



Chemicals, cans and factories: how grade school children think about processed foods

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Submitted 27 March 2019: Final revision received 19 August 2019: Accepted 4 September 2019: First published online 18 February 2020

Abstract

Objective: To determine how children interpret terms related to food processing; whether their categorisation of foods according to processing level is consistent with those used in research; and whether they associate the degree of processing with healthfulness.

Design: Qualitative data were collected from ten focus groups. Focus groups were audio-recorded, transcribed verbatim, and thematic analysis was conducted.

Setting: Four elementary and afterschool programmes in a large, urban school district in the USA that served predominantly low-income, racial/ethnic minority students.

Participants: Children, 9–12 years old, in the fourth–sixth grades (n 53).

Results: The sample was 40% male, 47% Hispanic with a mean age of 10.4 ± 1.1 years. Children's understanding of unprocessed foods was well aligned with research classifications, while concordance of highly processed foods with research categorisations varied. Five primary themes regarding the way children categorised foods according to their processing level emerged: type and amount of added ingredients; preparation method; packaging and storage; change in physical state or sensory experience; and growing method. Most children associated processing level with healthfulness, describing unprocessed foods as healthier. The most common reason provided for the unhealthfulness of processed foods was added ingredients, including 'chemicals' and 'sugar'.

Conclusions: The current study demonstrated that children have a working knowledge of processing that could be leveraged to encourage healthier eating patterns; however, their understanding is not always consistent with the classification systems used in research. The vocabulary used by researchers and consumers to talk about processing must be reconciled to translate findings into actionable messages.

Keywords
Processed food
Ultra-processed food
Children
Qualitative research
Nutrition education

Poor dietary habits, obesity and related metabolic diseases among children continue to be a major public health concern in the USA^(1,2). Experts argue that a focus on nutrients has led to the proliferation of highly processed food products that meet major nutrient targets, but are detrimental to overall dietary quality and health⁽³⁾. In response, researchers have called for a shift from nutrient-based dietary recommendations to food-based guidance^(3–5). There is also a need for simple, effective communication strategies to convey nutrition information to consumers, particularly children from racial/ethnic minority and low-income backgrounds who are at a higher risk for obesity^(1,6–10).

As interest in the effects of food processing on human health has gained traction among researchers, several classification systems, which distinguish between the processing levels of foods, have been used to conduct research in the USA^(11–15). The Nova system, developed in Brazil, classifies foods into four categories based on the nature, extent and purpose of industrial food processing; it is the most widely used food processing classification system in nutrition research^(16,17). Researchers at the University of North Carolina at Chapel Hill have adapted the Nova system to the US food supply, developing a classification scheme that categorises foods available in supermarkets by degree of

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processing⁽¹¹⁾. The International Food Information Council devised a system that categorises foods based on the complexity of processing and resulting changes to the food⁽¹⁵⁾. These three systems are often simplified to a three-tier model, categorising foods as minimally, moderately or highly processed⁽¹⁸⁾.

Studies stemming from these classification systems have reached various conclusions regarding the relationship among processing, obesity and health in children. While processed food is widely perceived to be a major contributor to childhood obesity and related health problems globally^(13,19–21), alternate studies conducted in the USA have underlined the positive effects of processing on food safety and affordability, and the wide variability in nutrient content across processed products^(15,18,22,23). Despite this contradiction, what we do know is that foods categorised as highly processed, containing high amounts of sugar, saturated fat and sodium, are detrimental to health^(2,24,25). Evidence suggests that children with overweight and obesity consume diets with an overabundance of highly processed foods^(20,26–29).

Although there is little research on the conceptualisation of processing among children, qualitative studies of children's food perceptions have yielded insights into early predictors of children's eating patterns, preferences and determinants of health. Researchers at the University of Calgary in Canada extensively studied the subject of children's classification of foods, focusing on children's perceptions of 'kid food' *v.* 'adult food'.^(30,31) Results demonstrated that focusing on values underpinning children's classifications, such as 'desirable' or 'boring', can help to illuminate children's development of food preference. A study by Cornwell *et al.* found that children's knowledge of fast food and packaged brands was a significant predictor of BMI, even after considering time spent viewing television⁽³²⁾. Throughout these studies, the term 'processed' was rarely used to talk about foods; however, these results suggest that children employ various classification methods that can influence their perceptions and consumption of foods.

As evidenced by the multiple classification systems currently used in research, the term 'processed food' lacks a clear, concise definition that can be communicated to a range of audiences, and there is no commonly accepted definition of highly or ultra-processed food⁽¹⁸⁾. While understanding the contribution of highly processed foods to health is important, of immediate urgency is the need to reduce the consumption of such foods⁽²⁹⁾, especially among socioeconomically disadvantaged children who are at a higher risk of developing obesity and related co-morbidities^(21,33). Research is, therefore, needed to identify how children from low-income communities and/or racial and ethnic minority groups perceive processed foods, including their classification and healthfulness.

The current study sought to determine how children interpret terms related to food processing; whether their

categorisation of foods according to processing levels is in line with research-based classification systems; and whether they associate the degree of processing with healthfulness. Investigating how children think and talk about different foods, as well as their understanding of processing categorisation, may offer important insights into policy and communication tactics to encourage healthier eating patterns.

Methods

Focus group research aims to give the researcher an insight into what people think and why in a congenial and non-threatening environment⁽³⁴⁾. For an exploratory research on the topic of processed foods, focus groups provide an ideal research method to investigate children's perspectives^(34,35). The focus group format overcomes some of the drawbacks of individual interviews, such as the desire to please the researcher, since the discussion frames the participant as an expert, and shyer individuals may feel more comfortable in a small group environment⁽³⁴⁾.

Recruitment and sample

Research suggests that children by age 7 develop the skills necessary to provide accurate and useful information during interviews or focus groups if the format is age-appropriate⁽³⁶⁾. However, others have noted that children below 11 years may not be able to give in-depth answers beyond sharing facts and experiences⁽³⁷⁾. To determine whether focus group questions and activities were appropriate and to test the most suitable age range, a pilot focus group was held with third- to fourth-graders (children between the ages of 8 and 12) during Spring 2017. Based on these results, third-graders (aged 8–9 years), who demonstrated limited understanding of processing language, were dropped from the sample. Children in the fourth to sixth grades, between 9 and 12 years old, were recruited from four urban schools or afterschool programmes in the Greater Boston area. Sites were selected to provide representation from a range of sociodemographic backgrounds, including a high percentage of students from racial/ethnic minority groups and low-income families, using a purposive sampling approach⁽³⁸⁾. Five principals or programme directors were contacted, and four agreed to allow us to recruit students from their schools or programmes. At each site, students were recruited through short, in-class presentations and provided with an information packet to take home. The packets included parent consent and child assent forms, a demographic survey, and details about the study. To participate, children had to be between 9 and 12 years old, enrolled in the fourth–sixth grades, speak English, have a parent willing to allow their child to participate in the focus group, and return their completed consent packet within 1 week of recruitment.

Focus groups took place from Fall 2017 to Spring 2018. After each session, researchers reviewed the transcripts to





identify new concepts; focus groups were held until no new themes emerged⁽³⁹⁾. Fifty-seven students participated in the study: sixty-one students returned completed consent packets, and of these, eight were unable to participate due to scheduling conflicts. Ten focus groups were conducted by the research team with five to seven children in each group.

Instrument development

In the USA, almost all (99%) the public elementary schools offer some type of nutrition education. However, there is no federal requirement regarding nutrition education and no standard curriculum offered to schools, leading to a wide variability in the breadth, intensity and quality of topics covered. Due to this lack of nutrition education coordination, the extent to which schools include information about processed foods in their curriculums is unknown. To assist in developing age-appropriate questions on the topic of food processing, we reviewed relevant nutrition education materials from recently published interventions. We found one nutrition education curriculum developed in the same state (but not in the same school districts) that provided information specific to processed foods for children in a similar age range as our sample population. The curriculum was developed as part of an intervention targeting nutrition and eco-friendly packaging and, therefore, included sections on the differences between packaged and unpackaged foods⁽⁴⁰⁾. Vocabulary from this curriculum was used as a guide to ensure that our questions were framed using age-appropriate language.

A semi-structured moderator's guide was developed to investigate children's thoughts and perceptions on the topic of processed foods. Key questions from the moderator's guide are included in Table 1. The first set of questions asked children how they would interpret words and phrases related to processing. These questions aimed to determine children's familiarity with words related to processing and to establish a lexicon for the children to discuss processing during the next activity. Three 'kid-friendly' terms were

chosen for a discussion based on the phrases used to describe unprocessed (*fresh*) and processed (*man-made* and *machine-made*) foods in the curriculum described above⁽⁴⁰⁾. Children were then asked about the meaning of unprocessed and processed foods. To explore the topic of classification, children were shown pictures of nine food products printed on large cards and asked to talk about how they would arrange these foods from least to most processed. Based on the results of pilot focus group, the number of food cards was reduced from nine to six to limit the length of focus group. Cards were presented in random order, one by one, to the group and placed in a line on the table. According to the processing classification systems used in research, two of the foods were unprocessed (an apple and a tomato), two were moderately processed (applesauce, tomato sauce in a can), and two were highly processed (flavoured apple juice drink, ketchup)^(11,17). All children were asked for their opinion about how to categorise the food cards and to explain their reasoning. Finally, children were asked to discuss how and why they would rank the same foods according to healthfulness.

Data collection procedures

Focus groups were held at each site during the time deemed convenient by school staff, separated by grade level (fourth, fifth or sixth). One research assistant (author 5) took notes, and one researcher (author 1) moderated all discussions. At least one school staff representative was also present during each session. The sessions lasted between 30 and 40 min and were audio-recorded. Children received a small gift card in appreciation for their participation.

Analytical methods

Author 5 transcribed all audio-recordings verbatim along with field notes from focus groups. All transcripts were reviewed by author 1 to ensure accuracy. A thematic analysis approach was used to analyse focus group data. This approach is ideal for exploratory work on under-studied topics, as it allows the researcher to be flexible in applying

Table 1 Overview of main questions included in the interview guide protocol for focus groups on the topic of processed foods with 9- to 12-year-old children, Massachusetts, USA, 2017

Section 1. Familiarity with terms related to food processing

- What does 'fresh foods' mean to you? What are some examples of 'fresh foods'?
- What does 'man-made food' mean to you? What are some examples of 'man-made foods'?
- What does 'machine-made food' mean to you? What are some examples of 'machine-made foods'?
- What does 'unprocessed food' mean to you? What are some examples of 'unprocessed foods'?
- What does 'processed food' mean to you? What are some examples of 'processed foods'?

Section 2. Categorising foods by degree of processing*

- Which of these foods are unprocessed or not processed? Could you tell me why you think of them as unprocessed?
- Which of these foods are moderately processed or processed a bit? Could you tell me why you think of them as moderately processed?
- Which of these foods are highly processed or processed a lot? Could you tell me why you think of them as highly processed?

Section 3. Healthfulness of foods*

- Which of these foods are most healthful? Could you tell what makes that food healthful?
- Which of these foods are least healthful? Could you tell what makes that food unhealthful?

*The six foods presented in Fig. 1 were shown on cards sized 8.5 × 11 inches.



Fig. 1 (colour online) Food cards included in the interview guide protocol for focus groups on the topic of processed foods with 9- to 12-year-old children, Massachusetts, USA, 2017

the method across a range of theoretical approaches⁽⁴¹⁾. Themes were identified from transcripts at the semantic level using an inductive approach. An inductive approach relies on the data to drive theme identification, allowing children's perspectives on the unexplored topic of food processing to be revealed and compared for thematic consistency or divergence. Members of the analysis team independently identified codes from each transcript, then discussed results to develop a list of categories and sub-categories. A codebook was developed based on the initial list. Using an iterative approach, the codebook was further refined and expanded into themes and sub-themes based on patterns that emerged from the data. Once a final codebook was established, inter-rater reliability was tested among the analysis team using two randomly chosen transcripts. After ensuring 80% agreement between coders, transcripts were coded by one analyst. NVivo12 (QSR International) was used to facilitate analyses. Methods were reviewed using the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.

Results

Children from four school districts participated in the study, with the majority coming from district 3 (Table 2). There was a greater percentage of female (58.5%) versus male participants, with a roughly even split among grade levels. Almost three-quarters (73.6%) of the sample were from a

Table 2 Sociodemographic characteristics of focus group participants, Massachusetts, USA, 2017 (*n*53)

| | <i>n</i> | % |
|-----------------------------------|----------|-----|
| Sex | | |
| Male | 21 | 40 |
| Female | 31 | 59 |
| Transgender | 1 | 1 |
| Age, years, mean (sd) | 10.41 | 1.1 |
| Grade | | |
| Fourth grade | 19 | 36 |
| Fifth grade | 16 | 30 |
| Sixth grade | 18 | 34 |
| Race/ethnicity | | |
| Non-Hispanic white | 14 | 26 |
| Non-Hispanic black | 12 | 23 |
| Hispanic | 25 | 47 |
| Multiracial/Asian/other | 2 | 4 |
| Free/subsidised lunch eligibility | | |
| Yes | 30 | 57 |
| No | 23 | 43 |

racial/ethnic minority group, and 56.6% were eligible for free or subsidised lunch, characteristics that are reflective of the districts overall. Students actively participated in focus group discussions and expressed excitement about the topic of food and its categorisation.

Meanings of words related to processing

With respect to words and phrases related to food processing, children had an inconsistent understanding of meanings. Understanding increased with age. Table 3 provides example questions and representative quotes from this section of focus group as well as definitions of terms.

Fresh food

Most children related this term to recently harvested foods, and considered fruits and vegetables to be the best examples of fresh foods. Several children in fifth and sixth grades (from different focus groups) mentioned organic foods as fresh, referring specifically to vegetables. Two sixth-grade students made explicit references to processing: 'It's food that hasn't been processed, or it may have been packaged but in an open package, like at a farmer's market'. Food with expiration dates, such as milk, came up in multiple groups. Several fourth-grade students had an alternate interpretation, describing 'hot foods' that were just cooked.

Man-made food

Fifth- and sixth-grade children brought up various junk foods, foods with multiple ingredients, and baked goods to describe man-made. Fourth-grade children across multiple focus groups had a more literal interpretation of man-made as 'made by people using their hands', or 'when your mommy or daddy makes something for you'. One male sixth-grader observed that the term could be interpreted as processed foods ('the people process it') or homemade foods ('I'm thinking it's something people make at home'), summarising the two main interpretations that emerged from focus groups. Although no other student explicitly referenced processing, most described man-made food with terms related to processing, such as packaging and added ingredients.

Machine-made food

Across all focus groups, factory imagery came up most often, along with references to specific machines (coffee machines, vending machines, ice-cream dispensers) and factories themselves. While the candy was often mentioned

**Table 3** Sample quotes and example foods to support 9- to 12-year-old children's descriptions of terms related to processing

| Definition | Representative quote | Common example foods |
|---|--|---|
| Fresh food Generally used to describe food that has not been preserved; may also be used to describe unexpired foods or just-cooked/prepared foods. | What does 'fresh food' mean? 'Cold food. Food that stays in the refrigerator'. (Male, fourth grade) "... food that you just now got, like for example, 'I just now plucked strawberries'". (Female, fifth grade) '... foods that were not individually wrapped and can't stay for too long. Like milk could be ... fresh because it expires in 7 d. So that's pretty fresh'. (Male, sixth grade) | Fruits, vegetables, meats, milk, 'organic foods' |
| Man-made food Man-made food often refers to packaged or fast foods, as an antonym to 'nature-made'. | What does 'man-made food' mean? '... when a man or a boy does everything. They would have to do a lot of work to make the food'. (Male, fourth grade) 'Makes me think of, Doritos, Sour Patch, and stuff that's not good for you'. (Female, fifth grade) 'I think of processed food, like packaged and made in factories'. (Female, sixth grade) | Hamburgers, hot dogs, chips, pizza |
| Machine-made food Similar to man-made, machine-made is used to describe mass-produced, packaged foods. | What does 'machine-made food' mean? 'It's when someone puts something in a machine and the machine just gives you the food already done for you to eat'. (Female, fourth grade) '... food that's made in a factory like candy'. (Female, fifth grade) 'Those are like processed foods. Like foods that go through a specific process in machines and get ... treated in a different way'. (Male, sixth grade) | Candy, hot dogs, french-fries |
| Unprocessed food Single-ingredient foods with no or slight modifications that do not change the inherent properties of food as found in its natural form (Nova definition) ⁽¹⁶⁾ . | What does 'unprocessed food' mean? '... food that didn't get put in the store'. (Male, fourth grade) 'I think it's a food that you eat whole instead of cutting it up'. (Female, fifth grade) '... unmodified, or unchanged ... something like a strawberry. Nothing would be different, just a natural food'. (Female, sixth grade) | Fruits, vegetables, breads, milk, eggs, 'junk food' |
| Processed food Highly processed foods are multi-ingredient, industrially formulated mixtures or dishes processed to the extent that they are no longer recognisable as their original plant/animal source (Nova definition) ⁽¹⁶⁾ . | What does 'processed food' mean? 'Maybe food that's cooked and ready for you'. (Female, fourth grade) '... foods that have gone through factories and have more chemicals'. (Male, fifth grade) 'Canned food, because they have to change all the stuff that goes into a can – it has to go through an elaborate process in a factory'. (Male, sixth grade) | Empanandas, fast foods, canned foods, hot dogs, fruits and vegetables |

as an example, including candy canes, jelly bellies and 'the Hershey factory', others referred to machine-made as 'greasy foods' from fast-food restaurants.

Unprocessed foods

Approximately one-third of fourth-graders reported being unfamiliar with the term 'unprocessed'. Several younger participants summed up the term as 'just fruits and vegetables', while others interpreted the term to mean 'not ready to eat' or an 'indigestible' food such as gum. It is worth noting that children from two fourth-grade focus groups switched the definitions of 'unprocessed' and 'processed' due to confusion with the prefix 'un-'. This trend began after one child in the group had trouble distinguishing between the two words, and others followed suit. Fifth- and sixth-grade students mentioned foods from farmers' markets, such as eggs,

bread and produce, that 'don't have the chemicals added'. Two participants from different groups described an experience of picking food (maize and apples) as associated with unprocessed. Finally, students from three separate groups cited a lack of machines or factories as indicators of unprocessed foods.

Processed foods

As expected, children offered opposite definitions for processed foods relative to their definition of unprocessed. In the case of focus groups employing 'flipped' definitions, children mentioned vegetables, fruits and 'healthy foods' as processed. In two groups, several children described processed food as prepared food that is ready to eat. Several offered junk foods and 'fatty stuff' as examples from separate groups. Participants from the sixth grade referenced

machines, including factory machines and smaller restaurant appliances such as coffee machines, foods with 'chemicals' and canned foods. Children from several groups brought up YouTube videos that explained the process of making hot dogs and chicken nuggets, which they described as processed foods. As one fourth-grader explained, "it showed me hot dogs are processed and machine-made and made me not want to eat 'em anymore". Children from the sixth grade had a similarly negative reaction to a video of chicken nugget production.

Categorisation of foods by processing level

Despite some lack of clarity in defining processing levels, children revealed a surprising degree of confidence in discussing how they would categorise foods. As described above, six cards with photographs of foods were presented to the focus group, displaying an apple, tomato, applesauce, tomato sauce, flavoured apple juice and ketchup. Most children categorised the apple (74%) and tomato (68%) as least processed items, the applesauce (68%) and juice (53%) as moderately processed, and the tomato sauce (57%) and ketchup (79%) as most processed. Children referenced the type and amount of added ingredients, preparation method, packaging and storage, change in physical state or appearance, and the perceived growing method of foods to support their decisions. Table 4 provides relevant quotations from children that are representative of each theme discussed.

Added ingredients

Children across all grades referenced the amount and type of added ingredients (perceived or actual) to categorise the six foods. The addition, or lack, of chemicals was singled out as the most common determinant of processing levels. As one fifth-grader explained, 'I've seen the label on tomato sauce before, and there's a lot of words I don't know ... a lot of stuff like chemicals, which means it's probably more processed'. A few children even ventured that canned, boxed and bottled products are less healthy due to the potential for contamination. According to one sixth-grade girl, 'something in a can or a box can get chemicals or bacteria stuff in there'. The opposite was true for children's explanations of less-processed foods (generally the tomato and apple): 'The apple is a fresh food, nothing changed, no chemicals added, nothing' (male, sixth grade). Artificial colours and flavours were referenced as well, but less frequently than 'chemicals'. Sugar and salt, often mentioned in the same sentence, were repeatedly used to support categorisations of more-processed foods. Children believed, in varying degrees, that the applesauce, tomato sauce, juice and ketchup had added sugar and salt. Several sixth-grade children pointed out that homemade food often has less added sugar and salt and, therefore, might be less processed.

Preparation method

The use of machinery was often mentioned, along with creative imagery of metal parts and appliances, to support the

Table 4 Quotations to support themes related to how children, 9–12 years old, categorise foods by processing levels

| Theme | Moderator: How would you put these foods into categories from least to most processed? Why? |
|--|--|
| Added ingredients | 'The tomato sauce isn't that processed because not really anything is added to it'. (Female, fourth grade) |
| Chemicals | 'The ketchup has the chemicals in it to make it taste more interesting'. (Female, fourth grade) |
| Sugar and salt | 'The apple juice – they had to do a lot of it to get the juices out of the apple and add the sugar in'. (Male, fourth grade) |
| Colours and flavours | 'The stuff that has more sugar in it ... and you think it tastes better, is the one that has been processed more, because it has more chemicals and sugar or salt put in it'. (Female, fifth grade) |
| Number of ingredients | 'With juices they come in different flavours, so they put different ... maybe, different artificial flavours in it that makes it more processed'. (Male, sixth grade) |
| Preparation method | 'Ketchup is the most highly processed. 'Cause out of all these, ketchup has the most ingredients, and sugar'. (Male, sixth grade) |
| Packaging and storage | 'To make applesauce ... maybe they have some kind of formula and machines ... and the containers go in the pulleys and then they squirt apple sauce out of it and it goes right into the cup ... So it's a process'. (Male, fifth grade) |
| Change in physical state or sensory experience | '[Processing] depends on the number of steps. So foods that have steps ... like meat. The first step would be hunting it and then adding flavour and then cooking it, and then maybe selling it?' (Female, sixth grade) |
| Growing method | 'Well, this is a dead giveaway that [the applesauce] is very processed: It's in a container. That means something happened to it'. (Male, sixth grade) |
| | '... most canned stuff doesn't expire until a year. So that's really processed 'cause they must have put some serious chemicals in, just for it to preserve for a year'. (Male, sixth grade) |
| | 'I think the juice and the applesauce are a little processed. Because it's only grinded and smashed'. (Female, fifth grade) |
| | 'Ketchup is so modified. See the picture of that bright red tomato? And then look at the dark red paste. They change it so much that I don't think it's a tomato anymore'. (Female, sixth grade) |
| | 'I think the apple is not processed? Yeah because nobody makes it, it's not man-made. It grows on trees'. (Female, fourth grade) |
| | 'I'm saying the apple and the tomato are a little processed because we don't know if it was really fresh ... if the farmer put like some type of coating so that the bugs won't eat it'. (Male, sixth grade) |



categorisation of tomato sauce, applesauce, juice and ketchup as most processed. Some children saw the tomato sauce and ketchup as requiring the most number of steps (making them highly processed), while others reasoned that the juice or applesauce were most preparation-intensive. Just as several children differentiated between the ingredients added to homemade *v.* commercially made foods, a few suggested that the act of making a food at home would render it less processed.

Moderator

So you think of the tomato sauce as more processed because of how it's made?

'Yeah, it's different than how I would make it cause at home I would just take some tomatoes, take that spoon right there, and make it fresh and honest'. (Female, fifth grade)

One fourth-grader observed that the processing of store-bought applesauce may depend on the type purchased, 'because some of them just mash the apple into bits until it's liquidy, but some they do more'. Others brought up the time required to make a food as an indicator of processing, with items like ketchup requiring 'a lot of tomatoes and that would take so much time'.

Packaging and storage

Tomato sauce can, applesauce container, juice box and ketchup bottle came up as indicators of a higher processing level, while the lack of a container signified less processing. When asked which foods were least processed, one fourth-grader pointed to the apple and tomato: 'These two, because they are the only things not in a bottle or something like that'. Packaging represents food going through a dramatic 'change' or 'process'. Storage and expiration days were tightly linked to packing. While less-processed food 'doesn't last as long', packaged foods are likely to sit on store shelves for extended periods. Sixth-grade participants in one group fixated on the potential for food contamination from the packaging itself, as further evidence that packaged products are highly processed.

Change in physical state or sensory experience

When discussing processing levels, many students pointed to a change in colour, texture, state (solid to liquid) or taste as rationale for processing level categorisation. Several argued that the applesauce and juice were only slightly processed, since the final products were still recognisable as apples. Several students, upon considering the journey from tomato or apple to sauce or juice, seemed baffled by the presumed level of processing that took place: 'The ketchup started out like that [pointing to tomato], whole, and now it's that [pointing to picture of ketchup], not whole, it's liquid! How can it go through all that and not be processed?' Others noted a change in colour from bright-red tomato to dark sauce or paste, as well as the 'sour' taste of ketchup as evidence of greater processing.

Growing method

Most children agreed that the apple and tomato were least-processed foods, reasoning that they were 'grown, and that's a natural process', as described by a sixth-grader. Fourth-grade children had a similar perception of the tomato and apple as 'natural' products, and several specifically cited the lack of human or machine involvement as a mark of unprocessed foods. A fourth-grade student explained, 'Nobody makes [the apple], it's not man-made, it just grows'. In two of the sixth-grade focus groups, several students came up with a more complex processing classification scheme based on whether the fruits had been sprayed with preservatives, farmed with growth hormones or were genetically modified.

Moderator

You're saying the apple and tomato are unprocessed?

'Well yeah, but it kinda depends on how it was grown. If a seed was put in the ground and it grew without any growth hormones then that would be one thing...'. (Male, sixth grade)

Another student added that if the apple and tomato were organic, they would be less processed since 'organic food tends to not have all the GM things within it'. Of note, children who mentioned specific growing methods seemed to reference growth hormones, genetic modification and organic interchangeably.

Healthfulness of foods

Children's discussion of healthfulness of the six foods centred on the number and type of added ingredients, with several students noting that processing level is associated with healthfulness. Just as participants focused on the effects of added sugar and 'chemicals', these ingredients were often referenced in the context of healthfulness. The sauces, ketchup and juice were all singled out as containing 'sugars and chemicals', making them 'probably not healthy at all'. It is important to note that, although the participants associated these ingredients with unhealthful products, they responded that they were unsure why. When pressed, one sixth-grade boy described salt as bad for health because it 'turns to sugar in the blood'. Several fourth-grade students offered a quantitative measure of healthfulness based on the amount of apple or tomato they perceived to be in the product: 'Apples are 100% healthy. I think the apple juice is half and half because it's half apples and the other half is chemicals and stuff they use for flavour'. Across focus groups, four students who professed to dislike tomato sauce categorised it as least healthy. While an explicit association between processing level and healthfulness was vocalised only twice, many students discussed themes from processing categorisation to determine healthfulness, including added ingredients, as well as packaging, preparation and the perceived growing method. Several students chose the tomato sauce as least healthy 'because it's in a can'. One fourth-grade student reasoned



that applesauce made at home is healthier 'since you can ask your mom not to put sugar in it'.

Discussion

To our knowledge, no study has systematically examined children's familiarity with the language of processed foods. The current study addresses this gap by asking a diverse group of children how they interpret the vocabulary associated with food processing, categorise foods according to their processing levels, and consider the healthfulness of foods from different processing categories. Our findings suggest that children are aware of the concept of food processing, but their perceptions of how foods are categorised by processing levels differ from the criteria used in food processing classification systems.

Children's interpretations of the terms *fresh*, *man-made* and *machine-made foods* provide guidance on the types of phrases understood by children. Fresh food was most often associated with minimally processed foods – fruits and vegetables, eggs, milk and meats; but children also cited unexpired, packaged products. The term 'nature-made', which is less likely to be associated with prepared foods, might align better with students' understanding of unprocessed, but this term was not tested in focus groups. Man-made food, although described by some as junk food and packaged products, consistently elicited literal interpretations from younger children. Machine-made food was better aligned with highly processed foods, bringing up images of hot dogs, candy and chips. These 'kid-friendly' terms require further testing to ensure that they are understood by broader youth samples. Future work could test terms used in processing classification systems (minimally, moderately and highly processed)⁽¹⁶⁾.

When presented with the task of discussing processed foods or categorising foods by processing levels, children employed certain visual 'clues'. Added ingredients came up as the most salient theme for children to categorise foods by processing levels, a criterion that aligns well with the Nova classification system. In this system, unprocessed foods are defined, in part, by the fact that they are single ingredients, and highly processed as multi-ingredient mixtures⁽⁴²⁾. Although the health outcomes linked to excess sugar and salt intake are not understood by children, they expressed a desire to limit these ingredients. Furthermore, children demonstrated a nuanced understanding of home-cooked food as potentially healthier based on one's control over ingredients. This presents an opportunity to draw associations between processing and healthfulness based on the number and type of added ingredients on food labels, as well as to encourage home-made meals. The addition of 'chemicals' was brought up throughout the focus groups, but children were unable to articulate further on the nature of these added ingredients. While many packaged and processed products contain preservatives,

flavourings and emulsifiers that may be described as 'chemicals', an overemphasis on these ingredients may encourage distrust of processed foods. Linking processing to added ingredients like sugar and salt is a simpler and more actionable message, as fresh or 'nature-made' foods do not have these added ingredients.

Packaging emerged as another central theme guiding children's categorisation. Containers, particularly cans, served as a clear indicator of high processing levels. A similar line of reasoning was used by participants in a project investigating food literacy in disadvantaged Canadian youth who perceived eating too many 'boxed' foods as unhealthy⁽⁴²⁾. In the current study, children focused on the addition of 'chemicals' to make packaged products last longer; however, the notion of 'added chemicals' as indicative of processing is somewhat misguided. Ingredients such as ascorbic acid, which prevents oxidation, may be interpreted as an unhealthy chemical. Children's purported concern for food safety is worrisome, since it suggests a blanket mistrust of packaged products and a black-and-white interpretation of the relationship between packaging and health. Teaching children to differentiate between ingredients for preservation (ascorbic acid) and flavouring (salt and sugar) may be a useful approach to introduce the topic of processing. Furthermore, a more nuanced view of packaging is important to encourage fruit and vegetable consumption from a variety of sources, as well as to discourage stigma associated with packaged goods. Explaining the basics of food safety, including the principles behind food preservation, would allow children to view preserved vegetables as a good alternative to fresh.

The topic of healthfulness elicited strong opinions from children, but their logic was often flawed. Many children described the ketchup as unhealthy 'because of how it's made', but were unable to describe the process. Similarly, the apple and tomato were almost universally described as healthy because they were 'grown'. Several children insisted that they avoid unhealthy foods such as juices and other 'sweetened' drinks, while others claimed that tomato sauce is unhealthy simply because they don't like the way it tastes. Food preferences certainly may bias children's opinions of healthfulness. On the other hand, added ingredients were the most cited contributor to the unhealthy qualities of foods, which further aligns with other indicators of processing levels.

Experts suggest that children's nutrition education is an ideal starting point to positively influence eating patterns that persist into adulthood⁽⁶⁾. A 2018 review by Murimi *et al*⁽⁴³⁾ identified parent engagement, identification of specific behavioural outcomes, teacher training, adequate duration (at least 6 months) and use of age-appropriate activities as key components of interventions targeting elementary school children. Recent research has focused on dietary patterns, rather than single foods or nutrients, as a superior determinant of obesity risk; this approach, however, represents a less-defined and wider focus for



consumer-targeted education and messaging efforts. In the context of food-based dietary recommendations, food processing may offer a novel strategy to encourage healthier eating among youth that is well aligned with dietary recommendations. In addition to nutrition education, which targets consumer demand for highly processed products, it is also important to consider the impact of packaged food suppliers. Approaches to improving dietary patterns among children are more likely to succeed if multiple sectors and stakeholders are involved^(19,44,45).

While the current study sheds light on the unexplored topic of children's conceptualisation of food processing, there are several limitations. Lessons gleaned from a population of low-income, ethnically diverse children from an urban setting may not be generalisable to children in other settings. We used a purposive sampling approach to recruit participants that was not randomised. However, this approach did allow us to reach a high proportion of racial/ethnic minority groups that are representative of the target demographic. Voluntary participation may have been a source of selection bias, favouring children who were more knowledgeable about food and nutrition or who had a greater interest in the subject. We did not segregate groups by gender, English-language learner status or socioeconomic status, as researching the impact of these factors was not a primary objective of our study. We also did not collect information on children's first language, primary language spoken at home or number of years they have been residing in the USA. These variables may affect participants' understanding of topics discussed in the focus group, and studying how these factors influence perceptions and knowledge of food processing would be useful in developing tailored curricula.

Conclusion

The topic of food processing has gained traction among science and research communities, but understanding children's perceptions of processing is necessary to translate findings into actionable messages for at-risk populations. Low-income and minority youth, who are at a high risk of obesity and associated chronic diseases, may benefit from targeted nutrition education efforts on the topic of food processing and its relationship to health. The current study demonstrated that children have a working knowledge of processing that could be leveraged to encourage healthier eating patterns; however, their understanding is not always consistent with the classification systems used in research. The vocabulary used by researchers and consumers to talk about food processing must be reconciled to translate findings into actionable messages. More research is needed to develop a common language that is accepted by the research and food manufacturing communities and is comprehensible to consumers. In addition, more research is needed to develop educational approaches to teach the concepts of food processing to children. Parents, who are generally responsible for food

purchasing and preparation, are an important target for future research on the topic of food processing perceptions, as are school teachers and administrators. Findings from this research may help inform strategies for effectively communicating information about processed foods to adults.

Acknowledgements

Acknowledgements: The authors would like to thank Catherine Wright, Paula Duquesnay and Alejandra Cabrera for their assistance with data collection. *Financial support:* The Boston Nutrition Obesity Research Center (BNORC) Small Grants Program, which is funded by the NIH Award P30 DK 046200, generously contributed funds to the present study. *Conflict of interest:* None. *Authorship:* The authors' responsibilities were as follows: R.B.S. designed the study; R.B.S. and C.B. collected and analysed data; R.B.S., J.G., E.W.E., K.C., C.B. and J.S. wrote the paper and take responsibility for the final content. All authors read and approved the final manuscript. *Ethics of human subject participation:* The current study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the Tufts University Institutional Review Board. Written informed consent was obtained from a parent or caregiver for all study participants, and written and verbal assent was obtained from all study participants.

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