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IMPROVING THE QUALITY OF PRODUCTS IN FOOD INDUSTRY. APPLICATION OF QUALITY FUNCTION DEVELOPMENT METHODOLOGY FOR CHICKEN LIVER PÂTÉ

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Abstract

Quality Function Development (QFD) is a systematic approach specific to quality management that facilitates product development by ensuring consumer requirements meeting "customer voice", these being taken into account from the design phase, then during the entire technological process, being reflected in the quality characteristics of the finished product. The purpose of this study was to apply the QFD methodology to improve the quality of products in the food industry, taking into account the technological process of chicken liver pâté (designing a new product that meets the requirements of consumers), thus providing a synthetic model. The working method consisted in the participation of a number of 250 consumers, aged between 20-24 years, who provided the list of consumer requirements, prioritizing and weighting them based on a standardized score from 1 to 5 points. The following stages were represented by the transposition of consumers' voice in quantifiable technical requirements, their correlation using predefined symbols, establishing the direction of improving the quality of the new product, assessing current competition and determination of target values. Following the analysis, the most important consumer requirements for chicken liver pâté were: the taste (15.63%), the smell (15.63%), the appearance/ color (15.63%), the small amount of saturated lipids/ without added lard (12.5%), the fine texture and spreadable (12.5%), without synthetic colorants and preservatives (12.5%), good price (9.37) and without flavor enhancers (6.24%). Thus, in order to meet consumer requirements, the replacement of sodium nitrite with turmeric powder (Curcuma longa L.), as alternative natural colorant and preservatives (curcumin the principal bioactive substance of turmeric) led to a healthy product, but which will have a higher price compared to the products currently available on the market. However, applying the level II/ III of QFD methodology the low cost was provided by mitigation of price of raw material's.

Key words*: chicken liver pâté, Quality Function Development.*

INTRODUCTION

In the last years, traditional meat-based products were the target of the food industry for innovation and improved products development. This trend is consistent with recent concerns about the consumption of these products due to their high saturated fat content, which is linked with disorders such as heart, diseases, cancers and obesity (Bis-Souza et al., 2019; Martins et al., 2020). The meat industry is paying attention to those strategies that aim to change the fat source to promote healthier dietary intake (Paglarini et al., 2022). However, despite the pâté being a popular food in many countries, its components, specially backfat, provide a caloric product with high saturated fatty acids (SFA). Consequently, these types of products are questioned by government agencies and consumers (Domínguez et al., 2017; Marin et al., 2019). Therefore, with the purpose to encourage the consumption of this product, the lipid profile improvement (lower SFA and high of PUFA) of pâté emerged as a promising approach to obtain a healthier product (Vargas-Ramella et al., 2022).

Pâté is a homogenized food product with a predominant content of meat or liver, the manufacturing being based on combining of various types of ingredients and methods of their processing (boiling, blanching, sautéing, frying, homogenization etc.) depending on the recipe (Marudova et al., 2018; Kabdylzhar et al., 2022). The composition of meat pâté can provide a significant impact on their nutritional characteristics with a wide variety of recipes, where chicken offal is added, that are sold on the world market. Chicken pâté are becoming more and more popular due to the increase in the global production of poultry meat; the production of by-products obtained after the poultry slaughter is increasing simultaneously

(Mokrejs et al., 2017; Carpes et al., 2020; Mielnik et al., 2002; Singh et al., 2013; Biswas et al., 2007).

Many companies compete to create new products that can speed up their marketing time. A commonly used method for product management is QFD (Rujito et al., 2020). Its double purpose is to ensure that the true needs of customers are properly developed and implemented throughout the design, "construction" and delivery of a new product, whether assembled, processed, maintained or even software, and to improve the product development process itself (Akao & Mazur, 2003). QFD is a comprehensive quality system that aims primarily at customer satisfaction (Pop et al., 2020). Since 2015, the QFD methodology has been transposed into the international standard (ISO 16355), which includes eight parts structured in several editions, the latest from 2021, and others that are still in progress, making QFD much more credible and practical. Conventional QFD consists of the following four phases (Sayadi et al., 2017; Dvoryaninova et al., 2020; Isharyani et al., 2019):

1. the first stage translates the marketing requirements into technical attributes;
2. the second phase translates the technical attributes into the characteristics of the parts;
3. the third phase transposes the characteristics of the part into manufacturing operations;
4. the fourth phase translates the manufacturing operations into production requirements.

The main planning tool used in QFD is the Quality House (HoQ). HoQ is a house-shaped matrix that connects the customer's wishes (WHAT?) and how the product will be designed and made to meet the customer's wishes (HOW?).

The purpose of this study was to apply the QFD methodology to improve the quality of products in the food industry, taking into account the technological process of chicken liver pâté (designing a new product that meets the requirements of consumers increasingly informed and more concerned about nutrition and health), thus providing a synthetic model. In this study, the replacement of carmine and of sodium nitrite or other food colorants and preservatives with turmeric was the novelty for technological production of liver pâté. Turmeric is a natural antiseptic. Due to its extra-ordinary molecular structure it shows strong anti-oxidative, as well as anti-inflammatory properties. It is extensively used for imparting color and flavor to the food. In traditional medicine, turmeric is used to treat a wide variety of diseases (Dada Khalandar et al., 2018). The active component of turmeric, a common Indian spice, which is derived from the dried rhizome of the *Curcuma longa* (a member of the *Zingiberaceae* family plant) is curcumin, a yellow substance belonging to the polyphenols superfamily. Numerous studies have demonstrated that curcumin possesses anti-oxidant, anti-inflammatory and anticancerous properties. Curcumin and its analogues have been demonstrated to possess various anticancer properties in a series of cancer cell lines, such as pancreatic, lung, ovarian, oral, colorectal, breast carcinoma and even in melanoma cells. In the future, further research will certain or not the potential of curcumin analogues as effective chemotherapy agents (Vallianou et al., 2015).

MATERIALS AND METHODS

The methodology consisted in the participation of a number of 250 chicken liver pâté consumers, aged between 20-24 years (students from three different Food Engineering specialties', because the QFD methodology recommends the use of multidisciplinary work teams), which provided the list of consumer requirements, prioritizing and weighting them based on a score from 1 to 5. The next steps were to transpose consumers' voice into quantifiable technical requirements (design requirements), establishing measurement units for each requirement, correlating them to "the roof" of HoQ to identify possible technological problems, establishing the relationship between technical measures and the customer's voice using pre-defined symbols, establishing the direction to improve the quality of the new product (which are technical criteria that require a decrease or increase to meet customer requirements), the *Benchmarking*-assessment of current competition (establishing the strengths and weaknesses of the newly designed product, X) and determining the target values (which need to be improved). Next stapes for the level II and III of QFD methodology are: exploring the product and processes alternative, selecting

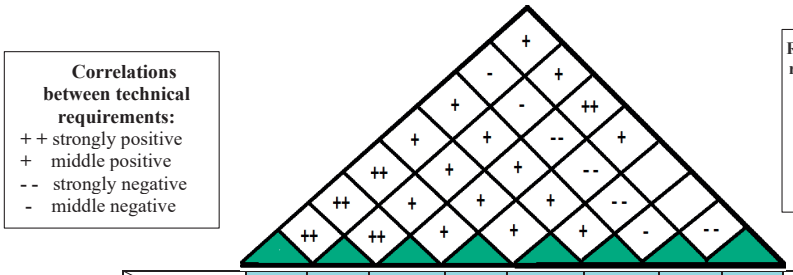
the best alternative after application of process flowchart with the parameters, the CPs, the CCPs and the critical limits established for each stage of the chicken liver pâté.

RESULTS AND DISCUSSIONS

The consumers are increasingly informed and more concerned about health and nutrition.
The consumer's requirements (Figure 1), were mainly represented by the sensory properties *(good taste; pleasant, characteristic smell; appearance/color; fine texture and spreadable)*, nutritional quality from the perspective of the positive/negative influences on the consumer's health after ingesting the product *(small amount of saturated fat/ without added lard; without synthetic colorants and preservatives; without flavour enhancers)* and its price.
The "customer's voice"/consumer requirements (WHAT?) was translated practically in technical criteria with related measure units (HOW?):

- % of liver, onion, salt;
- % of liver and spices;
- % of liver, turmeric, paprika;
- % walnuts oil;
- sieve diameter (Ø=2mm), % of liver broth;
- % turmeric, paprika and salt;
- Low Production cost (RON);
- % of protein, liver, spices, oil.

To meet these requirements, a new product has been designed, with a higher proportion of liver (72%) compared with current option of Romanian market (between 20÷45% liver), innovative in terms of ingredients traditionally added to chicken liver pâté manufacturing technology (Figure 2), replacing the chicken skin/saturated fats with walnut's oil, the food dye (carmine) and preservative (sodium nitrite) with turmeric and paprika; alongside, the flavour enhancers were eliminated also by the use of a higher proportion of liver (72%).
Predetermined symbols are used to highlight the relations between the customer's voice and quantifiable technical measures (WHAT vs. HOW?) placed in the cell located at the intersection of each row vs. column.
At the level of the "foundation" of the HoQ, the higher the values obtained, the more important those characteristics are (the good taste and without flavor enhancers (both with 16%) and very close the pleasant/characteristic smell (15.9%) and the appearance/colour (15.5%) and without synthetic colorants and preservatives (10.8%) because there are strong correlations between the ingredients of chicken liver pâté and the specific parameters/ technical criteria of the stage of technological flow (HOW MUCH?).
The results from the first house (HoQ 1. product planning) are further used in the following matrices specific to the QFD methodology (level II/III process design).
The room on the right side of the HoQ is the assessment of current competition (*Benchmarking*) used to measure the success of the newly designed product that competes with those on the market; thus a scale from 1 to 5 is used for the assessment (1 indicates a requirement that is not met and 5 indicates a requirement that is fully met). By averaging the numbers in each column, depending on the score obtained, a measure of the degree of customer satisfaction for each product under study is obtained.
Following the comparative analysis of the newly designed X product, with products of five competing companies (*Ardealul, Bucegi, Capricii și delicii, Sadu, Scandia Sibiu* randomly coded with A, B, C, D and E), a good position of product X was obtained (36 points), compared to the current competitors (20 points for product C, 21 points for product A and B, 27 points for product E, respectively 30 points for product D); the weaknesses being represented by the price of the product. This score from *Benchmarking* reflects a concrete/quantifiable customer requirements satisfaction.
The determination of target values is based on the values established by the evaluation of competing products and product X, establishing strategies to maintain strengths and improve weaknesses.
The strengths of product X are transposed into the technical criteria represented by the elimination of saturated fat/ added lard, of flavor enhancers, synthetic colorants and preservatives from the ingredients vs. use of carefully selected quality of chicken liver, walnuts oil, turmeric and paprika from controlled origin, certified with quality standards (with declaration of conformities and analysis bulletin from the stage of qualitative reception).



Technical requirements (HOW?) / (WHAT?) Consumer requirements	Importance 1-5	Importance %	Improvement direction ⇧ % of liver, onion, salt, pepper	⇧ % of liver and spices	⇧ % of liver, turmeric, paprika	⇩ % walnut oil	⇩ sieve Ø, % meat broth	⇧ % turmeric, paprika and salt	⇩ Production cost (RON)	⇧ % of protein, liver, spices, oil	Benchmarking NEW PRODUCT= X 1p	2p	3p	4p	5p
Good taste	5	15.63	●	●	●	O	▽	●	O	●		A, B	C, E	D	X
Pleasant smell	5	15.63	O	●	O	▽	▽	O	▽	●		A, B	C	E	D,X
Appearance/ colour	5	15.63	●	●	●	▽	O	O	▽	O		B	A, C	D,E	X
Small amount of saturated fat	4	12.5	O	▽	▽	●	●	-	O	●		B, A	C,E	D	X
Fine texture and spreadable	4	12.5	●	O	O	▽	●	▽	O	O		C	A,D	E	X,B
Without colorants and preservatives	4	12.5	O	O	●	-	▽	●	●	O	A,C	B	E	D	X
Good price	3	9.37	●	●	●	●	O	O	●	●	X	D	C, E	B	A
Without flavour enhancers	2	6.24	●	●	●	▽	O	●	●	●		B, C	A, E	D	X
	32	100%	656	650	631	293	363	444	406	656	=4099				
		%	**16**	**15.9**	**15.5**	**7.1**	**8.8**	**10.8**	**9.9**	**16**	100%				

Figure 1. House of Quality (HoQ) for chicken liver pâté

⇧=*parameter increase*; ⇩=*parameter decrease*

The ingredients of the products under the study was:

1. For product A: water, chicken liver 20% (EU origin), chicken meat, chicken skin, sunflower vegetable oil, palm vegetable oil, soy vegetable protein, potato starch, poultry animal protein, wheat starch, sugar, salt, onion, tomato paste, spices, extract of yeast.
2. For product B: chicken liver 20% (origin: EU), water, chicken meat, sunflower oil, soy protein, iodized salt, sugar, onions, white wheat flour, spices, dextrose, emulsifiers: monoglycerides and diglycerides of fatty acids, stabilizers: sodium diphosphates and triphosphates, yeast extract, thickening agent: xanthan gum, aroma, colouring: carmine, preservative: sodium nitrite.
3. For product C: chicken liver (20%), water, poultry meat, non-hydrogenated sunflower vegetable oil, soy vegetable protein, corn starch, iodized salt, sugar, onions, spices, dye: carmine, preservative: sodium nitrite.
4. For product D: chicken liver 45%, water, vegetable oil, salt, onion, spices and spice extract (paprika, pepper, mustard, thyme, coriander, rosemary), flavor enhancer (yeast extract).
5. For product E: chicken liver (20%), chicken meat, vegetable oil, non-hydrogenated sunflower, soy protein, water, iodized salt, sugar, corn-starch, sour cream powder, milk powder, onion, spices, garlic.
6. For product X: liver 72%, onion, water, walnut oil, pepper, nutmeg, ***turmeric***, paprika and salt.

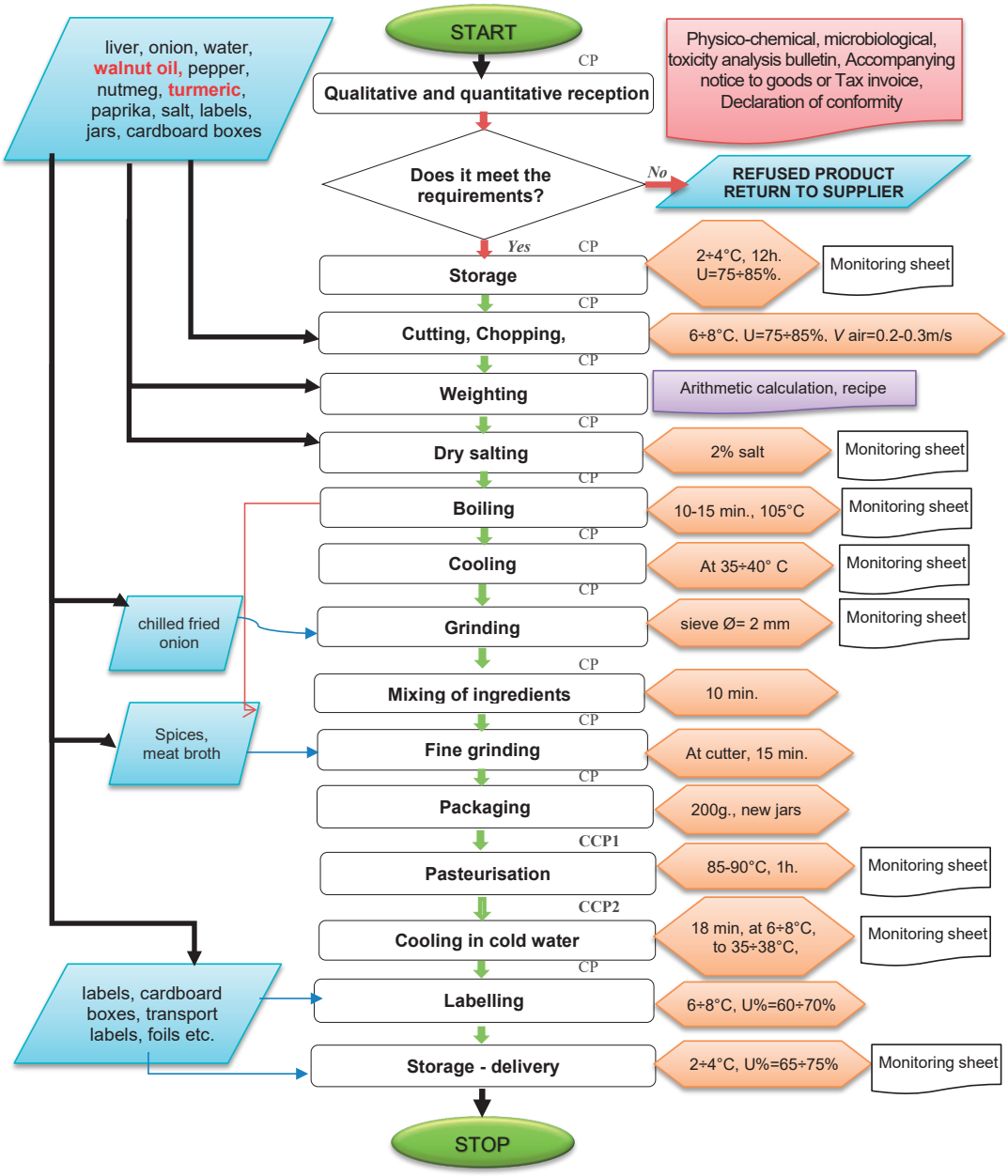


Figure 2. The flowchart for the new design product (*chicken liver pâté*, X product)

For maintaining the quality characteristics of new X product/chicken liver pâté, the technological parameter and monitoring sheet will be periodically checked and completed by the qualified and trained human resources. Next stapes for the level II and III of QFD methodology are: exploring the product and processes new solution, selecting the best alternative after application of process flowchart with the parameters, the CPs, the CCPs and the critical limits previously established for each stage of the chicken liver pâté technology (Figure 3).

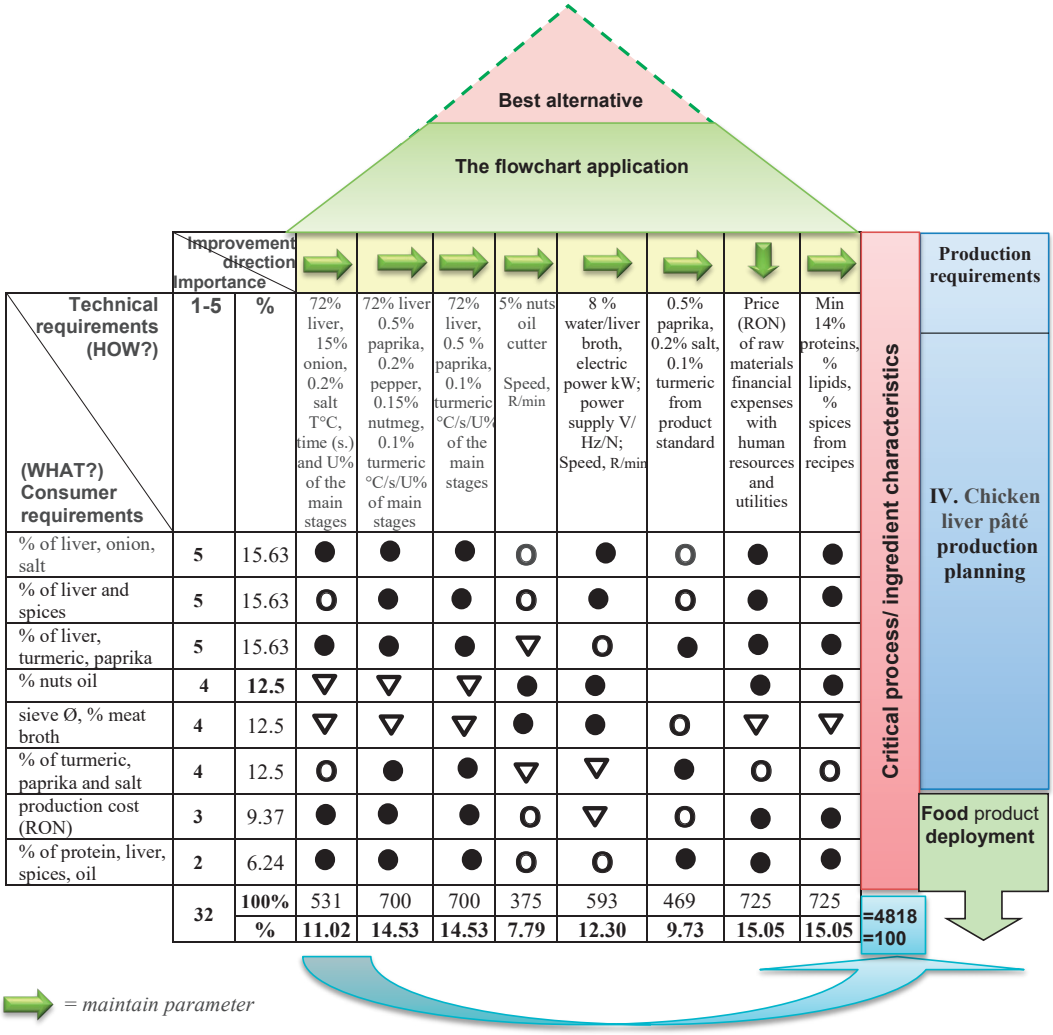


Figure 3. QFD matrix level II/ III and IV, design requirements for identify key design characteristics of chicken liver pâté, synthesis

The most important relation was found for production cost (RON) and of protein content, liver, spices and oil proportion/*without flavour enhancers* (15.5% for booth), followed by the proportion of liver and spices/*pleasant smell* and turmeric and paprika/*appearance-colour* (14.53% for booth).

Critical process- ingredient characteristics/ the proportion of ingredients for the voice of consumer satisfaction were represented by: 72% liver, 15% onion, 8 % water/liver broth, 5% walnuts oil, 0.5% paprika, 0.2% salt, 0.2% pepper, 0.15% nutmeg, 0.1% turmeric (from product standard/recipe's); temperatures/T°C,

time (s) and humidity/(U%) of the main stages; electric power kW; power supply V/Hz/N; Speed, R/min for grinding machine; Cutter Speed, R/min; Price (RON) of raw materials; financial expenses with human resources and utilities; minimum 14% proteins, the proportion of lipids and spices from recipes.

Maintaining and improving the critical parameters (after several attempts in production) ensures the success of the sale and the high profit obtained for the new design product (X product).

CONCLUSIONS

In order to meet consumer requirements, the replacement of sodium nitrite with turmeric powder (*Curcuma longa* L.), as alternative natural colorant and preservatives, led to a healthy product, but which will have a higher price compared to the products currently available on the market. However, applying the level II/ III of QFD methodology the low cost was provided by mitigation of price of raw material's.

What should be noted in the QFD methodology applied to the food industry (and of particular importance) are the inter-correlations between the ingredients and processes (that cannot be considered separately), with the influence on the quality characteristics specific to the finished product obtained.

The correct management of the technological processes, of the parameters related to each technological stage, respectively of the critical limits and the compliance of the technical specifications are the key elements that lead to the satisfaction of the consumers' requirements and to the improvement of the quality of the finished products.

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