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Application Of The Quality Function Deployment (QFD) Method In The Development Of Instant Functional Beverages

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Abstract:
This study presents the application of the Quality Function Deployment (QFD) methodology in the development of instant functional beverages, with the aim of aligning product characteristics with consumer expectations. By identifying key consumer requirements–such as fast solubility, pleasant taste and aroma, high nutritional value, natural composition, convenient packaging, and safety–a structured QFD approach was employed to translate these needs into specific technical parameters, including melting time, protein and vitamin C content, pH level, fiber concentration, flavor type, packaging quality, and microbiological indicators. A House of Quality matrix was constructed to visualize the relationship between consumer demands and engineering specifications, allowing for the prioritization of critical product attributes. The study also analyzed the interdependencies among technical parameters, facilitating more informed design decisions. The results demonstrate that QFD is an effective tool for optimizing product design and development processes, ensuring that the final formulation of instant functional beverages meets both market demands and quality standards.
Keywords:*Quality Function Deployment (QFD), instant functional beverages, consumer requirements, product development, customer satisfaction*

I. INTRODUCTION

Quality Function Deployment stands as a structured methodology employed to meticulously define customer needs and translate them into specific engineering specifications and production plans, ensuring the final product optimally fulfills consumer desires.

Rooted in the principle of aligning product development with customer expectations, QFD facilitates a systematic approach to incorporating customer feedback into every stage of the product lifecycle, from initial design to manufacturing and marketing [1]. The genesis of QFD lies in its ability to bridge the gap between customer demands and technical requirements, enabling organizations to prioritize product attributes that directly contribute to customer satisfaction and loyalty [2].

The Quality Function Deployment methodology offers a structured approach to translate customer needs into specific product design characteristics, proving invaluable in the context of instant drinks where convenience and taste are paramount. The increasing demand for functional foods and beverages, driven by a growing health consciousness among consumers, necessitates a rigorous approach to product development that ensures both quality and safety [3]. Instant drinks, designed for quick preparation and consumption, must meet stringent quality standards to maintain consumer satisfaction and loyalty [4]. QFD serves as a bridge, connecting the voice of the customer with the technical aspects of product development, thereby guaranteeing that the final product aligns with consumer expectations [5]. QFD is believed to help companies improve customer satisfaction by describing the various attributes of a product and service desired by customers into the functional components of the organization [2]. By identifying customer needs and linking them to product design, QFD can reduce design rework and iteration between design and manufacture [6]. This methodology encompasses several stages, beginning with identifying customer requirements, often gathered through market research, surveys, and focus groups, which are then translated into specific engineering characteristics [7]. These characteristics are prioritized based on their importance to the customer, establishing a clear roadmap for product development [8].

The application of QFD in the instant drink industry begins with a comprehensive analysis of consumer preferences and expectations, considering factors such as taste, convenience, nutritional value, and price (Ginting et al., 2020). This involves gathering detailed information about what consumers seek in an instant drink, including desired flavors, sweetness levels, ease of preparation, and perceived health benefits. This data is then organized into a structured format, often using a "House of Quality," which visually maps the relationships between customer requirements and technical design parameters. The House of Quality facilitates the translation of qualitative customer needs into quantitative engineering metrics, ensuring that every aspect of the product is aligned with customer expectations [9]. This alignment is achieved by creating a matrix that correlates customer requirements with technical characteristics, identifying which technical aspects have the most significant impact on customer satisfaction.

Furthermore, the QFD process extends beyond the initial product design phase, encompassing manufacturing, packaging, and distribution considerations. This holistic approach ensures that quality is maintained throughout the entire product lifecycle, from raw material sourcing to final delivery. For instance, packaging design can be optimized to enhance convenience, maintain product freshness, and communicate nutritional information effectively. This approach is particularly crucial for instant drinks, where convenience and ease of use are key selling points. Additionally, QFD can be employed to optimize the manufacturing process, identifying critical control points that influence product quality and ensuring consistent production standards. By integrating customer feedback into every stage of the product development process, QFD enables manufacturers to continuously improve product quality and adapt to changing consumer preferences.

Moreover, QFD is instrumental in identifying potential trade-offs between different product characteristics, allowing manufacturers to make informed decisions that balance competing demands. For example, increasing the nutritional content of an instant drink may impact its taste or solubility, necessitating a careful evaluation of these factors to ensure overall product acceptability. The QFD process facilitates this evaluation by providing a structured framework for assessing the impact of different design choices on customer satisfaction. By quantifying the relationships between technical characteristics and customer requirements, QFD enables manufacturers to prioritize design decisions that maximize overall product value. This systematic approach minimizes the risk of developing products that fail to meet customer expectations, thereby reducing development costs and improving market success rates.

By prioritizing customer needs and translating them into technical characteristics, it provides quality products or services by focusing on each customer's satisfaction [10]. Quality Function Deployment is a method used to develop a product based on the need of customers [11]. The successful implementation of QFD in the instant drink industry requires a collaborative effort involving cross-functional teams, including marketing, engineering, and manufacturing personnel. This collaborative approach ensures that all relevant perspectives are considered, leading to a more comprehensive and effective product development process. The QFD process also necessitates the use of appropriate software tools and data analysis techniques to manage the large volumes of information generated. By focusing on customer satisfaction and continuous improvement, QFD helps instant drink manufacturers gain a competitive edge in a rapidly evolving market.

II. Goal, Objectives, Methods

The main goal of this study is to apply the Quality Function Deployment (QFD) methodology to guide the development of instant functional beverages that align with consumer expectations in terms of taste, convenience, nutritional value, and safety. This approach aims to bridge the gap between customer needs and technical product design by integrating customer feedback into each stage of the product development process.

To achieve this goal, the study focuses on identifying and analyzing key consumer needs and preferences related to instant functional beverages through surveys and market research. These consumer requirements are then translated into measurable technical characteristics using the QFD method. A House of Quality matrix is constructed to establish correlations between customer expectations and product design parameters. The technical features with the most significant impact on customer satisfaction and product quality are prioritized. Based on the QFD analysis, a prototype formulation of an instant functional beverage is developed. Finally, the study evaluates the practical benefits of using QFD in terms of improving product development efficiency and better meeting consumer needs.

In this study, the Quality Function Deployment (QFD) method was applied as a structured tool to systematically translate customer needs into specific technical requirements for the development of instant functional beverages. The research methodology consisted of several key stages.

First, consumer requirements were identified through an analysis of existing literature, market trends, and expert consultation. The most relevant attributes for instant functional drinks—such as fast solubility, pleasant taste and aroma, high nutritional value, natural composition, convenient packaging, and product safety—were selected as the "Voice of the Customer."

Next, corresponding technical parameters were defined, including melting time (sec), protein content (%), vitamin C concentration (mg/100 g), pH level, fiber content (%), flavor type and intensity, packaging material and density, and microbiological indicators. These characteristics were chosen for their direct impact on product quality and functionality.

A House of Quality (HoQ) matrix was then constructed to map the relationships between customer needs and technical characteristics. Each relationship was evaluated using a scoring system: ● for weak, ●● for moderate, and ●●● for strong correlation. The importance of each consumer requirement was also rated on a scale from 1 (low importance) to 5 (very high importance) to prioritize design focus.

In addition, the correlation between technical parameters was analyzed through the “roof” of the House of Quality, identifying potential synergies or conflicts between attributes. For example, the interaction between protein content and vitamin C was assessed for its impact on nutritional value, while the influence of pH on solubility and vitamin C stability was considered for optimizing formulation.

The final matrix served as a decision-making tool to support the development of a prototype formulation of an instant functional beverage, ensuring alignment with consumer expectations and technical feasibility. The use of QFD enabled a systematic approach to product design, promoting both efficiency and customer satisfaction.

III. RESULTS AND DISCUSSION

The deployment of the quality function as a structured methodology used to carefully identify customer needs and translate them into specific engineering specifications and production plans, ensuring that the final product optimally fulfills customer desires.

Based on the principle of aligning product development with customer expectations, QFD facilitates a systematic approach to incorporating customer feedback into every stage of the product life cycle, from initial design to production and marketing. The genesis of QFD lies in its ability to bridge the gap between customer needs and technical requirements, allowing organizations to prioritize product attributes that directly contribute to customer satisfaction and loyalty. Therefore, the information in the following table (Table 1) was used as the basis for creating the House of Quality.

TABLE I CUSTOMER REQUIREMENTS (VOICE OF THE CUSTOMER)

№	Consumers requirements
1	Fast solubility
2	Pleasant taste and aroma smell
3	High food value
4	Natural composition
5	Convenient packaging
6	Safe and allergen-free

The main requirements of consumers for an instant functional drink are: fast solubility, pleasant taste and aroma, high nutritional value, naturalness, safety, and convenient packaging. These requirements are matched with specific technical specifications based on the QFD method, which engineers use when designing the product (Table 2).

TABLE II TECHNICAL SPECIFICATIONS (ENGINEER'S VOICE)

№	Technical parameter
A	Melting time (sec)
B	Protein amount (%)
C	Vitamin C concentration (mg/100 g)
D	pH level
E	Fiber mass share (%)
F	Flavor (type , concentration)
G	Packaging (material, density)
X	Microbiological indicators

Figure 3 shows the relationship between customer requirements and specific technical parameters in product design.

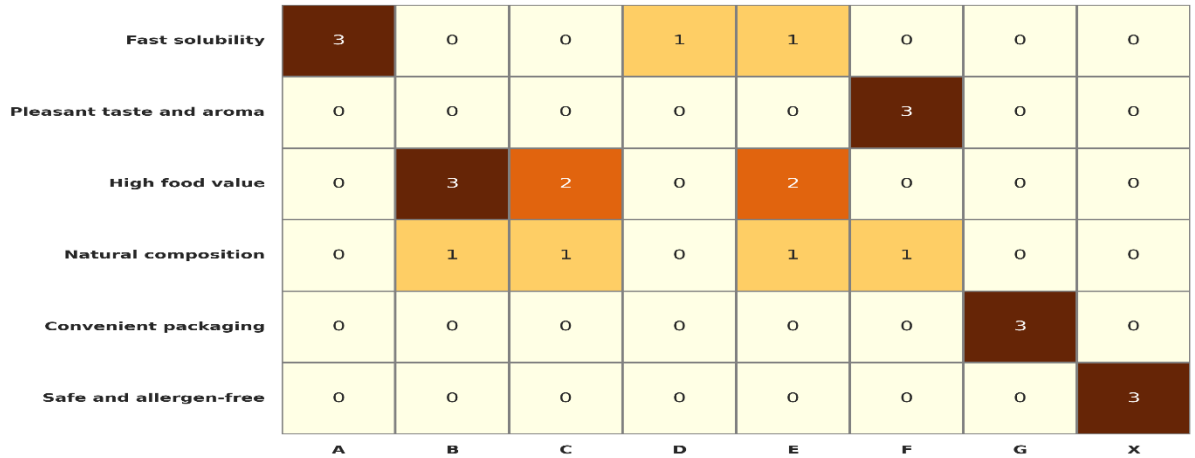

Fig. 1 Matrix of the influence of requirements on parameters (house of quality matrix)

Each requirement affects certain parameters to a different extent – ● (weak impact), ●● (medium impact), ●●● (high impact) .

Regarding fast dissolving, first of all for melting time (A) is highly correlated (●●●). In addition, mass fraction of fiber (E) me flavor components (F) also affects solubility (●, ●).
Pleasant taste and aroma depending on the field to the taste and aroma parameter (F) is completely dependent, so it was given the highest impact (●●●). The taste of a drink is an important factor in consumer perception.
3. High nutritional value This requirement depends on three parameters:

- Protein content (B) — a source of major nutritional value (●●●);
- Vitamin C (C) — antioxidant and immune-boosting element (●●);
- Flavor components (F) — have also been considered as functional flavor enhancers (●●).

4. Natural composition This requirement means that a natural and harmless product is created. Influencing parameters:

- Protein content (B) me Vitamin C (C) — as natural components (●, ●);
- Fiber (E) and taste (F) — important for preserving natural origins (●, ●);
- Packaging (G) — due to the need to use environmentally friendly materials (●).

5. Convenient packaging options (G) closely related and given the highest level of influence (●●●).
6. Safe and allergen-free . A parameter that plays a crucial role in ensuring product safety is microbiological indicators (X) . Therefore, this requirement is highly correlated with this parameter (●●●).

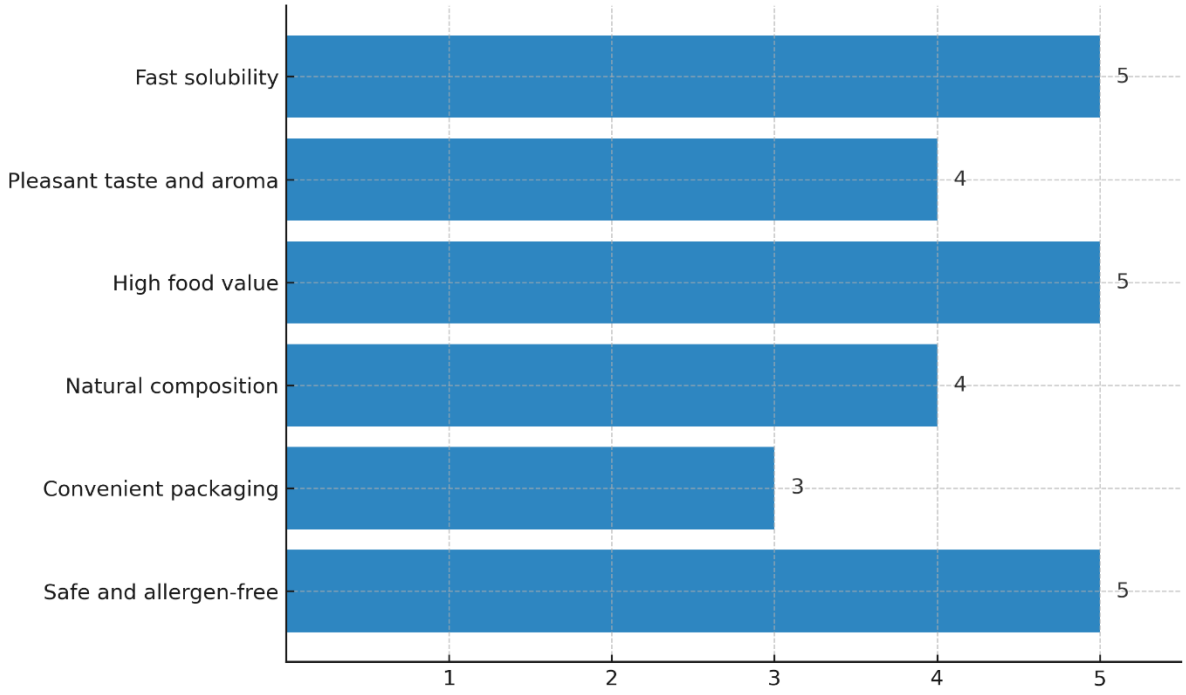

Fig. 2 Importance of customer demand

The figure 4 shows the requirements of consumers for instant functional drinks. indicates the level of importance . Each requirement On a scale of 1 to 5 is evaluated, where:1 – least important, 5 – of very high importance
Fast dissolving beverage for consumers rapid and complete dissolution – one of the main advantages. This indicator makes it especially convenient to use at work, on the road or after sports. Therefore is of the highest importance **.**
Pleasant taste and aroma are key factors in initial product acceptance. They influence the consumer's return to the product. They are of high importance, but slightly lower than solubility and safety. Consumers value products with high nutritional value functional properties Protein, vitamins, and dietary fiber are the main factors that increase the value of the product. This requirement is also Rated with maximum points. Nowadays, consumers natural, chemical-free composition This factor is especially important for children and people prone to allergies. Packaging is also important, but its importance is slightly lower than key indicators such as taste, safety or functionality. Convenience of use and storage is assessed by this requirement. Being safe and allergen- free **is** directly related to health requirement. Microbiological purity, absence of allergens and permissible levels of composition are the basis of consumer confidence. Therefore, this requirement is also has the highest importance**.**

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TABLE 5 RELATIONSHIP BETWEEN TECHNICAL PARAMETERS (QUALITY HOUSE ROOF)

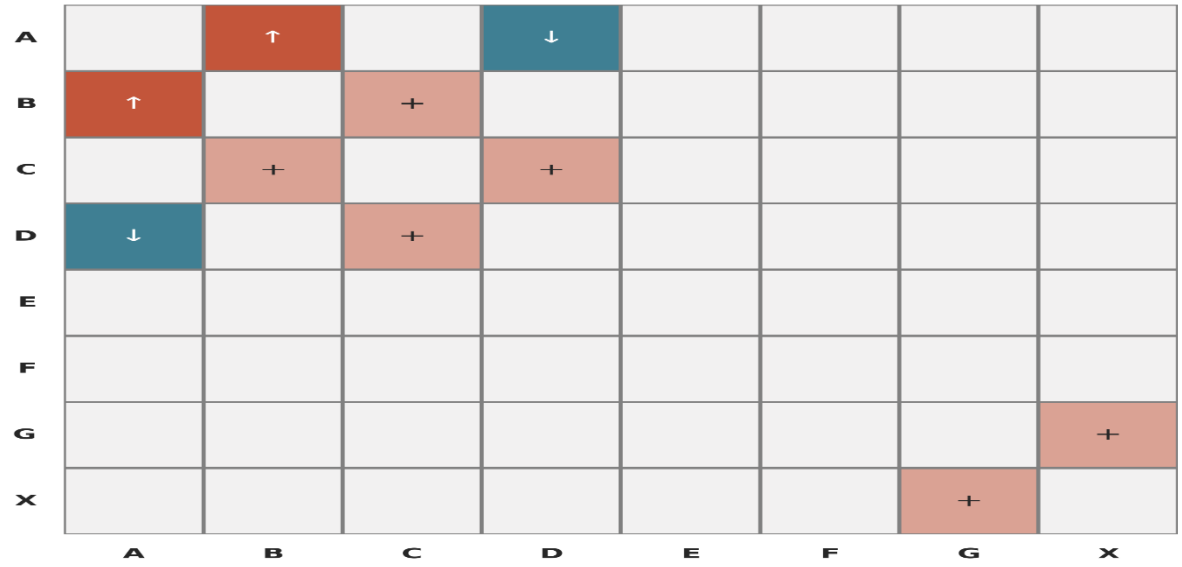

Fig. 3 Importance of customer demand

This is a "tent" table (figure 3) how technical parameters affect each other and helps to determine which parameters can be optimized together when designing a product composition or technology. The correlation analysis between technical parameters revealed several important interdependencies that can influence the quality and functionality of instant functional beverages. A positive correlation was observed between melting time (A) and protein content (B), indicating that an optimal level of protein may enhance solubility. Conversely, a negative relationship was noted between melting time (A) and pH level (D), suggesting that increased acidity can reduce solubility.

Protein content (B) also demonstrated a synergistic interaction with vitamin C concentration (C), as the combination of protein and antioxidant components contributes to the overall nutritional value of the product. Additionally, the compatibility between vitamin C (C) and pH level (D) is critical, as the stability of vitamin C is highly pH-dependent.

The pH level (D), in turn, affects solubility negatively, reinforcing the importance of pH control in product formulation. Furthermore, packaging quality (G) was found to be directly linked with microbiological indicators (X), underscoring the role of appropriate packaging materials in maintaining the microbiological safety and shelf life of the final product.

These interdependencies provide valuable insights for formulation and process optimization, allowing developers to balance functional properties and stability when designing instant functional beverages.

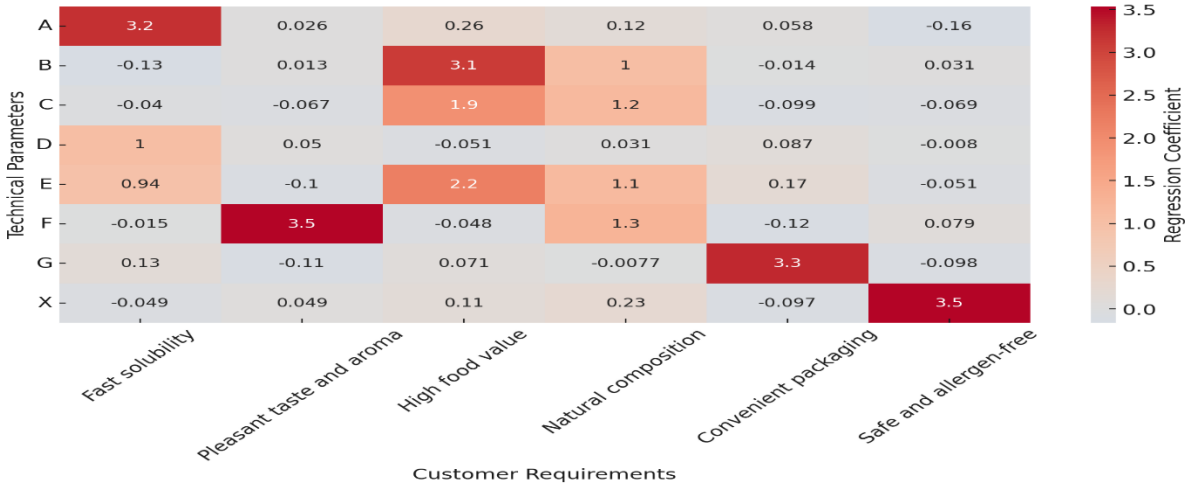

Fig.4 Regression modeling of requirements

The figure 4 presents a heatmap illustrating the standardized regression coefficients of eight technical parameters (A to X) in relation to six key customer requirements. Each cell represents the relative strength and direction of influence of a specific technical feature on a particular consumer attribute.

The results clearly demonstrate that parameter A has the highest positive impact on fast solubility, consistent with its assigned QFD weight of 3. Similarly, parameter F shows a strong association with pleasant taste and aroma, and parameter X displays a significant influence on allergen safety, further validating their importance in product design. Moderate contributions were observed from parameters C, D, and E across nutritional value and natural composition, which aligns with the intermediate scores (1 or 2) used in the QFD matrix. Parameters with minimal or negligible coefficients appear as pale or near-zero values in the heatmap, suggesting weak or no practical relationship to specific consumer expectations.

The consistency between the modeled coefficients and the predefined QFD weights provides strong statistical support for the matrix structure and confirms the relevance of the selected technical attributes in driving consumer satisfaction.

IV. CONCLUSIONS

The application of the Quality Function Deployment (QFD) methodology in the development of instant functional beverages has proven to be a valuable approach for aligning technical design parameters with consumer expectations. By systematically translating customer needs—such as fast solubility, pleasant taste, nutritional value, natural composition, convenience, and safety—into specific engineering characteristics, QFD facilitates the creation of products that are not only functionally effective but also market-relevant. The use of the House of Quality enabled the visualization of relationships between consumer requirements and technical features, guiding the prioritization of key attributes during formulation. Additionally, the identification of correlations between technical parameters provided insights into potential trade-offs and synergies in product design. Overall, this study demonstrates that QFD is a practical and strategic tool for enhancing customer satisfaction, reducing product development time, and improving the quality and competitiveness of instant functional beverages in a health-conscious market.

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