Augmenting Food with Information

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ABSTRACT
Eating is not only one of the most fundamental human needs but also among the most regular activities. Acquiring food, preparing meals, and socializing around food are deeply rooted in all human cultures. In this paper we show how food can not only serve to satisfy hunger but also become a new display technology. Through food augmentation, a dinner could communicate its ingredients, convey messages, or provide instructions such as the recipe of a meal. We show how to augment a large range of food with laser. We conducted a series of focus groups to gather people's first impressions and derive a broad range of meaningful augmentation scenarios. We discuss the perceived benefits, opportunities, and concerns. Additionally, we evaluated a number of scenarios through an online survey. The most readily accepted augmentation scenarios include adding practical information, increasing awareness about the food, and augmenting food items with a natural skin.

CCS Concepts
•Human-centered computing → Human computer interaction (HCI);

Author Keywords
Food; augmentation; eating; cooking; laser cutter; information.

INTRODUCTION
Eating is one of the few essential human activities. Consequently, preparing meals is deeply rooted in all human cultures. What we eat and the way food is prepared constantly changed throughout history. Advances in technology and skills enable the creation of highly sophisticated meals that cross the boundary between art and craft. Today, eating and food preparation serves many purposes far beyond simply stilling hunger.

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While food enthusiast experimented with novel ways of cooking and food preparation throughout most of human history, we recently saw an uprising interest to digitize food preparation within the maker culture but also in industry. Recent commercial food processors such as Kenwood's Cooking Chef[1] are highly sophisticated devices that can cook, knead, steam, mince, and mix. The hacker community tries to open commercial kitchen devices but also build new devices like the EveryCook[18] an Internet connected food processer that aims to guide users through the cooking process and automatically share responsibilities between the human and the electronic cook.

Novel devices are currently emerging that take food production one step further. Using commercial off-the-shelves laser cutter researchers proposed to cook bacon with a high resolution that enables to fry specific parts

In this paper we investigate food as a general means to communicate information. We explore how food can be augmented with information and serve as a new type of display. Through food augmentation, a dinner can communicate its ingredients and it can provide instructions or other information in a way that can hardly be avoided. Using a laser cutter as a prototyping tool we show how to alter common food such as bread, fruits, vegetables, and cereals (see Figure 1). Based on a series of focus groups we discuss use cases for food augmentation and assess the type of food and information users want on their food. Using the findings, we derive seven types of information and create scenarios for them. We conduct an online survey to investigate the scenarios and obtain more insights about the advantages and disadvantages of information on food.

RELATED WORK
Food and eating are fundamental for our survival. Prior work investigated different approaches to assist food preparation, change the eating experience, and augment foods with information.

Food preparation and eating in HCI
A significant body of work investigated food preparation and eating from an HCI perspective. In particular, researchers developed tools to enrich and support food preparation. Grimes and Harper surveyed previous work from HCI on human-food interaction [7]. They state that much of the prior work on

[1]Kenwood Cooking Chef http://www.kenwoodworld.com/uk/products/food-mixers/cooking-chef

Figure 1. Examples of food augmented with information using a laser cutter. Examples from left to right: A wrap with folding instructions, sweep pepper with general information about the plant, cereals showing calendar entries, and fruits that tell their origin and how they have been transported.

technology and food is motivated by a desire to fix the problem that individuals are thought to have with cooking, eating, or understanding what food can do to them.

Researchers developed a number of tools to support food preparation. To support even before the actual food preparation starts they developed approaches help people in deciding what to cook. An example for such a system is Kalas a social recipe recommender [15]. A comparison of recipe recommender algorithms has been conducted by Freyne et al. [5]. The authors conclude that making recipe recommendation is a far more complicated task in reality. A number of tools for supporting cooking have been developed and studied. Nakauchi et al. developed what they call 'intelligent kitchen' that recognizes the users activities and suggests what he or she should do next [11]. Similarly, Mennicken et al. developed an interactive kitchen counter that provides step-by-step instructions on two displays [9] and Lee et al. augmented a kitchen through top-projection and other visual output devices [3].

Eating itself and the surrounding context has also been assessed by the HCI community. Aiming to learn about eating practices, Hupfeld and Rodden conducted a study and discuss implications for digitally augment dining [8]. One direction is to use dinners to bring separated groups and families together. Barden et al. studied telematic dinner parties that aims to enable users to share a meal over a distance [2].

Food augmentation

The UbiComp community and related fields investigated the augmentation of food. A growing body of work augments the eating and drinking experience and aims towards gustatory displays. Using augmented reality, Narumi et al. changed the appearance and scent of edible markers [12]. Thereby, the system gives the eater the impression of eating different kinds of cookies. Narumi et al. further looked at increasing the number of perceptible tastes by proposing electric taste [10]. Similarly, Ranasinghe et al. developed a system that changes the drinking experience by changing the drink's illumination and electrically stimulating the tongue [14]. While work on gustatory displays is promising we are less interested in changing the eating experience and more into food as a medium for conveying information.

Closely related to our work is the work by Wei et al. who studied the use of food for personal messaging [17]. Wei et al. deployed a food messaging service in a company that enabled users to send messages to a food printer. Recipients were informed about the arrival of a message and could pick up the messages that were printed on icing sheets and pasted onto cookies. It was found that food messages combine characteristics of text messages and gifts. They are preferred in close relationships as they evoke positive emotions. As the results are highly encouraging we believe that food has the potential as a general medium for information and communication.

Tools for food augmentation

Adding information on food is already widely used for special events but also on an industrial scale. It is common to add names, greetings, and images on cakes, for example the names of the couple on a wedding cake. Companies put the name of their brand on chocolate and candies. It is even possible to order M&Ms that are personalized with messages and photos. The used technologies are diverse. However, they are specialized for specific types of food and do not allow exploring different types of food as information media. In addition, the used technologies are directed towards high volumes and do not allow personalized content on individual food items.

Recent development in digital fabrication has also been applied to food. 3D printers are available for printing different kind of food. Commercial printers for chocolate [1], pasta [4], and candy [13] have been announced. Unfortunately, current 3D printers for food are similar to most of their counterparts for other material as they only print a single material.

Another tool that has been widely adopted by the DIY and Maker community [16] are laser engraving and cutting systems. Using a standard laser cutter, Fukuchi et al. [6] showed that laser cutter can fry bacon, write on chocolate and cheese, and print 2D markers on white bread. Laser engraving and cutting is not bound to a specific type of food. We assume that this approach is therefore very suitable to prototype information-augmented food.

Summary

In conclusion, previous work from a broad number of domain investigated approaches to assist food preparation, change the eating experience, and to augment food with information. Food augmentation, in particular, is not something new but already widely used for special occasions. Recent progress in the development of tools to augment food, however, dramatically eased the augmentation of food. Augmenting food with personalized information is currently becomming easily doable. Recent work by Wei et al. [17] provided first insights into augmenting food with peronalized information.

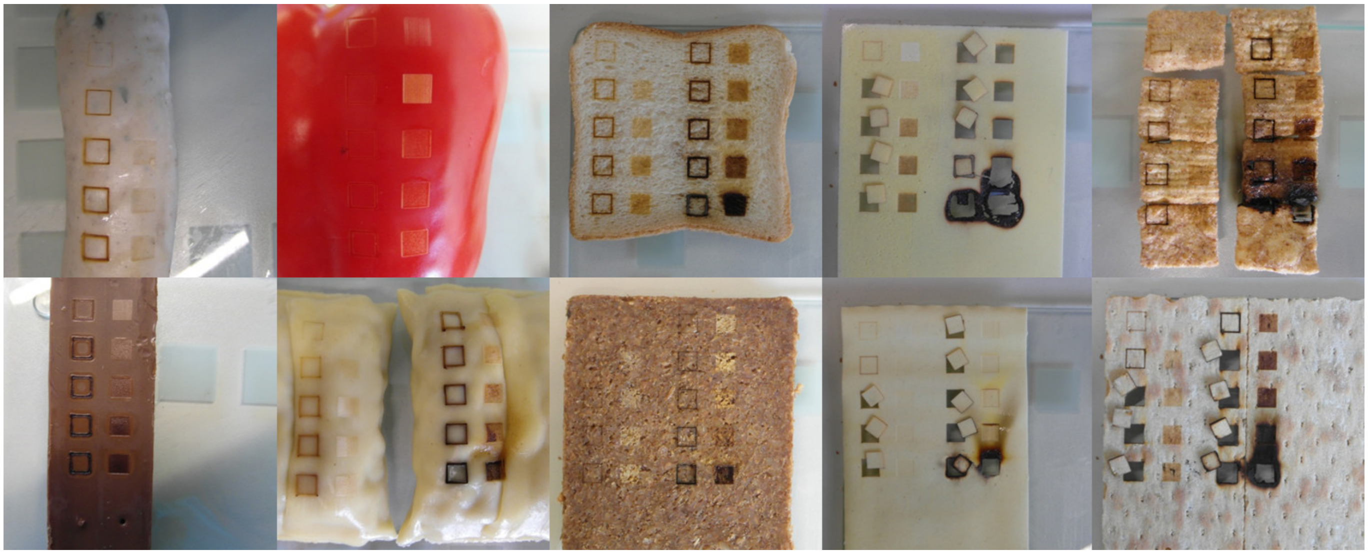

Figure 2. Ten test samples produced with an Epilog 35 watt CO2 laser engraver and cutter. The materials shown are (left to right / top to bottom) veal sausages, sweet pepper, toast, edible paper, breakfast cereals, chocolate bar, filled pasta squares, brown bread, lasagne, and crispbread.

So far, however, augmenting food with information has only been investigated for very specific scenarios. To guide furutre research we therefore follow a user-centred approach to provide a broad perspective on augmenting food with information.

FOOD AUGMENTATION WITH A LASER CUTTER

We systematically explored how a laser cutter can be used to augment food with information. Therefore, we tested a wide range of food and edible materials. In a first step we produced test samples using a standard laser cutter. We used an off-the-shelf Epilog Zing 6030 30 watts[2] CO2 laser engraver and cutter. Five or ten different settings were tested with each material. We used the laser cutter in engraver mode as well as in cutting mode. For some objects we stopped the test sequence after the first half as the laser started to damage the food for both cutting and engraving. The test settings for the first half were 10%, 30%, 50%, 70%, and 90% power with 100% speed. We used 90%, 70%, 50%, 30%, and 10% speed with 100% power for the second half. We used a resolution with 500dpi and adjusted the laser's focus to the average height of the food before each test run.

Figure 2 shows ten examples of the test samples we produced. The first and third column (if available) on each food shows cutting while the others show engraving. Cutting can be used in two ways. It can either be used to cut through the material (as shown for lasagne and edible paper in Figure 2) or to mark lines (as for the veal sausages). Engraving revealed some interesting effects. For some vegetables (e.g., paprika) lower power settings can result in marks that are more visible than higher power settings. The reason is that lower settings only scratch the surface leaving it intact while stronger settings remove the outer surface revealing the layer below.

[2]Epilog Zing 6030 30 watts CO2 laser engraver and cutter: https://www.epiloglaser.com/products/zing-laser-series.htm

For all tested food, we found at least one setting that leaves clearly visible marks on the food using either cutting or engraving. We continued by adding different information on different food to get an impression of the visibility of the marks and how well added content can be perceived. Figure 3 shows examples of different food and other edible items that have been augmented with information. We tested, for example, generating caramel on top of a desert similar to crème brûlée. This approach can be used to write on deserts either using a simple text or by an inverted image of the text resulting in a higher amount of caramel. Through cutting, round slices of ham can be cut in new shapes. By melting sugar, solid sugar objects can be created. Figure 3 further shows one

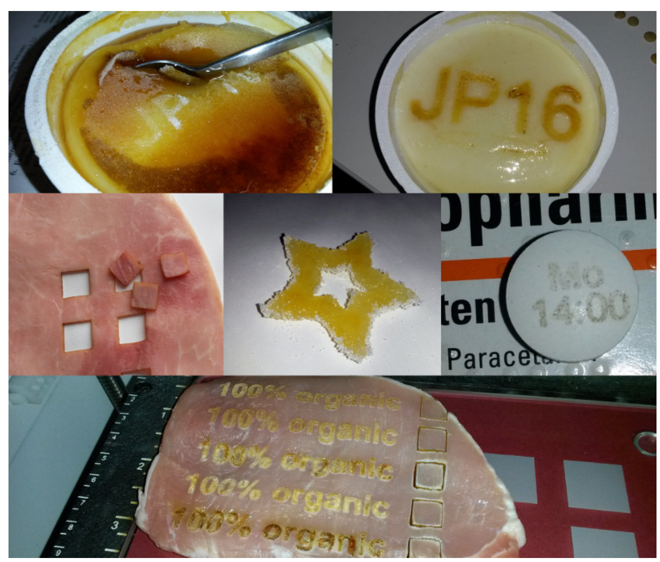

Figure 3. Examples of food altered by a laser cutter. The examples show (from left to right and from top to bottom): Two alternative ways to generate caramel on top of a desert, rectangles removed from a slice of ham, a star made out of melted sugar, a paracetamol tablet indicating a point in time, and a piece of organic pork.

of the tablets we enriched with the time it should be taken and a piece of pork that states that it is organic.

FOCUS GROUPS AND PARTICIPATORY DESIGN

We started our explorative user research by running three focus groups, to understand the concept of augmented food from the end users' perspective. Focus groups are an established method of social research. They are effective for the generation and evaluation of early ideas and facilitating rich discussion between various types of potential users. The goals of the focus groups were: (1) identifying potential scenarios for information-augmented food based on user needs (what information and what food), and (2) inquiring the perceived strengths and weaknesses of the overall idea. Additionally, following a participatory design approach, the new ideas elicited in the focus groups were planned to serve as a basis for selecting a broad and relevant set of scenarios for the upcoming online survey.

After we received ethical approval we recruited 20 persons that participated in the three focus groups. We organized one session in Germany and two in Finland to gather data from a broader cultural diversity. Although both Germany and Finland generally represent a Western European culture, the attitudes and activities related to food differ to some extent.

Participants

We had altogether 7 male and 13 female participants in the three sessions. Participants' ages varied from 11 to 50 (M=31, SD=9.5). Participants had various attitudes and relationships related to food and food activities: food enthusiasts, people with dietary restrictions (allergy-based, religion-based or preference-based), housewives, cooks and confectioners, medical professionals, people interested in applying technology to food, and naturally also people who simply like cooking and/or eating. In general, the participants had a positive attitude towards new technology and considered being open-minded persons.

Procedure and Stimulus Material

The three sessions followed the same overall procedure, however leaving room for new topics of discussion. First, the topic of augmenting food with information was introduced with example pictures (see Figure 3). In the presentation, it was emphasized that many other kinds of food items (e.g., meals, snacks, as well as ingredients) and types of information could also be seen in various kinds of food-related activities (from eating to buying, preparing, growing, and talking about food) and contexts of use (e.g., at home, in company, at restaurants, in events). In addition to pictures, we showed three types of food items as tangible examples: a banana with a message "Good luck to the exam!" (user-created message), an egg with decorative symbols and a person's name engraved on the shell, and candies with calorie information. This phase ended with the participants writing down their first impressions with short sentences, as well as a few broad interview questions about their expectations. Second, we asked participants to brainstorm additional examples of food and information on it they would need in everyday live. This was done

Figure 4. Examples of augmented or otherwise modified food, used as a stimulus for participants (from left to right and from top to bottom): an egg with decorative symbols and a person's name, lasagna plates cut in new shapes, candies with their calories to highlight a potential application, a banana with a message "Good luck to the exam!" and an almond with small text to show the possible resolution of the information.

first individually with the help of post-its, followed by a pairwise iteration of the ideas, and finally discussing the ideas in the whole group. In the end, semi-structured interviews inquired the participants' opinions and the early experiences from multiple viewpoints: what they perceive as the added value of the information, short- and long-term effects of the augmentations, food or information that should not be utilized, placement and visualization of the information, sources of the information, and effects on social interaction. The interview questions and themes were modified on the fly based on participants' backgrounds and the presented ideas.

Each session took approximately 1½ hours. As a thank-you gift the participants were offered vouchers or other gifts worth approximately 15EUR. The discussions were audio recorded for the analysis.

Results

After conducting all focus groups we digitized and transcribed participants' feedback. The data was analyzed with a qualitative bottom-up procedure: identifying common themes from the data and iteratively grouping the interview transcriptions and brainstorm notes into a hierarchy of themes.

First Impressions:

As first impressions participants formed a range of positive and negative opinions that we grouped in five categories: (1) being impressed about the overall idea, its novelty and innovativeness, and how fun it would be to use such food products; (2) perceived usefulness of the added information (e.g., "convenient", "information will be needed"); (3) doubts about the usefulness in long term; (4) expected negative experiences (e.g., feeling guilty or distressed while eating, frightening and suspicious feelings); (5) perceived risks in the production and ecosystem, such as "is it healthy to eat", "how much does it add to food price", problems to get the information, how to print it, as well as legislation issues. Overall, although the diversity of the opinions at this stage is not surprising, the breadth of issues identified already based on simple demonstrators was encouraging for the upcoming idea creation and discussion.

Brainstormed Scenarios - Types of Food and Information:
The participants wrote 126 mostly unique ideas on the post-its. In the following, not all ideas are reported in detail but an overview of the kinds of food and information that were brought up is presented.

Most of the ideas focused on the type of information rather than the food that is augmented. Approximately one third of the ideas were such where the food could be of almost any kind (e.g., calorie reminder about any kind of unhealthy food, or decorations on any ready-to-eat food). Nevertheless, in the ideas where the type of food was specified there was interesting variance: similar food products as presented in the stimuli (e.g., snacks, candies, fruits and ranch products), as well as more insightful ideas, such as food with natural peel or shell, entire meals, spices, stimulants like energy drinks, pet food, medicine, and self-made products like jam.

One group of information relates to being informed about food ingredients and background. This was discussed especially with respect to critical, personal restrictions, such as medical conditions (e.g., celiac), allergies (e.g., containing nuts), cultural traditions (e.g., halal), or diet choices (e.g. low-sugar). Also less critical needs for specifying product ingredients were commonly expressed: from which animal is the meat, additives and vitamins, nutrition facts, how spicy is the food, etc. These were envisioned as simple symbols and facts on the food. Another type of product details mentioned several times is the production method (e.g., regarding use of genetically modified fodder, child labor, fair trade). Several notes highlighted the need for origin information: from which country or farm is the food item and the route and handling along the way. The participants wished for more information about a number of things basically to be able to choose food items that fit to their values.

The second main group of information was instructions. Many mentioned the need for preparation instructions (e.g., how long to cook some items that are not anymore in the original package). Some mentioned the need for balancing the overall diet: for example, how much water should be drank to compensate the salt intake of a meal. Automatic indicators were also often proposed: for example an invisible stamp would show only when meat is cooked enough, a fruit is ready to eat, or a color indicator if food has gone bad (e.g., cold product kept in warm for too long). Another common theme was the conditions to preserve food (e.g., dairy products that can be kept in the room temperature). Additionally, long-term effects on one's health or the environment (e.g., carbon footprint) should be more visible on the products, hence instructing people in their everyday choices.

The third main group relates to social information. Enjoyment-related examples of food augmentation include adding decorations and messages, either by the producer or by another user. This was expected to enrich the eating experience with a social twist (e.g., "who made this meal"). A few brainstorm notes brought out that other consumers could provide interesting additional views to the food based on their own experiences: for example, recommending recipes and how to enjoy the food in new ways. One note also identified a possibility for advertisements if food items would advertise other items that match particularly well with it.

Benefits, Opportunities, and Concerns
The data from the interviewing and discussion phase were classified in three main topics.

Benefits. In general, participants readily accepted the idea of adding information on food. It was seen pragmatically useful to have critical information available also after throwing away the package (if any). Participants also mentioned that adding information on the food itself would make it seem more credible, in comparison to having it on the package (e.g., a stamp added already at the production farm). For fruits and other perishables, having unobtrusive engravings were preferred over the currently used price tags.

Another perceived benefit was the added value with small cost. Augmenting a food product would give an edge over competitors. Similarly, it could provide a personalized experience that makes the food experience richer (e.g., Easter egg hunting with pre-named eggs). Regarding social events, the added trivia facts could trigger discussion or joint activities (e.g., solving a puzzle on a pizza).

Opportunities. Overall, the opportunities were seen fruitful. On one hand, already the current product packages are missing commonly needed info, such as the country of origin. On the other hand, most of the same information as on the packages could be added on the product itself. A set of universally understandable symbols could be established to create international standards. QR-codes or similar could even provide a link to additional information. As for specific user groups, the augmentation was considered useful also for visually impaired (engravings and embossing) and motivational for children with negative attitudes towards specific food. One group also discussed the possibility for not only engraving the information but also decorating with other food (e.g., with chocolate).

Concerns. A main concern was that food is perceived as a natural, even intimate thing. Therefore, the original appearance of food should not be tampered. As one Finnish participant said, "I'm naturally taking this with a pinch of salt just because it's so new and relates to food that you eat". The added information was feared to create a sense that the food contains something poisonous or irritating (e.g. ink). Laser-printing or engraving was said to sound scary, especially for non-technical or elder people, which means that the augmentation technology might be cleverly hidden, and of course tested for health effects. Adding color to encode information was perceived challenging as color often creates an expectation of the taste. Finally, many wanted to generally preserve the natural looks of food items. Generally, visually coded information like symbols seemed more preferable than purely textual information.

Finally, the augmentations should not reduce the enjoyment of eating. For example, becoming aware of how many calo-

Figure 5. Photos of the seven scenarios used in the online survey. Scenarios are (from left to right and from top to bottom): Ravioli with the word ”vegetarian” (a). Toast with the social trigger ”hug the person on your right” (b). Sausages with instructions to cut them (c). Wraps with instructions how to fold them (d). Sweet pepper providing general information about the plant for education (e). Cereals showing personal calendar entries (f). Fruits that tell where they are from and how they have been transported (g).

ries one consumes might feel oppressive and add distress. The experience of eating depends of the intention of the food; snacks and candies are meant for pleasure, and constantly reminding about negative consequences would give the desired enjoyment a negative tone. Interestingly, one participant brought up the aspect of emotional attachment to items: receiving meaningful messages through food might bring new meanings to the food item, turning it into a gift rather than a consumable, thus hindering to original eating purpose.

All in all, the focus groups provided an interesting pool of ideas. The proposed ideas contain various viewpoints of which many could be recontextualized to another type of food or information. Some types of food were such that people indicated a variety of information needs related to them (e.g., about meat or fish: origin, freshness, nutrients, ethical concerns like carbon print or production methods). At the same time, some were such that adding info would not be technically feasible, and the focus was on the need for the additional info (e.g., information about liquids without a container). Similarly, some of the requested information is something that can already be learned from product packaging or that even would make more sense having on the package instead of food itself.

COMPARING FOOD AUGMENTATION SCENARIOS

The results of the focus group provided us with initial feedback about the information users might need related to their food. To obtain comparable results, we carried out an online survey. We presented seven scenarios of augmented food derived from the focus groups and collected further subjective feedback.

Presented Scenarios

The focus groups allowed us to identify three main groups of desirable information and a variety of possible food items to augment. Using these themes, we composed seven scenarios with different types of information and food types. For each of them, we prepared the food with augmented information to be presented as illustrated scenarios.

For the first theme of information, food ingredients and background, we developed three scenarios: *origin information*, *dietary information*, and *general knowledge*. For the origin information we considered fruits, i.e, oranges and bananas, and augmented them with information about the transportation route (Figure 5.g). For the dietary information, we used the raviolis and wrote on them that they were vegetarian (Figure 5.a). For the general knowledge information, we use the paprika and engraved the general information about the production of pepper in the USA, i.e., “Did you know that the USA procudes 1,064 ktones of pepper?” (Figure 5.e).

For the second theme, instruction information, we derived two types of information: *cooking instructions*, and *handling instructions*. For cooking instruction, we engraved the instruction of preparing a wrap on a tortilla bread. The instruction explains where to place the ingredients and how to roll the wrap (Figure 5.d). We used traditional Bavarian sausages, augmented them with instruction information how it should be eaten for the handing instruction information. The augmented information showed the steps how to cut the sausage (Figure 5.c).

For the last theme, social information, we considered two types of information: *message*, and *social triggers*. We augmented the cereals with the events obtained from a calendar. The information included different meetings and appointments during a day (Figure 5.f). For the social trigger information, we considered a social trigger statment (“Hug the person on your right”) and engraved it on toast bread (Figure 5.b).

In total we considered seven scenarios associated with the seven types of information identified. For each scenario we prepared the food and took a photo for illustration (see Figure 5). We embedded these pictures in an online survey to collect subjective feedback from users.

Survey Structure

For each scenario we prepared the food and took a photo for illustration (see Figure 1). We embedded these pictures in an online survey to collect feedback about the scenarios. The survey consisted of three parts. 7-point Likert scales were used for all quantitative questions. In the first part we asked about participants' demographics and their attitudes towards new technologies, food, and food-related activities. In the second part, we showed the scenarios one by one and asked to rate the food, rate the presented information, and to provide positive and negative aspects in open text fields. The order of the scenarios was randomized. Finally, we asked to rate the scenarios' seven types of information and how suitable for augmentation nine different types of food derived from the Codex GSFA's food category system are. After receiving ethical approval, we put the survey online for two weeks. The survey was distributed through mailing lists and social networks.

Quantitative Results

134 participants started to fill the questionnaire but not all completed the survey. We only considered participants who answered all questions. This resulted in 63 participants (35 female) with an average age of 31.41 years (SD=9.15) and 18 different nationalities. In the following we use Friedman's ANOVA and Wilcoxon signed-rank post-hoc tests for statistical analysis.

The most preferred scenario (see Figure 6) was the origin of fruits (M=5.00, SD=2.18), followed by cooking instruction on wraps (M=4.92, SD=2.30), dietary information on raviolis (M=4.76, SD=2.19), and information about the production of pepper (M=3.71, SD=2.25). Least preferred were the appointments on cereals (M=2.48, SD=1.85), messages on toast (M=3.51, SD=2.02), and instructions on sausages (M=3.54 , SD=2.26). The scenarios' ratings differ significantly (X2(6)=127.45, p<.001). Post-hoc tests showed that the differences between the following scenario are significant (all p<.002): paprika/wrap, wrap/ravioli, wrap/sausage, paprika/cereals, ravioli/cereals, sausage/cereals, paprika/fruits, ravioli/fruits, toast/paprika, toast/sausage, toast/ravioli, and sausage/ravioli.

Users found the dietary information most important (M=5.70, SD=1.78) following by cooking instruction (M=4.54, SD=2.18), handling instructions (M=4.49, SD=2.10), and messages (M=3.76, SD=2.11). Users rated the categories general knowledge (M=2.34, SD=1.69) and entertainment (M=2.76, SD=1.98) worst. Ratings of the information categories also differed significantly (X2(5)=130.83, p<.001). The difference between all types of information were significant (all p<.004) except for handling instruction/cooking instruction.

The rating of the suitability for augmentation of different types of food (see Figure 7) are statistically significant

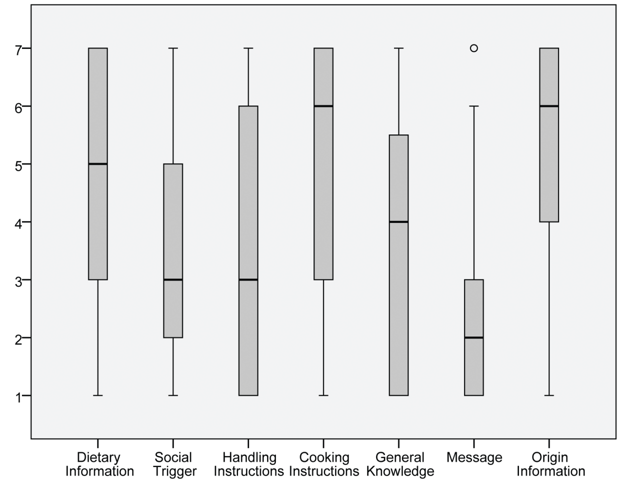

Figure 6. Responses to the statement "I would like that food like this had information on them" asked for the seven specific scenarios. Answers are on a 7-point scale from 1=completely disagree to 7=completely agree.

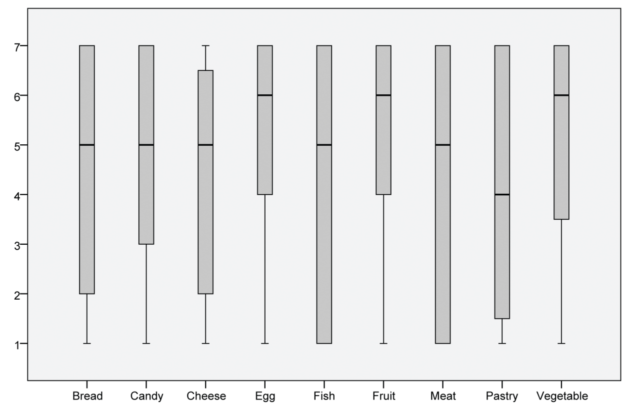

Figure 7. Responses to the statement "I would like to augment the respective food with information". Answers are on a 7-point scale from 1=completely disagree to 7=completely agree.

(X2(8)=26.32, p<.001). However, only the differences between cheese and egg (p<.001), cheese and fruit (p<.001), and egg and pastry (p<.001) are significant.

Qualitative Results

We collected 223 qualitative comments for the seven scenarios. Comments for different scenarios were often similar and confirmed the findings of the focus groups. Participants were concerned about the appeal of the food, how information will be printed on food, and whether it is healthy. The change in cost of the food and reliability of information were other concerns. In the following we focus on feedback for the three themes of information.

For the first theme (origin information, dietary information, and general knowledge), nine participants considered the information particularly useful. Eighteen participants found that the origin and the dietary information can increase the awareness about the food. A participant commented "This kind of information might have a heavy influence on peoples' buying decisions". However, four participants were concerned about misunderstandings of the origin information as symbols may not be sufficient to convey the information, e.g., "a long text is needed to convey this information". Four participants found that dietary information on food should differ from information provided on the food package. Ten participants expected that the general knowledge information would have a learning effect particularly for children, for example, "learn facts about the vegetables while cooking" or "children can starting to learn on vegetables".

For instruction information, 21 participants expected that the cooking instruction ease cooking (e.g., "it gets easier to make food" or "very helpful and no more need to explain it on additional paper"). However, some participants stated that it can also limit the creativity (e.g., "This suggestion requires us to use our brain less and less" or "I can't show off my (non-existent) cooking skills") and decrease the fun of cooking (6 participants). On the other hand, 5 participants mentioned that the handling instruction can overcome the differences between food cultures, e.g., "I think for foreigners it could be an easy way to overcome differences in food culture".

For social information, five participants found that the messages ease the access to the information while eating, e.g., "it's right in front of the eye" or "...it saves time because I can check my calendar events during breakfast". However, 8 participants mentioned that providing such information at breakfast can cause distress, e.g., "I could not enjoy my breakfast". Regarding the social trigger, 8 participants found such information funny and 6 participants stated that it could be suitable for social events like parties (e.g., "It would be actually interesting to have conversation topics suggested by cookies"). At the same time, five participants believed that such social information could be disturbing in certain contexts or having different cultural backgrounds (e.g., "... disturbing if you eat alone", "this form of socializing does not always work for example in business meal or other cultures").

DISCUSSION

Overall, the results of the focus groups are encouraging in the sense that participants readily accept food as a medium for displaying information. Participants could imagine having information of food that is already provided through other means, such as the package but also envisioned to add other, in particular personalized, information. They expected a wide range of opportunities that augmenting food with information could bring. One of the main concerns was that food producer might have no interest in adding certain information, such as the ingredients or potentially negative health effects. Furthermore, the participants were concerned that adding information on food could negatively change how specific types of food are experienced.

Through the online survey, we further explored specific scenarios derived from the focus groups. We investigated which types of food are seen as most promising for adding information. We found that practical information, such as instructions, as well as information that increase awareness about the food itself, such as its content are the most appreciated ones. While one group of participants believed that information provided on packages can also be augmented on food, other participants suggested to use food augmentation to provide additional information. Furthermore, we found that fruits, vegetables and eggs were seen as the most promising to be augmented with information.

The results of the conducted studies are constrained by different factors. Both studies were conducted in specific cultural settings that influence the results. To alleviate this effect, we conducted the focus groups in two different countries and recruited participants from 19 nationalities for the survey. Nonetheless, repeating the studies with participants with other cultural background might reveal additional insights. While we presented various examples of augmented food to participants, we did not deploy laser-augmented food in the wild. Based on discussions with nutrition experts, chemist and engineers from an industrial lasers manufacturer, we assume that it is not unhealthy to eat the prepared food. However, we would require formal approvals to conduct studies with lasered food. Finally, there are a number of other approaches to augment food with information, such as using food coloring for writing information on the food. While we are mainly interested in the general approach of augmenting food with information, we also believe that using a laser cutter as a prototyping tool provides a flexibility that other approaches cannot provide.

CONCLUSION

In this paper, we took a first step towards food as a new medium to present information. We proposed using an off-the-shelf laser cutter to add information on food. We systematically explored how a laser cutter can be used to augment food with information and provided examples for a wide range of different food. The examples show that laser cutters are very valuable tools to create prototypes of food with information. Based on a series of focus groups we provide insights about the benefits, opportunities, but also about people's concerns when food is augmented with information. The online survey we conducted, further explored specific scenarios. We provided insights about the food that is most promising for augmentation and the information that seems most valuable for the users.

We see that the ongoing trend for personalization will further gain importance for food. While most tools to digitally produce or augment food are too complicated or expensive today, consumer demand will make them more usable and reduce their costs rapidly. Supported by our results, we believe that food is a very valuable and direct medium to present information. When the corresponding tools are available to the average consumer, we expect that food augmented with information becomes ubiquitous.

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REFERENCES

1. Aamoth, D. The delicious future: 3d chocolate printer finally available for purchase. In *http://techland.time.com/2012/04/09/the-delicious-future-3d-chocolate-printer-finally-available-for-purchase* (2012).

2. Barden, P., Comber, R., Green, D., Jackson, D., Ladha, C., Bartindale, T., Bryan-Kinns, N., Stockman, T., and Olivier, P. Telematic dinner party: designing for togetherness through play and performance. In *Proceedings of the Designing Interactive Systems Conference* (2012), 38–47.

3. Bonanni, L., Lee, C.-H., and Selker, T. Counterintelligence: Augmented reality kitchen. In *Proceedings of the conference Human Factors in Computing Systems (extended abstracts)* (2005), 2239–2245.

4. Davies, L. 3d-printed pasta — the shapes of things to come? In *http://www.theguardian.com/lifeandstyle/2014/jan/09/3d-printed-pasta-shapes* (2014).

5. Freyne, J., and Berkovsky, S. Intelligent food planning: personalized recipe recommendation. In *Proceedings of the international conference on Intelligent user interfaces* (2010), 321–324.

6. Fukuchi, K., and Jo, K. Laser cooking: an automated cooking technique using laser cutter. In *Proceedings of the Conference on Tangible Embedded, and Embodies Interaction* (2011), 163–168.

7. Grimes, A., and Harper, R. Celebratory technology: new directions for food research in hci. In *Proceedings of the Conference on Human Factors in Computing Systems* (2008), 467–476.

8. Hupfeld, A., and Rodden, T. Laying the table for hci: uncovering ecologies of domestic food consumption. In *Proceedings of the Conference on Human Factors in Computing Systems* (2012), 119–128.

9. Mennicken, S., Karrer, T., Russell, P., and Borchers, J. First-person cooking: a dual-perspective interactive kitchen counter. In *Proceedings of the conference Human Factors in Computing Systems (extended abstracts)* (2010), 3403–3408.

10. Nakamura, H., and Miyashita, H. Augmented gustation using electricity. In *Proceedings of the Augmented Human International Conference* (2011), 34–43.

11. Nakauchi, Y., Fukuda, T., Noguchi, K., and Matsubara, T. Intelligent kitchen: cooking support by lcd and mobile robot with ic-labeled objects. In *Proceedings of the International Conference on Intelligent Robots and Systems* (2005), 1911–1916.

12. Narumi, T., Nishizaka, S., Kajinami, T., Tanikawa, T., and Hirose, M. Augmented reality flavors: gustatory display based on edible marker and cross-modal interaction. In *Proceedings of the Conference on Human Factors in Computing Systems* (2011), 93–102.

13. Press-release. 3d systems sweetens its offering with new chefjet 3d printer series. In *http://www.3dsystems.com/press-releases/3d-systems-sweetens-its-offering-new-chefjettm-3d-printer-series* (2014).

14. Ranasinghe, N., Lee, K.-Y., and Do, E. Y.-L. Funrasa: an interactive drinking platform. In *Proceedings of the International Conference on Tangible, Embedded and Embodied Interaction* (2014), 133–136.

15. Svensson, M., Höök, K., and Cöster, R. Designing and evaluating kalas: A social navigation system for food recipes. *ACM Transactions on Computer-Human Interaction 12*, 3 (2005), 374–400.

16. Tanenbaum, J. G., Williams, A. M., Desjardins, A., and Tanenbaum, K. Democratizing technology: pleasure, utility and expressiveness in diy and maker practice. In *Proceedings of the Conference on Human Factors in Computing Systems* (2013), 2603–2612.

17. Wei, J., Ma, X., and Zhao, S. Food messaging: using edible medium for social messaging. In *Proceedings of the conference on Human factors in computing systems* (2014), 2873–2882.

18. Wiasmitinow, A. Everycook – cooking gets digital. In *29C3 - Not My Department* (2012).