E-learning tools for food technology and development education – novel pasta development case study

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Abstract. The E-learning tools for food technology and development education (E-Food) project aims to expand the opportunities for training through digital forms in the field of food technology. By creating special educational materials (databases, training courses, e-rapid tools) the aim is to achieve synchronization of the curricula offered at different universities in the European Union. An important element in the implementation of the project is the work of students and doctoral students on the development of new food products in a virtual environment under the guidance of mentors from the partner universities in the project. The purpose of this work is to present the approaches and principles for developing case studies for a new food product - pasta by using the materials developed within the framework of the project implementation. "SmartPasta for Healthy Life" is an innovative line of functional and personalized pasta products tailored to modern health-conscious consumers. Combining three unique concepts—beetroot pasta for natural flavor and color enhancement, fruit-purée-colored pasta for children, and functional "SmartPasta" enriched with protein, fiber, and low-carb ingredients—the product line addresses various dietary needs.

1 Introduction

In recent years, there has been a growing interest in the development of functional foods that offer enhanced nutritional benefits beyond basic sustenance. Pasta, a staple food in many cultures, has become a key focus for innovation in this area. In the modern food industry, foods are developed not only to satisfy basic satiety requirements but also to reduce the risk of nutrition-related diseases and to improve human physiological well-being [1-3]. This has led to the emergence of a new category of foods, known as „functional foods". Among the various functional food products, those containing probiotics dominate the market due to their positive effects on intestinal health [1]. In addition, probiotic fortification can improve the nutritional quality of food products and extend their shelf life by producing antimicrobial substances [4, 5].

In the age of smart homes, smart wearables, and smart cities, it's no surprise that even something as traditional as pasta is getting a high-tech upgrade. Smart pasta technology is an innovative fusion of food science, material engineering, and digital design aimed at transforming how pasta is produced, cooked, and consumed. From shape-shifting noodles that respond to boiling water to pasta embedded with sensors for nutritional tracking, this technology opens up a new frontier where culinary tradition meets intelligent design. As food sustainability, personalization, and efficiency become increasingly important, smart pasta stands at the intersection of science and gastronomy, promising a more interactive, efficient, and customizable dining experience. Traditionally made from refined wheat flour, conventional pasta is often low in essential nutrients such as fiber, protein, and certain micronutrients. To address these nutritional gaps, researchers and food manufacturers have been developing new types of pasta with increased biological value. These enhanced pasta varieties often incorporate alternative ingredients such as legumes, whole grains, vegetable powders, and protein-rich sources, aiming to improve their amino acid profiles, fiber content, and overall health benefits. Some authors indicated that, pasta can be supplemented with several ingredients that may have a positive impact on health. In this context, several studies have investigated pasta enrichment by adding different ingredients, including vegetables and fruits [6, 7], microalgae [8-10], insects [11-13] and agro-industrial by-products, such as olive pomace [14, 15], onion skin [16], and watermelon rind [17]. This shift reflects a broader trend toward health-conscious food choices and the demand for products that support well-being while maintaining desirable taste and texture.

Functionally beneficial foods and nutritionally balanced diets have driven research into the development of food products that not only meet basic

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nutritional needs but also offer additional health benefits. In this context, incorporating regional plant-based ingredients into pasta production has become a promising strategy to enhance its nutritional and functional profile. Ingredients such as legume flour, tubers, and oilseed flours have shown potential to increase the protein content, dietary fiber, and antioxidant compounds in pasta, contributing to a more balanced and healthy diet [18]. Consequently, the growing demand for these products has encouraged research on the incorporation of bioactive compounds into everyday foods [19]. Among these compounds, polyphenols and dietary fiber have gained particular attention for their well-documented health benefits, including antioxidant, anti-inflammatory, and gut health-promoting properties [20, 21].

Several studies have demonstrated that partially replacing wheat flour with pseudocereal flour, including amaranth, buckwheat, and quinoa, significantly augments the pasta nutritional value [3, 22]. These pseudocereal-enriched pastas, whether composed solely of pseudocereal flours or in a combination with wheat flour or semolina, boost elevated levels of micronutrients and phytonutrients, along with a more balanced amino acid profile compared to traditional cereals like rice, wheat, and corn [23]. Additionally, the use of pseudocereals favors the food nutritional profile, increasing the content of vitamins, minerals, and dietary fibers.

Another research aimed to develop a 3D-printed pasta formula that, when cooked in various-flavored waters, turns its color into appealing colors that can be used as a cooking indicator. For this aim, a new pasta formula composed of wheat flour (WF), olive oil (EVOO), and red cabbage juice (RCJ) (containing the smart material anthocyanin) was used as print inks. Subsequently, the color changing, cooking quality, flavor profile (by E-nose) and consumer acceptability of fresh and freeze-dried (FD) 3D-printed pasta cooked in various-flavored waters were evaluated. Results revealed that adding EVOO enhanced the printability and smoothness of the pasta dough [24].

The addition of new ingredients in pasta, although nutritionally interesting, modify their structure and negatively impact their technological and sensory properties, and therefore decrease their acceptance by consumers [25]. The addition of non-conventional ingredients in common gluten-free pasta which are already organoleptically far from traditional pasta, could have less impact on the consumer acceptance. The partial replacement of refined wheat semolina by non-conventional ingredients, such as fibers, vegetables or legume in pasta has been already attempted in order to improve their nutritional quality [3, 26] and notably both the quantity and quality of proteins, fibers and mineral content while keeping a low gluten index [27-29].

SmartPasta for Healthy Life is an innovative line of functional and personalized pasta products tailored to modern health-conscious consumers. There is no data in the scientific literature on the use of beetroot, with the addition of blueberry, raspberry, strawberry, and blackberry puree and utilization of probiotics and postbiotics in pasta production.

The aim of this work was to present a case-study framework for the conceptual development of a health-oriented pasta product line, using the educational resources created within the E-Food project.

2 E-Food approach for novel food development

E-Food is a cooperation partnership project within the framework of Erasmus+ cooperation that builds a unified, cloud-based e-learning tools for food technology and product development. The E-Food approach converts educational standards, harmonized courses, and case-study competitions into a practical pipeline for generating novel-food concepts. It targets disparities in curricula, platforms, and access by creating common rules for development, audit, and use of digital materials; public (registered) access to a training platform; and structured activities that connect students, teachers, and businesses.

E-Food includes the following **Objectives**, which are directly related to the development of new foods and beverages through the development of Case Studies (CS) by multinational teams of students and mentors:

- Analysis of existing curricula and electronic systems used for training students in the field of food technology (O1);
- Development of educational standards, including for CS, through which a unified educational content in the field of food technology and the development of new foods and beverages will be created (O2);
- Creation of unified content in the form of databases (short materials describing various foods, beverages, processes, raw materials, etc., which students can use as a basis for creating a new product) and training courses that cover a wide range of disciplines, providing the necessary knowledge for the creation of new foods and beverages (O3);
- Deployment/adaptation of an open-access, cloud e-learning platform (O4);
- Development of concepts for the creation of new foods and beverages, through the conduct of virtual competitions (O5).

E-Food presents the following architecture for developing a new food product in the form of CS: (1) curated knowledge bases that make raw materials, processes, and innovations searchable and comparable; (2) unified courses that ensure a common vocabulary and baseline skills; (3) CS that translate industry tasks into student-led technology designs; and (4) e-rapid modules that upskill professionals for targeted needs. Internal/external audits standardize quality and traceability; the cloud platform enables blended/virtual mobility and equitable access for students and adult learners. Green-transition topics (by-product valorisation, secondary energy, reduced consumption) are embedded across courses and activities.

3 SmartPasta for Healthy Life – Case study

The development of this case study is based on the knowledge of various raw materials, processes and innovations that are the subject of the development in the project. First of all, it was necessary to familiarize ourselves with the structure of the case study, which was defined within the framework of the implementation of the E-Food project (Fig. 1).

Fig. 1. Case study structure

The market analysis was conducted as a desk-based review of recent literature and publicly available market reports and was used to position the concept rather than as a standalone empirical consumer study. The global pasta market is experiencing a period of significant diversification, driven by increased consumer interest in health, sustainability, and food innovation. Traditionally dominated by wheat-based products, the pasta segment is evolving to include functional, plant-based, high-protein, low-carb, and allergen-free variants. The global market size for pasta was valued at over **$45 billion in 2023**, and it is projected to grow at a **CAGR of 4.5% until 2030**, according to Market Research Future. A particularly dynamic subsegment is **functional pasta** — products enriched with additional health benefits such as protein, fiber, vitamins, and probiotics. This category is expected to grow at **7–8% annually**, aligning with broader trends in functional and personalized nutrition. Consumer behavior has shifted notably in recent years: Over **60% of global consumers** actively seek products with **clean labels** and natural ingredients; More than **40% of pasta consumers** report interest in **gluten-free or reduced-carb options**; There is a rising demand for **plant-based and high-protein alternatives**, especially among fitness-conscious individuals, vegans, and flexitarians.

Through the created databases (Fig. 2), the team developing the **SmartPasta for Healthy Life** concept became familiar with various traditional, innovative and sustainable products, processes and raw materials, typical for Bulgaria, France, Hungary, Spain and Romania. The developed databases provide an opportunity to select the best practices and raw materials, through which a unique product based on modern production and nutrition trends can be developed.

Three types of pasta were offered in the product line:

- ***beetroot pasta*** emerged from a desire to break away from conventional pasta, which often lacks visual appeal and added health value. At concept level, beetroot purée was considered the most suitable option for color and flavor integration. When combined with semolina flour and water, the dough achieved optimal firmness and elasticity.

- **fruit-purée pasta for children -** to encourage healthy eating among children, a colorful variant was developed using white wheat and rice flours, blended with natural berry purées (blueberry, raspberry, strawberry, and blackberry). These ingredients contribute vibrant, naturally derived colors, antioxidants, and subtle fruity aromas. The pasta is shaped into fun forms such as stars, letters, or animals, making meals more playful and engaging.

- **pasta for athletes –** a **high-Protein Pasta** made from lentil, pea, or black bean flour, enriched with prebiotics (inulin), postbiotics, and plant-based protein

The R&D process reflects commitment to developing inclusive and personalized nutrition solutions that match the expectations of modern, health-conscious consumers. For each type of pasta, a technological scheme was proposed (Fig. 3) and technological descriptions, including the main guidelines for the production of the specific assortment, were developed. Each of these three types of pasta can be developed by adding postbiotics, prebiotics, vitamins and minerals during production.

For example, the pasta for children is produced from a combination of white and rice flour with the addition of natural purees of various fruits, which give a different color and distinctive taste and aroma to the final product. These purees increase the antioxidant capacity and nutritional value of the product. In this case, a tailor-made concept is used, in which the product is adapted to different target groups. The concept relies on the ideas of personalized nutrition, natural ingredients and

orientation towards different consumer groups. For example, in the production of children's pasta, the focus is not only on the flavor profile, but also on the vision of the packaging and logo. With innovative recipes, engaging shapes, targeted functionality, and sustainable packaging, SmartPasta meets the needs of a rapidly evolving, health-conscious, and eco-aware global audience.

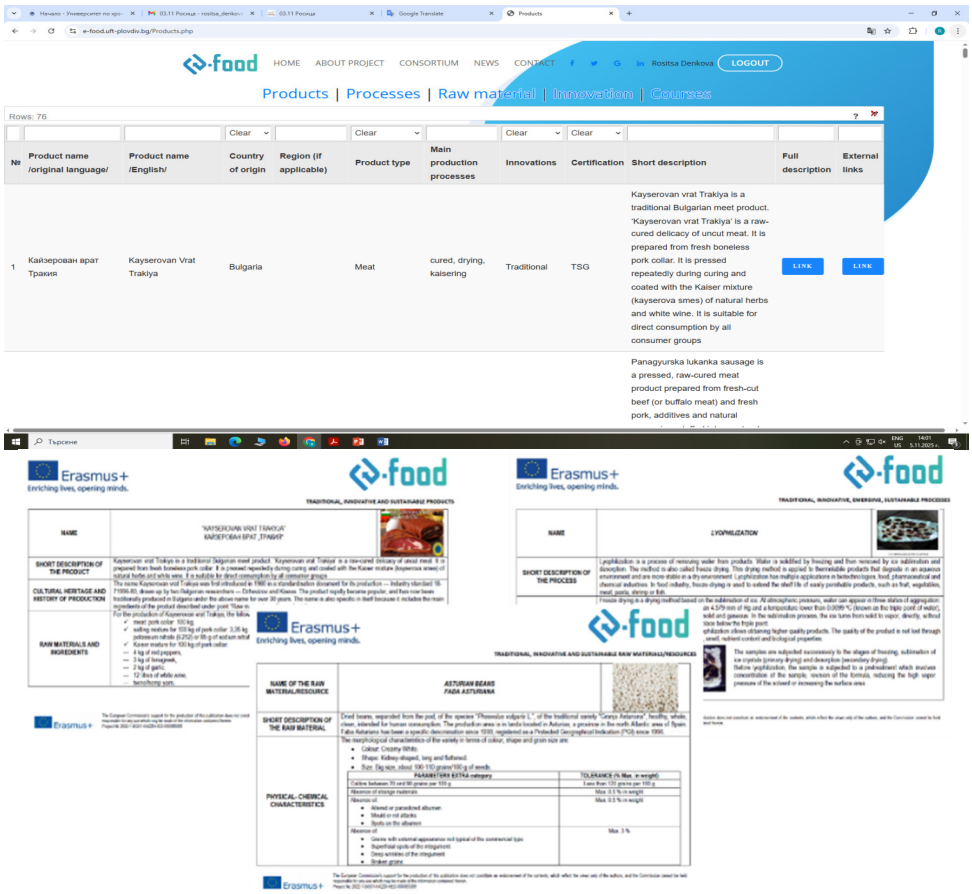

Fig. 2. Databases

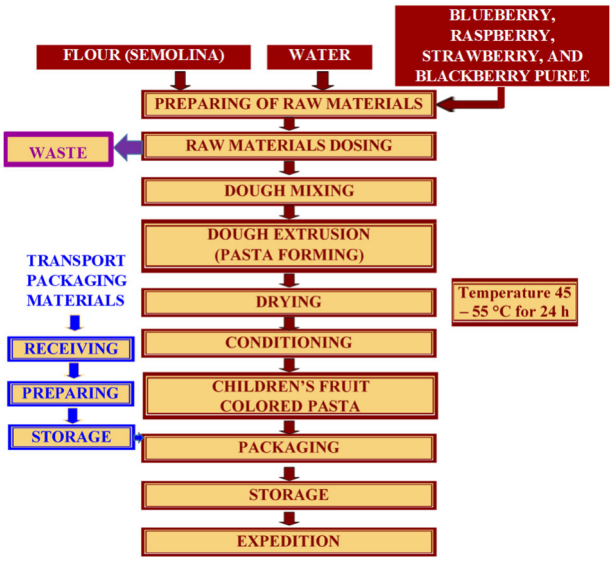

Fig. 3. Process flowchart for smart pasta production

A proposed marketing strategy for SmartPasta for Healthy Life was developed to illustrate the product-positioning stage within the case study. The products will be positioned in the **premium functional food segment**, targeting health-conscious families, athletes, and consumers with special dietary needs (fig. 4). The packaging will be made from **eco-friendly paper with a transparent window**, allowing consumers to see the actual colorful pasta—enhancing trust and eliminating the need for misleading images. Labels will be printed

directly on the back of the pack, reducing waste and improving recyclability. Children's pasta will feature **playful and educational designs**:

- Packaging with **shaped windows** (e.g., stars, bears) to showcase the product.
- Boxes with **mini-games or stories** related to ingredients or food adventures.
- **Kid-friendly nutrition facts** (e.g., "Blueberries help your eyes like a superhero!").

Fig. 4. SmartPasta packaging

The financial viability of the SMART PASTA project, specifically the beetroot-enriched pasta variant, is grounded in a detailed cost and revenue estimation. The production cost per 250 g pack includes the following components: raw materials (semolina, beetroot) – €0.70, utilities – €0.10, labor – €0.40, eco-friendly packaging – €0.20, logistics – €0.25, and facility/rent overheads – €0.15, resulting in a total unit cost of approximately €1.80.

To ensure sustainability and competitive positioning in the premium health food sector, a 40% markup is applied, leading to a retail price of €2.50–€2.70 per pack. In initial operations, small-batch production will be targeted at boutique organic shops and farmers' markets. Projected monthly sales in this pilot phase are between 300 and 500 units, corresponding to monthly revenue of €750–€1,350 and gross profits of around €270–€450.

Bringing *SmartPasta for Healthy Life* to market comes with several practical **challenges and risks** that will need careful management. One of the first hurdles is ***market entry***. While smaller organic and specialty stores are more open to new functional foods, larger supermarket chains usually require evidence of demand before allocating shelf space. To build this track record, the plan is to start with small batches sold in specialty outlets and farmers' markets, where early adopters are more receptive.

Another challenge is ***consumer acceptance***, particularly the unfamiliar colors of the pasta. While the red tones from beetroot or the fruit-based colors for children are entirely natural, shoppers may hesitate if they do not understand the benefits. Clear on-pack communication, recipe ideas, and partnerships with influencers and dietitians can help normalize these features.

Seasonal ***ingredient availability*** — especially for fresh beetroot and berry purées — also adds a degree of uncertainty. Working with several local suppliers and using frozen or semi-processed ingredients when needed will help maintain consistency.

Production costs are higher than for conventional pasta due to premium raw materials and eco-friendly packaging. Positioning the brand in the premium functional food segment can justify pricing until scale-up reduces costs.

Finally, entering international markets requires meeting diverse ***regulatory standards***. Early involvement of food regulation experts will ensure compliance with EU, FDA, and national requirements.

The **international expansion** of *SmartPasta for Healthy Life* will rely on the versatility of the product line and the growing global interest in nutritious, clean-label foods. With three distinct concepts — beetroot pasta, fruit-purée pasta for children, and high-protein functional pasta — the brand can adapt naturally to different dietary cultures. Minor adjustments in flavor, such as adding Mediterranean herbs or spicier Asian notes, will help align the products with local tastes without altering their identity.

A **digital-first approach** will support early market entry. A multilingual website, active social media presence, and participation in international food fairs will introduce the brand to a wider audience. Smart packaging with QR codes will guide consumers to localized recipes, nutrition information, and sustainability messages, making the product easier to understand and trust.

Regulatory alignment is essential for global growth. The brand will follow **EU Regulation 1169/2011**, **FDA requirements**, and seek additional **Halal and Kosher certifications** where appropriate. To reach diverse consumer groups, two versions of the products will be offered: one containing egg protein and one fully vegan.

The **sustainability profile** of *SmartPasta for Healthy Life* is built into every stage of the product's lifecycle. A key strength is the use of ***locally sourced ingredients***, which reduces transport emissions and supports regional farmers. Most vegetables and berries used in the recipes come from Bulgarian producers, ensuring freshness and a smaller carbon footprint. Semolina is the only imported ingredient, chosen for its quality and suitability for pasta production. Using seasonal produce and natural purées also contributes to reducing food waste.

Production methods have also been designed with resource efficiency in mind. During warmer months, pasta is solar-dried, significantly lowering energy consumption. When solar drying is not possible, low-energy drying processes help maintain consistent quality with minimal environmental impact. Water usage is optimized by controlling dough hydration and improving cleaning processes.

Packaging is another important sustainability element. SmartPasta uses recyclable ***paper-based packaging*** with a small biodegradable window so that consumers can see the product without relying on artificial imagery. Plant-based inks and safe adhesives further reduce environmental impact. The dried nature of pasta provides a long shelf life, which helps minimize food waste both in stores and at home.

Digital tools play an important role in how SmartPasta is developed, presented, and communicated to consumers. The brand's website features a clean, user-friendly online store that introduces the main product categories — Beetroot Pasta, Kids Edition, Athlete Pasta, and other specialty items — along with a clear message about transparency, natural ingredients, and fast EU-wide delivery. During product development, the team uses ***AI-based trend analysis*** to track shifts in consumer interest, such as the popularity of plant-based diets or low-glycemic foods. These insights help refine recipes and identify opportunities for new variants. SmartPasta also incorporates ***QR-enabled smart labels***, giving consumers easy access to preparation guides, ingredient origin, nutrition breakdowns, and environmental information. This enhances transparency and helps build trust.

Fig. 5. **Scan to open SmartPasta web page**

To understand how different audiences respond to specific messages and visual styles, social media listening tools like Sprout Social and Brandwatch are used. This allows the team to tailor its communication more effectively to families, young adults, or athletes. For sales and distribution, SmartPasta integrates with e-commerce platforms such as Shopify or Etsy, which are particularly useful for testing small-batch products or limited editions. For business partners and retailers, the brand is prepared to use ***blockchain-based traceability***, ensuring reliable documentation of sourcing and production — an increasingly valued feature in international markets.

A proposed **consumer communication plan (**fig. 6) for *SmartPasta for Healthy Life* aims to make the brand's benefits clear and relatable for three main groups: families with children, active consumers, and health-conscious adults. The central brand message— **"Eat Smart, Live Strong"** — captures the idea of choosing food that supports both health and daily energy.

To keep messaging focused, four benefit pillars guide all communication. For the health segment, the emphasis is on clean-label recipes, real vegetable ingredients, and high fiber. For athletes, the focus shifts to smart carbohydrates and the natural performance benefits of beetroot. For families, the children's line is presented through playful, friendly language such as "Heroes Eat Smart!", highlighting colorful shapes and easy recipes. Finally, sustainability messages reassure consumers that the packaging is eco-friendly and that QR codes provide CO_2 transparency.

A simple, intuitive visual identity helps communicate these benefits. Each line uses clear icons for features like "high fiber," "no preservatives," or "eco pack," and color coding helps consumers quickly find the product that suits them. QR codes on the pack lead to recipes and ingredient stories.

The communication plan uses a mix of channels:

• **In-store** tastings and recipe cards;
• **Digital** content such as short cooking videos on Instagram, TikTok, and YouTube;
• **Community events** like school fairs, running clubs, and farmers' markets;
• **Influencers**, including family creators, coaches, and eco bloggers.

This combination ensures consistent visibility and encourages trial while building long-term trust in the SmartPasta brand.

4 Conclusion

This case study illustrates how pasta can be used as a platform for concept-level development of health-oriented products targeted at different consumer groups. The work proposes formulation directions, indicative processing considerations, and market-positioning elements within the educational framework of the E-Food project. At the present stage, the paper should be interpreted as a concept-development and teaching-oriented case study; experimental validation, physicochemical characterization, and consumer acceptance testing remain subjects for future work.

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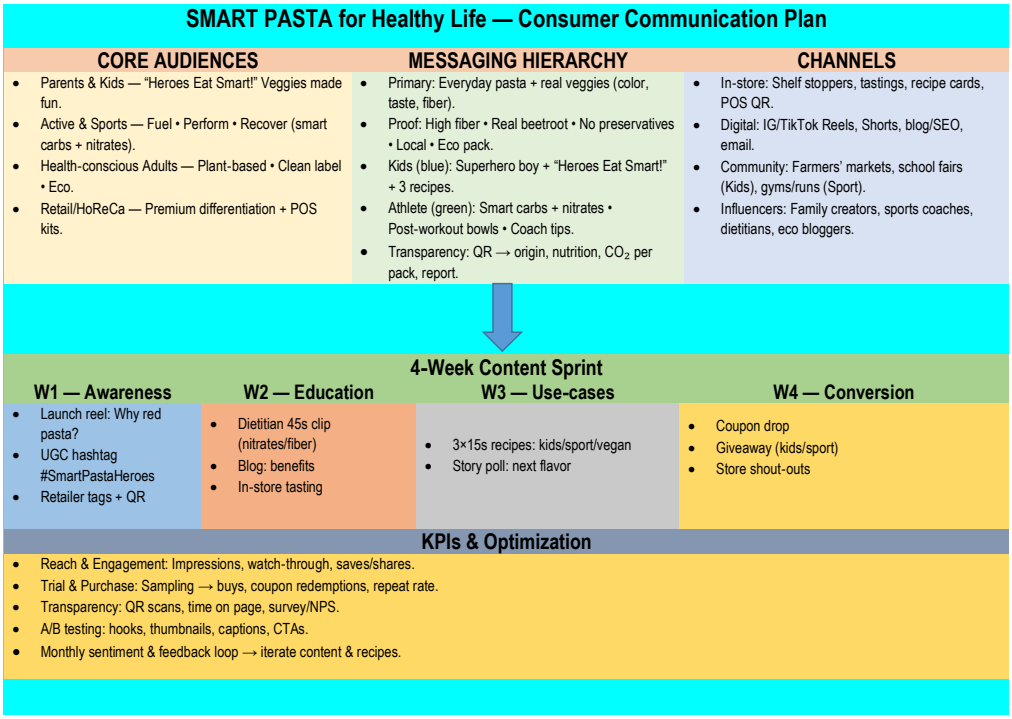

Fig. 6. Consumer communication plan

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