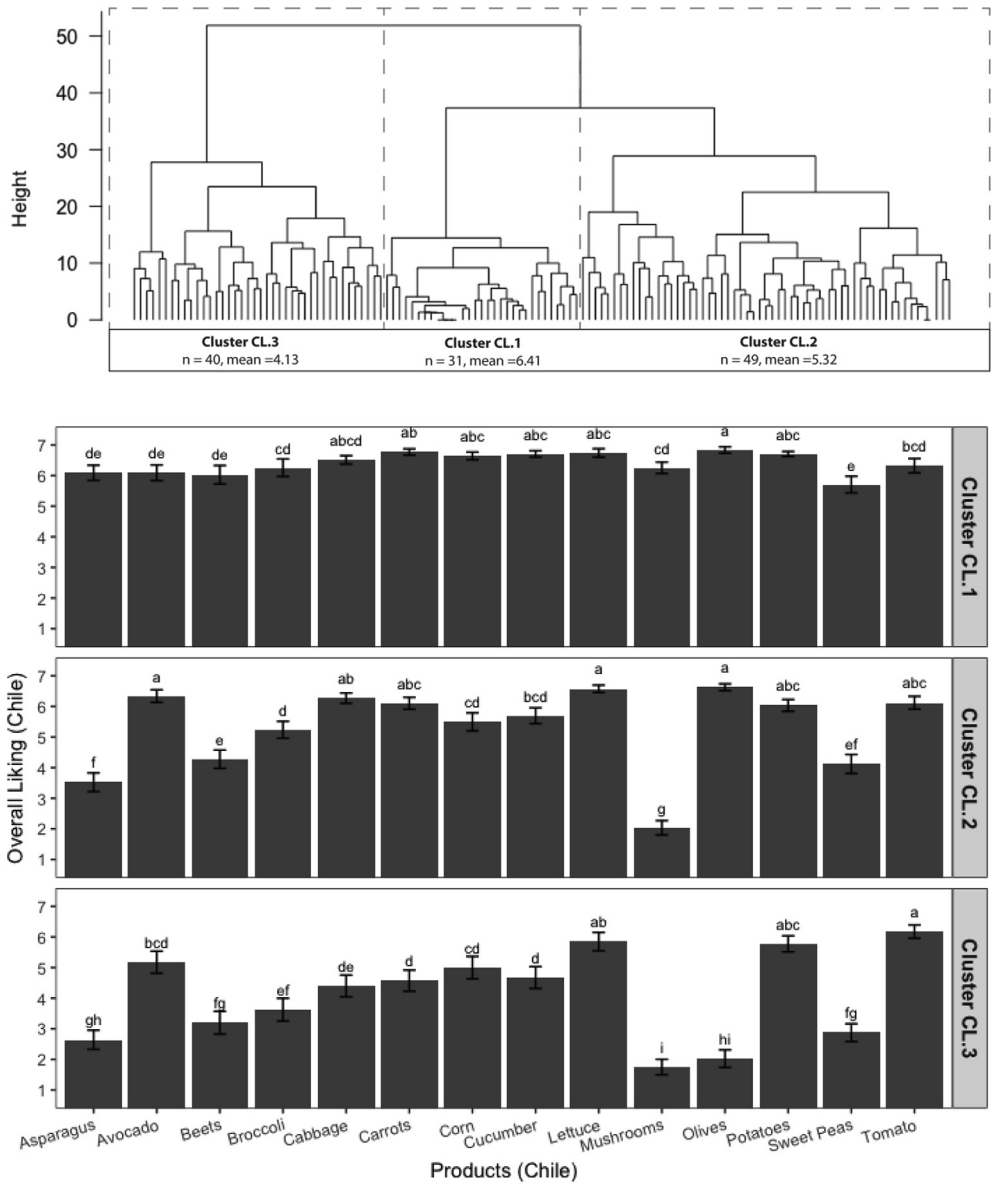

Fig. 4. Above: The three children's preference segments in Chile (Cluster CL.1, Cluster CL.2 and Cluster CL.3). The number of children in each cluster is represented by "n", and the mean rating of all vegetable samples for each cluster is represented by "mean".

and USA.1 were the preference segment groups in which mothers stated that their children had a varied diet, in contrast with group CL.3, CN.3 and USA.2, in which mothers reported a lower variety in the diets of their children. The questions regarding the percentage of vegetables on children's plate seems to be connected with the vegetable liking scores of children in Chile and China for lunch, and in the US for dinner. In this sense, the preference segments CL1, CN1 showed that the highest proportion of vegetable intake was at lunch time. 35.5% (CL1) and 20.1% (CN1) reported eating a lunch plate composed of 50% or more vegetables. While the preference segments CL3 and CN3 showed the lowest proportion of vegetable on their plate at lunch, with only 12.5% (CL3), and 5.5% (CN3) reporting eating a lunch plate composed of 50% or more of vegetables. In the case of the US, the vegetable liking score was related with dinner time. Specifically, 23% of children in the preferences segment US.1 reported eating a plate composed of 50% vegetables, while in preference segment US3, only 13.5% of them reported eating the same amount of vegetables at dinner time. The question "Are you happy with your child's vegetable intake?" was a question that differentiated the vegetable liking score for American children. Specifically, 73% of the mothers of US1 children stated that they were happy with their child's eating habits in terms of vegetables intake, while 48% of the mothers of children on US2 stated the same.

4. Discussion

4.1. Hedonic comparison between mothers and children in the three countries

When mothers and children's vegetable liking scores from the three countries were analyzed together, our results showed that mothers liked vegetables more than their children. This can be explained by the sensory characteristics of vegetables, which are usually not sweet, are low in energy content and can often taste bitter (Drewnowski & Gomez-Carneros, 2000; Gibson & Wardle, 2003). In this regard, vegetables are not foods that are innately liked by children, and that is why preference for them should be developed though exposure (Birch, 1999; Beauchamp & Mennella, 2009), as liking and preferences are usually increased that way (Barends, de Vries, Mojet, & de Graaf, 2013; Wardle, Herrera, Cooke, & Gibson, 2003), and food neophobia decreases (Dovey, Staples, Gibson, & Halford, 2008), with these foods becoming

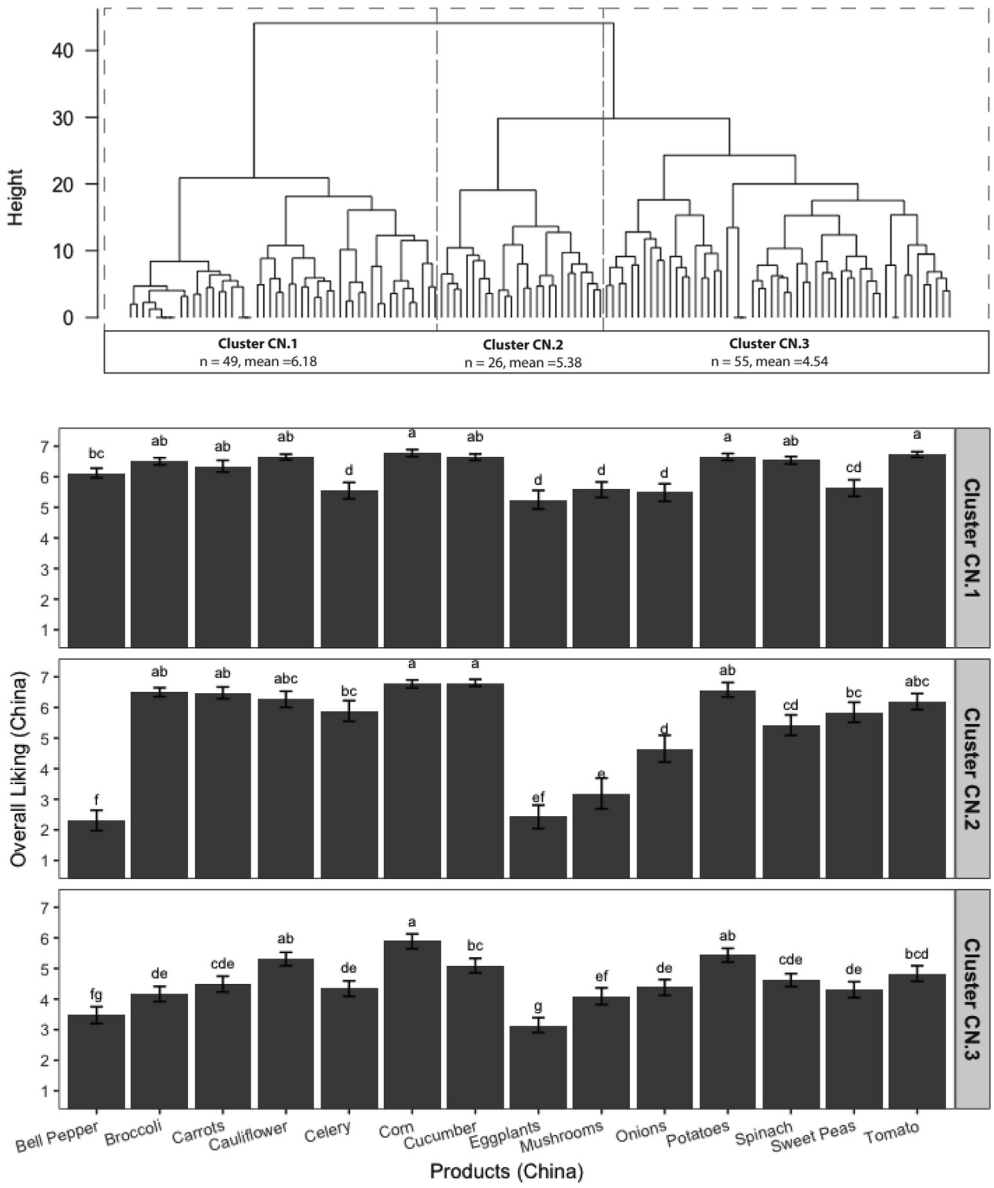

Fig. 5. Above: The three children's preference segments in China (Cluster CN.1, Cluster CN.2 and Cluster CN.3). The number of children in each cluster is represented by "n", and the mean rating of all vegetable samples for each cluster is represented by "mean".

more familiar.

However, this general pattern - that mothers like vegetable more than their children- was not observed for all of the countries when analyzed individually. Specifically, when the mean overall liking of the 6 common samples tasted in each country was analyzed the results showed that in Chile and in China mothers liked vegetables the same amount as their children, while in the US mothers liked vegetable more than children in the same country. Moreover, specifically for the Chilean population it was found that Chilean mothers liked a smaller variety of vegetables than their children. The reason for Chilean mothers' relative distaste for vegetables is not provided by the present study. However, it is possible to think that it is related with the nutritional problems that Chile is facing in the last decades (Vio, Albala, & Kain, 2008). In less than 20 years, Chile have shifted from a stage of high rates of undernutrition to a high rate of obesity (Vio et al., 2008). Specifically, in Santiago, city in which our study was conducted in Chile, the percentage of obese women between 1988 and 1992 almost doubled (from 14% to 24% respectively) (Vio & Albala, 2000). Moreover, the high rates of overweight in pregnancy is particularly alarming, increasing from 31% in 1987 to 54% in 2000 (Mardones, 2003). This nutritional problem linked to changes in eating habits (Vio et al., 2008) could also be reflected in their liking for vegetables and the variety of vegetables consumed.

4.1.1. Use of the 7-point hedonic scale by mothers and children in the three countries

The whole pattern of individual consumers answers can give interesting information about the use of the hedonic scale by consumers in different countries (Lee et al., 2010; Yao, Lim, Tamaki, Ishii, kim & O'Mahony, 2003; Yeh, Kim, Chompreeda, Rimkeeree, Yau & Lundahl, 1998). When we analyzed the liking score patterns of children and mothers, our results showed a more polarized use of the scale by children in the three countries than mothers in China and in the USA. Previous studies supported the idea that children show a tendency to give extreme responses when they are using Likert scales, which is more evident in younger children than older ones (Chambers and Johnston, 2002). However, in the case of Chile, our study showed that Chilean mothers gave a similar polarized pattern of answers to children. Some previous studies have analyzed different use of the hedonic scale by different cultures (Lee et al., 2010; Yao et al., 2003; Yeh et al., 1998).

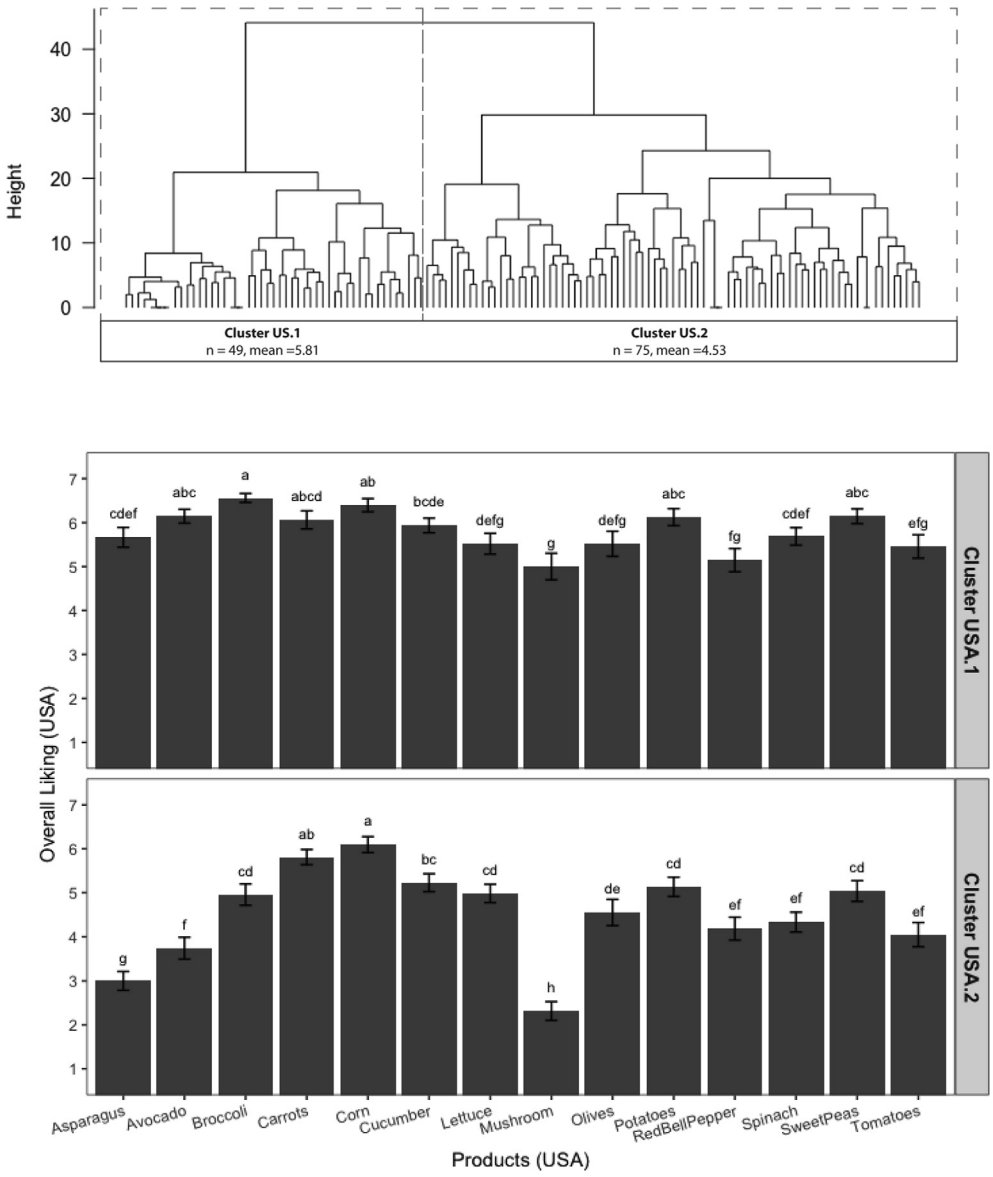

Fig. 6. Above: The two children's preference segments in the USA (Cluster CN.1, Cluster CN.2 and Cluster CN.3). The number of children in each cluster is represented by "n", and the mean rating of all vegetable samples for each cluster is represented by "mean".

Table 5
Exit survey questions that characterize children preference segments in Chile (n = 130, 3 preference segment), China (n = 130, 3 preference segment) and in the USA (n = 124, 2 preference segment). Questions that differed by at least 5% between clusters are included.

Exit survey questions answered by mothers	Chile	China	USA
For LUNCH, what percentage of your child's plate is vegetables (on average)?	*	*	
For DINNER[1], what percentage of your child's plate is vegetables (on average)?			*
Are you happy with your child's vegetable intake?			*
How varied is the diet of your child?	*	*	*

* Significant at $p < 0.05$ established by Chi-squared analysis.
[1] Considering cultural differences this question in Chile was structured as < Dinner or last meal of the day (e.g. "once"*) >
* "Once" is a kind of late afternoon brunch, that in some Chilean families replaces dinner.

Specifically, Yao et al. (2003) and Yeh et al. (1998) have reported that adult Asian consumers use a smaller range of the 9-point hedonic scale than adult American consumers when a range of different products is analyzed. On the other hand, when the liking rating scores of Korean and American consumers have been compared, the opposite trend has been reported (Lee et al., 2010). In our study, independent of the country analyzed different kind of participants (mothers/children) showed a similar pattern of answers, with the only exception being Chilean mothers. In the case of Chilean mothers, the polarized use of the hedonic scale, is probably due to Chilean mothers not liking the majority of the vegetables samples tasted (from the 14 vegetables tasted, Chilean mothers rated only five of them as liked). And this was reflected in their pattern of answers.

4.1.2. Characterization of children's vegetable preference segments

In order to characterize children's vegetable liking, exit survey questions answered by mothers were used to understand the different levels of children's vegetable liking scores. In the three countries analyzed, mothers' perceptions of the variety of their children's diet was a determinant factor that characterized the children's vegetable liking

score. The results of our study show that children who eat fewer varieties of food were related with lower vegetable liking in Chile, China and in the USA. A varied diet suggests a higher exposure to the different sensory properties of foods. Considering that vegetables naturally come in different colors, flavours and texture, a varied diet can increase the acceptability of vegetables by increasing the exposure to different foods' sensory properties (Meengs, Roe, & Rolls, 2012). The analysis of food variety and vegetable consumption has been assessed in a longitudinal study where it was observed that the variety of the diet of children 2–3 years old was related with the variety of diet of the same participants at 22 years old, and moreover with the variety of vegetables consumed (Nicklaus, Boggio, Chabanet, Issanchou, 2005). Moreover, Gerrish and Mennella (2001) reported that exposure to a variety of vegetables in infants increased the acceptances of new foods. Therefore, it is possible to think that a varied diet increases vegetable consumption and vice versa, vegetable consumption can promote a varied diet. Moreover, considering the effect of sensory satiety, vegetable variety has been shown to be a successful strategy for increasing vegetable intake (Meengs et al., 2012).

This study also showed that the meal that reflects vegetable intake is a culturally dependent factor. In Chile and China, the amount of vegetable intake during lunch was related with the level of children's vegetable liking. While in the USA, the level of children's vegetable liking was related with the amount of vegetable eaten at dinner. This difference may be due to the different level of importance lunch and dinner have in different countries. In Chile lunch and dinner are commonly hot meals, however, according to the National Survey of Food Consumption, only 26% of the Chilean population reported eating dinner, while 80% reported only eating "once" (a late afternoon brunch), and around 6% eat both (ENCA, 2011). Considering this, it is possible to think that, in the case of Chile, lunch is the most important meal in terms of vegetable intake, this is because it is much more likely that Chilean lunch contains more vegetables than the late afternoon brunch "once", which is based on the consumption of bread and tea. In the case of the USA, it is common to eat a hot meal once a day, at dinner time (Meiselman, 2008). Moreover, the adult population in the USA tends to skip lunch more often than dinner (Kerver, Yang, Obayashi, Bianchi, & Song, 2006; Kant & Graubard, 2015). Families in the USA values having a family dinner, even if this tradition has significantly declined over recent decades (Gillman et al., 2000). The importance of having family meals has been studied in American culture, showing a positive association between the frequency with which children eat dinner with their families and the intake of foods that contribute nutritional value in children's diet (Gillman et al., 2000). Taking all this information into account, it is possible to think that in US culture, dinner is the most important meal of the day in terms of vegetable intake. In the case of China, drawing conclusions about which is the most important meal in terms of vegetable intake is more complicated, considering that the Chinese population presents higher levels of vegetable consumption (Li et al., 2017). A recent study has calculated an average consumption of vegetables by Chinese adults of more than 350 g a day, which is a considerable amount considering that the current recommendation from the World Health Organization (WHO) is to eat 400 g of fruit and vegetables a day (WHO, 1990). In Chinese culture vegetables can be eaten in every meal (breakfast, lunch and dinner), depending mainly on the region. While Cantonese breakfasts include vegetables, the northern regions generally do not include them (Ma, 2015). Lunch and dinner generally are hot meal (Meiselman, 2008) and both contain vegetables (Ma, 2015). One big difference between lunch and dinner in China is related to where and with whom these meals are eaten. A study done with school children in the same region as this present study was conducted (Jiangsu region), showing that only 26% of the students eat school lunch, while the rest go home to eat lunch, or bring lunch from home (Shi, Lien, Kumar & Holmboe-Ottensen, 2005). Moreover, dinner in China is usually the largest meal of the day, including 2 to 4 different kinds of dishes and a soup, constituting an important time where the family shares (Ma, 2015). Considering all this information, one explanation about the relationship between the amount of vegetable consumption at lunch with Chinese children's vegetable liking (a relationship that was not found for vegetable consumption at dinner) is related with the abundance and diversity of the dishes offered during Chinese dinner. This can give children more chances to choose what to eat, which can cause Chinese children's vegetable intake to be lower at dinner in comparison with lunch.

To understand more about the relationship between mothers' and children's vegetable liking, we also asked mothers if they were happy with their children's vegetable intake. Considering that children tend to eat what they like (Drewnowski, 1997; Gibson et al., 1998; Marty, Chambaron, Nicklaus, & Monnery-Patris, 2018; Nguyen, Girgis, & Robinson, 2015) and vegetable preferences tend to develop with exposure (Barends et al., 2013; Wardle et al., 2003), it would be expected that children who like vegetables are those who eat a considerable amount of them. However, the results of our study showed that the level of satisfaction with children's vegetable intake by mothers was an indicator of vegetable liking for American children, but not for Chilean and Chinese children. In Chile and in China, this question was not able to characterize the different preference segments because mothers in all the 3 preference segments wanted their children to eat more vegetables than they were currently. The question "Are you happy with your child's vegetable intake?" takes into account the amount of vegetables eaten by children, but also the perception of their mothers. In this sense, it is possible to think that the American mother analyzed in this study have more realistic expectations of their children's vegetable intake, than mothers in Chile and in China.

In the case of Chile, findings showed that Chilean mothers were not satisfied with the amount of vegetables that their children eat (even for the group of Chilean children that liked all the vegetables samples tasted). However, they were the same Chilean mothers that showed to like less variety of vegetables than their children. Based on these results it is possible that Chilean mothers expect their children to eat vegetables even if they as mothers do not like vegetables. The underlying reasons why Chilean mothers are pickier than their children (in terms of vegetable liking) should be explored in more detail in future studies, considering the possible implications that this result can have on future interventions aimed at increasing vegetable consumption of children in Chile.

It is important to report some limitations of this study. The recruitment process for the participants in this study was carefully defined in order to have comparable participants across countries. In this sense, all mothers that participated in this study had completed -or were completing- higher education and lived in the city in which the study was conducted for each of the countries. The requirement to have similar samples give the limitation that the results of this study reflect the vegetable liking of mothers and children, with higher education living in Santiago-Chile, Wuxi-China and Davis-Ca-USA. In order to have a broader understanding of children's and mothers' vegetable liking in these three countries there is a need for future studies that analyze vegetable liking at different socioeconomic levels and in different geographic areas.

The second limitation of this study is that during the recruitment participants were invited to participate in tasting sessions with vegetables. Considering that, it is possible that very picky mothers and children were discouraged from participating in this study, and the vegetable liking scores obtained in this study could be higher than in the real population.

5. Conclusions

This study showed that the relationship between mothers' and children's vegetable liking is culturally dependent. In general, mothers liked vegetables more than their children, however specific patterns were observed for each of the countries analyzed. In this sense, it was

observed that American mothers liked vegetables more than their children, while Chilean and Chinese mothers liked vegetables the same as their children. Moreover, in terms of the variety of vegetables liked, Chilean mothers liked a less variety than their children. The specific reasons of Chilean' mothers behavior need to be analyzed in future studies. This study also found that, in the three countries, children who liked vegetables were the children that eat more variety of food, and the children that eat more amount of vegetables at lunch (in the case of Chile and China) and at dinner (in the case of the US). Finally, mothers in the US showed a more realistic expectation about how much vegetables their children should eat, compared to mothers in Chile and in China that would like for their children to always eat more vegetables. The results of this study showed cultural differences in children's and mothers' vegetable liking, emphasizing the importance of taking into account the cultural factor when designing interventions oriented toward increasing children's vegetable intake, as well as acknowledging mothers as an important factor in the promotion of healthy eating habits in childhood.

CRediT authorship contribution statement

Karinna Estay: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Shuliang Pan:** Investigation. **Fang Zhong:** Investigation. **Jean-Xavier Guinard:** Investigation, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank all participants (mothers and children) who took part in this research in Chile, China and the US. We also would like to thank Pauline Lestringant for her assistance with statistical analysis and Sara Yang for her support in the conduction of the tasting sessions. This research did not receive any specific grant from any funding agencies in the public, commercial, or non-profit sectors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2020.104000.

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