

## ***HaliTeddies*: A Vegan Gummy Bear to Inhibit Halitosis Using Carnosic Acid Extracted from Rosemary**

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### **Abstract**

*HaliTeddies* are made of carnosic acid present in rosemary and aim to inhibit the action of halitosis causing bacteria. A need for this product was identified due to the mandatory use of facial masks because of COVID-19, which has had a negative outcome when it comes to breathe malodour. A vegan gummy bear product was selected as the best idea to satisfy this need since it is an appealing approach for a younger audience of 15- to 49-year-olds. The strategy for production includes rosemary being bought from a national producer, whereas extraction of the active principle, production, and packaging is done at the production facilities. Lastly, an economic analysis has shown that this project requires an investment of 7 M€. The product would be sold at pharmacies at a retail price of 11.99 €. This analysis has shown that *HaliTeddies* may be considered to be a profitable and viable business.

**Author Keywords.** Rosemary. Vegan. Gummy-bears. Halitosis. Carnosic Acid.

**Type:** Research Article

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### **1. Introduction**

Sustainability and environmental responsibility play an increasingly important role in consumer awareness ([Yadav et al. 2019](#)). Nowadays, clients demand transparency when purchasing a product. Plant-based and natural ingredients, responsible production, and country-origin of the product are some of the concerning factors.

Another aspect of modern customer silhouette is their propensity to buy national or local products. The importance of the product's country of origin has increased over the past decade since today's consumer looks for authenticity in the products they buy ([Kim and Huang 2021](#)). Hence, this new generation of customers focuses not only on the

product itself and its performance but also on eco-composition, the promise to be environmentally friendly, and improving the national economy (Khan and Mohsin 2017).

The global COVID-19 pandemic has influenced the entire population as over 105 million cases were confirmed worldwide (data on February 1, 2021) (WHO 2021). Therefore, a different reality has settled, new complications emerged, and different needs have risen. As the face mask became a mandatory accessory in almost every country, especially in Europe, an existing problem that used to go unnoticed was uncovered. Many people felt bothered by their breath malodour, which worsened due to the daily usage of these masks as they enhance risk factors for an increased anaerobic bacterial load.

*Streptococcus sanguinis* (*S. sanguinis*) and *Streptococcus mitis* (*S. mitis*) bacteria can be one of the causes of this emerging issue. They produce volatile sulphur compounds (VSCs) such as hydrogen sulfide, ethyl mercaptan, and methyl mercaptan, which have a pungent odour (Yanti, Juniardi, and Lay 2019). The action of these bacteria can be suppressed with carnosic acid. This compound is a phenolic (catecholic) diterpene endowed with antioxidative and antimicrobial properties (Birtić et al. 2015). Carnosic acid shows inhibitory action against the bacteria responsible for halitosis when present at the concentration of 50 µg/mL (minimum inhibitory concentration, MIC) (Bernardes et al. 2010). It can be extracted from rosemary as it is one of the phytochemicals mainly present (Ahmad Ganaie 2021).

Rosemary belongs to the mint family (*Lamiaceae*) and is native to the Mediterranean region. In Portugal, it occurs more in the south, centre, and interior of the Douro valley. This aromatic plant has a height between 1.5 to 2 meters and a strong camphor aroma. Regarding productivity, 1 acre is needed to produce 2.5 tons of dry rosemary leaves<sup>1</sup> (Vilas Boas 2020). Rosemary leaves extract can carry up to 10 % of carnosic acid (C<sub>20</sub>H<sub>28</sub>O<sub>4</sub>, M<sub>w</sub> = 332.4 g/mol) (Nakagawa, Hillebrand, and Nunez 2020). At room temperature, the isolated compound can be found as a yellow powder and soluble in organic solvents but insoluble in water (National Center for Biotechnology Information 2005).

In order to reduce the emerging problem, halitosis should be treated orally. Therefore, the product must be edible, thus being important to evaluate the oral LD50 (Median Lethal Dose) of the active principle. For rosemary leaves extract, this value is superior to 8.5 g/kg (Fiume et al. 2018); these extracts belong to the mint family, so their odor could fight halitosis. Under the Commission Regulation (EC) 1333/2008, Rosemary extract is approved as a food additive, and it established a temporary acceptable daily intake (ADI) of 0–0.3 mg/kg body weight (Younes et al. 2018).

The purpose of this article is to set forth the stages of designing a chemical product based in extracts of rosemary that meets the necessity of the market. These include a process based on Cussler and Moggridge's (2011) product development method that includes the following steps: Needs, Ideas, Selection, Manufacture, and Economic Analysis.

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<sup>1</sup>Wikifarmer, s.v. "Rendimento da planta de alecrim e do óleo essencial", accessed December 8, 2020, <https://wikifarmer.com/pt-br/rendimento-da-planta-de-alecrim-e-oleo-essencial/?fbclid=IwAR0GtJkubBmtdnJJnpmohk8giPGOOnSpPVwB841LUz7FzGkt6QpLqck5apk>.

## 2. Chemical Product Design (CPD)

To start designing the chemical product, it was important to specify customer needs for a new product that had carnosic acid as the active principle and to identify the users that would benefit from it (Cussler and Moggridge 2011). A target market with consumers having 15- to 49-year-olds, who value plant-based ingredients and care about consuming a cruelty-free product, was considered.

The needs were organized as *essential*, *desirable*, and *useful*. Essential needs are those that are crucial for the product to be successful and must be met. Desirable needs ensure the competitiveness of the product and there is an attempt to meet them. Lastly, useful needs are those that add interest to the product but may not be achieved (Cussler and Moggridge 2011). This information can be found in Table 1.

| Essential                                    | Desirable     | Useful              |
|--|---------------|---------------------|
| High efficiency in breath malodour reduction | Eco-friendly  | Nationally produced |
| Edible                                       | Long lifespan | Easy access         |

**Table 1:** Identified needs for a product that has carnosic acid as the active principle

According to the needs previously defined, the next step was to brainstorm product ideas to meet them. For breath malodour reduction, chewing gum, hard candy, and gummy bears were considered. To prepare for product manufacture, it was important to select the best idea out of the three that were mentioned.

The innovative aspect of halitosis improving gummy bears made them stand out from the other ideas. In fact, a gummy bear product that aims to satisfy the essential need of Table 1 is not yet available on the market. Furthermore, since a 15- to 49-year-old target-market was considered and this type of product is usually targeted at a younger audience, the halitosis improving gummy bears were considered the best idea to be selected for the project.

Finally, a commercial name for the product was defined. *HaliTeddies* seemed appropriate as it combines the name of the disease that causes bad breath (halitosis) with the shape of the gummies that are being developed (teddy bears).

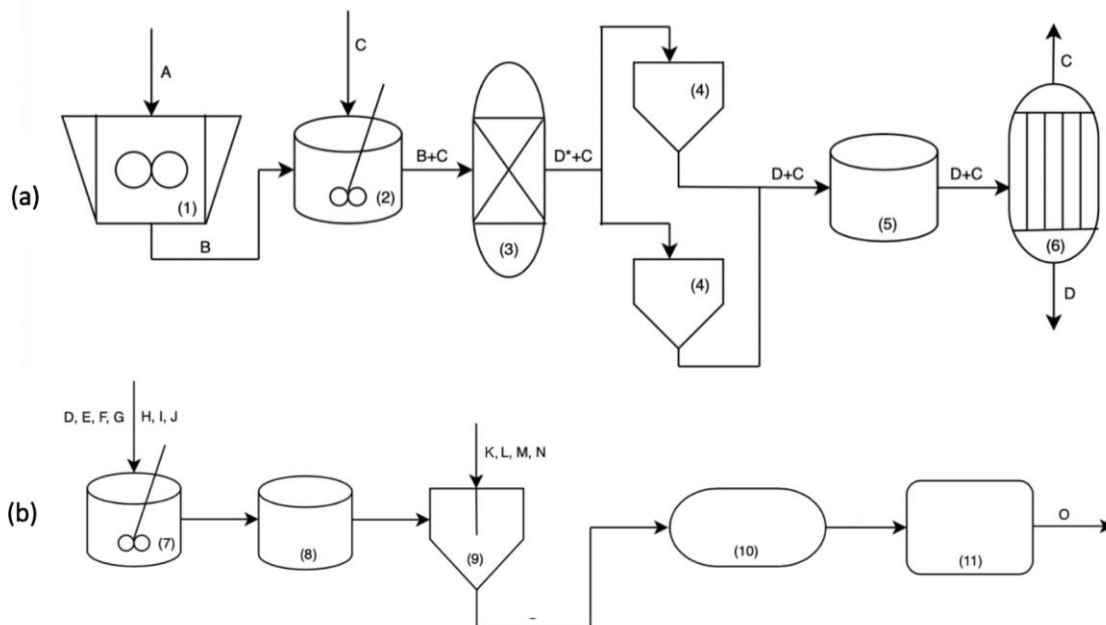
## 3. Product Manufacture

*HaliTeddies* are gummy bears that reduce breath malodour caused by *S. sanguinis* and *S. mitis*. Their active principal ingredient is carnosic acid at a concentration of 50 µg/mL (Bernardes et al. 2010). For the study case, each box of *HaliTeddies* has 30 gummy bears; each has 50 µg/mL of carnosic acid. The recommended dosage will be one gummy bear per day, and there is no specific time to consume. 50 µg/mL of carnosic acid.

This product shows no risk of intoxication, including the possibility of children ingesting the entire box of gummy bears at once. Nevertheless, *HaliTeddies* containers will have a childproof cap to avoid this situation.

### 3.1. Manufacture process

Figure 1 shows the process flowchart for the manufacture of *HaliTeddies*. Two distinct areas can be identified: extraction of carnosic acid from dry rosemary leaves followed by the actual production and packaging of the gummy bears.



**Figure 1:** (a) Extraction process flowchart: (1) grinding machine, (2) pre-cooled tank, (3) extractor, (4) filters, (5) liquid storage tank, (6) evaporation recovery system, A – dry rosemary leaves, B – rosemary leaves powder, C – ethanol; D\* – extract with solids, D – extract; (b) *HaliTeddies* manufacture flowchart: (7) jacket dissolving cooker, (8) storage tank, (9) depositing unit; (10) cooling tunnel, (11) packaging and labeling, E – citric acid, F – water, G – sodium citrate, H – pectin, I – organic cane sugar, J – organic tapioca syrup, K – blueberry natural flavouring, L – raspberry natural flavouring, M – blue pigment, O – *HaliTeddies*

Rosemary leaves are purchased from a national producer and therefore arrive at the production facilities already dry. They are immediately transferred to the extraction department and are firstly ground to a fine powder in a grinding machine (1 in Figure 1a). Raw material, 62 kg, is introduced into the 120-mesh grinder to ensure that the amount required monthly is available. This first step lasts one hour at the beginning of each month. The powdered product will be kept dry in a storage cylinder.

The rosemary extraction process is carried out using a Low-Temperature Ethanol Extraction Machine that has a 300 L capacity, through an operation that lasts 1 hour and 35 minutes per day. The process starts in a pre-cooled tank (2 in Figure 1a), operating at  $-47^{\circ}\text{C}$ . In this unit, 2 kg of powder rosemary are mixed with 36 L of absolute ethanol. The mixture stands in a low-temperature freezer and the ethanol will separate the soluble components of the extract during this soaking period (Oliveira et al. 2016).

The third element of the equipment is an extractor (3 in Figure 1a). The ethanol and extract are recirculated with a pump that provides turbulence and mass transfer to improve extraction rates and yields. The pump can then be used to drain the tank at the end of the cycle and push it through the in-line filter modules (High Purity Extractions 2019). The extract obtained will be composed of 44.5 g of carnosic acid, 8.4 g of carnosol, and 11.8 g of rosmarinic acid. This step lasts for 15 minutes (Oliveira et al. 2016).

The mixture proceeds to the filters (4 in Figure 1a) to remove all solid materials with a simple filtration step requiring two vacuum pumps associated with two filter vessels of 150 L each. After the material has been filtered, a solution of ethanol and extract remains, and it will be stored in the liquid storage tank (5 in Figure 1a) before going to the evaporation recovery system (6 in Figure 1a).

Lastly, to separate the extract from the ethanol, an evaporator recovery system is used. When connected to a vacuum pump, the evaporator uses the vacuum to lower the boiling point of ethanol, resulting in quicker evaporation. This step lasts for about 1 hour and 20 minutes. The resulting extract will be completely free of ethanol.

After obtaining the active principle, the production of the gummy bears can begin. The equipment set responsible for this stage is designed with a capacity of 150 kg per hour and operates 6 hours per day for a daily production of 878 kg of *HaliTeddies*.

Firstly, all ingredients must be melted down in the jacket dissolving cooker (7 in [Figure 1b](#)). For each batch of 1 hour, 32 L of water, 1 kg of citric acid, and 0.5 kg of sodium citrate must be added. Citric acid acts as a preservative to ensure long shelf life, whereas sodium citrate is responsible for the gummy's uniformity and purity. These compounds must be completely dissolved before adding the pectin. Since both are very soluble in water, this process only takes a few minutes. With the cooker operating at 90 °C, the pectin and the organic cane sugar are added to the solution (5.5 kg and 66 kg, respectively). The cooker assures that this mixture is continuously stirred. When the boiling point is achieved and everything is dissolved, 39 kg of organic tapioca syrup is added alongside 9.2 g of dried extract, and the heating process is stopped ([iSweetech 2019](#)). To ensure the continuous operation of the gummy bear production, the mixture can be stored in a storage tank (8 in [Figure 1b](#)), allowing the daily production required to be achieved ([iSweetech 2019](#)).

The next step occurs in the depositing unit (9 in [Figure 1b](#)), which contains the colour and flavour-adding system. Therefore, the blueberry and raspberry natural flavours (300 g and 100 g, respectively), the blue pigment (39 g) as well as the remaining citric acid (1.2 kg), which helps to enhance the flavour, are added at this stage ([iSweetech 2019](#)).

The moulds are then filled automatically by the gummy depositor and are transferred into the cooling tunnel (10 in [Figure 1b](#)). The pallets move onto rails at a fixed speed, and the unit has fans that force ambient air in, while drawing heated air out. This allows the gummy bears to dry fast, creating an outer skin which is important to ensure that the product is easily de-moulded ([iSweetech 2019](#); [Pinco SA 2015](#)). Once the pallets reach the end of the tunnel, the de-moulding is done automatically, and the product is ready for packaging.

The final stage of the manufacturing process takes place in an automatic packaging and labeling machine (11 in [Figure 1b](#)) that works for 2 hours per day. This unit fills the containers with the 30 gummy bear dosage and adds the *HaliTeddies* label. These are 150 mL plastic containers with a screw cap to seal them. To ensure the longest shelf life possible, it is extremely important that the containers are vacuum sealed and waterproof so that when the product is exposed to high humidity conditions, the moisture of the surroundings does not migrate into the gummy bears ([iSweetech 2019](#)).

#### **4. Economic Analysis**

The first step regarding the assessment of *HaliTeddies* economics and its potential was to make a Gantt chart ([Table 2](#)) of the complete product development process. The Gantt chart emphasizes the workload of each team/division during a four-year time frame.

|                                   | Year 1 |       |           |   | Year 2 |   |   |   | Year 3      |   |   |   | Year 4 |   |   |   |
|-----------------------------------|--------|-------|-----------|---|--------|---|---|---|-------------|---|---|---|--------|---|---|---|
|                                   | 1      | 2     | 3         | 4 | 1      | 2 | 3 | 4 | 1           | 2 | 3 | 4 | 1      | 2 | 3 | 4 |
| <b>CPD</b>                        | Needs  | Ideas | Selection |   |        |   |   |   | Manufacture |   |   |   |        |   |   |   |
| <b>Marketing</b>                  |        |       |           |   |        |   |   |   |             |   |   |   |        |   |   |   |
| <b>Research &amp; Development</b> |        |       |           |   |        |   |   |   |             |   |   |   |        |   |   |   |
| <b>Engineering</b>                |        |       |           |   |        |   |   |   |             |   |   |   |        |   |   |   |
| <b>Production</b>                 |        |       |           |   |        |   |   |   |             |   |   |   |        |   |   |   |
| <b>Sales</b>                      |        |       |           |   |        |   |   |   |             |   |   |   |        |   |   |   |

**Table 2:** Gantt chart for *HaliTeddies*

Regarding the chosen target market, an annual production of 4.6 million boxes was forecasted to meet the consumers’ demand. Furthermore, to assure the product’s safety, reliability, and effectiveness, the gummy bears would be distributed to pharmacies.

After an analysis of all costs associated with the manufacture and marketing of the product, it was established a 20 % of the gross operating margin and, consequently, the respective selling price of *HaliTeddies* to the pharmacies. This value, based on other existing products, should increase by 1 % per year, as shown in [Table 3](#).

By analysing ([Table 2](#)), it is predicted that the sales to the pharmacies begin in the third quarter of the second year, while sales to the public will only start at the beginning of the third. The retail price is estimated to be 11.99 €.

|  | Year 1 | Year 2 | Year 3 | Year 4 |
|--|--------|--------|--------|--------|
| <b>Quantity of boxes sold (millions)</b> | 0.00   | 0.46   | 3.84   | 4.03   |
| <b>Growth rate of units sold (%)</b>     | -      | -      | -      | 5.00   |
| <b>Product Price (€)</b>                 | -      | 8.00   | 8.08   | 8.16   |

**Table 3:** Sales and the respective product price to the pharmacies, over 4 years of investment

To assess the feasibility of the business project and its respective investment, it is necessary to consider some economic parameters, such as Cash-Flow, Net Present Value (NPV), return on investment (ROI), internal rate of return (IRR), and payback time. The economic analysis was based on the business plan simulator provided by [IAPMEI \(2020\)](#). Through the analysis of these different economic factors and considering the parameters of the study case, an initial investment of around 7 million euros would be necessary.

In [Table 4](#), the forecasted Cash-Flow and ROI are presented over the first 4 years of investment. It stands out that a 15 % discount rate for the calculations was used.

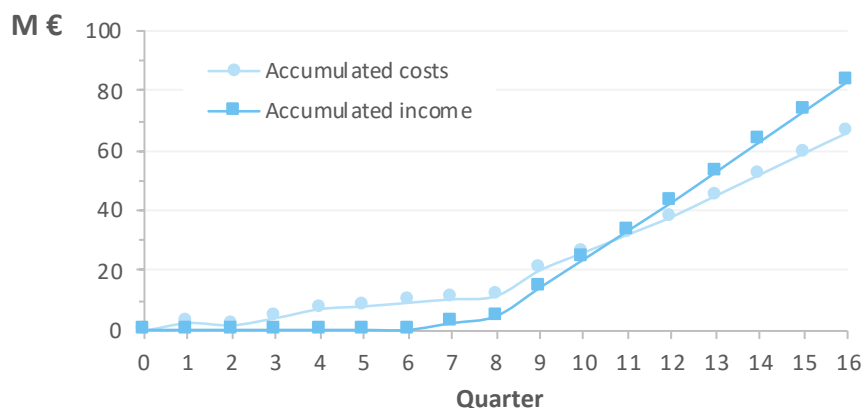
|                                      | Year 1 | Year 2 | Year 3 | Year 4 |
|--------------------------------------|--------|--------|--------|--------|
| <b>Net Cash-Flow (millions of €)</b> | -7.9   | -7.7   | 4.2    | 16.7   |
| <b>PV Net Cash-Flow (€)</b>          | -7.4   | -7.3   | 1.0    | 8.6    |
| <b>ROI (%)</b>                       | -      | -      | 10.4   | 93.8   |

**Table 4:** Company Cash-Flow and ROI, over 4 years of investment

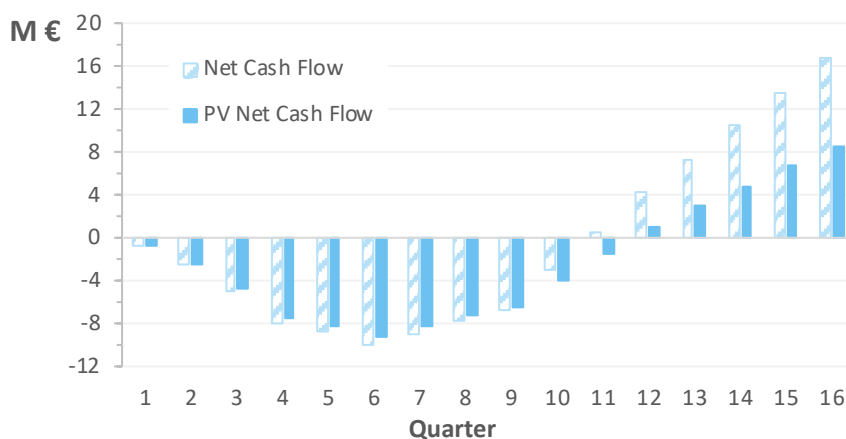
At the end of the first two years, the Net Cash-Flow, as well as PV Net Cash-Flow, are negative. This can be explained by the fact that the product projection phase takes place (with no production involved) during this period of time. On the other hand, the ROI for this project is 93.8 % after four years. NPV was another economic parameter that was evaluated, and a value of 2.7 million euros was obtained. Since this value is higher than 0, the investment is viable to be materialized according to the scenario that was set for the economic evaluation. After all, it manages to remunerate all the capital invested at the rate of the cost of capital.



Lastly, it was estimated the IRR and a value of 43.1 % was obtained. Also, when analysing this value, it was observed that the highest rate that the investor can finance this project without any loss is 43.1 %. The payback time is determined by the moment when the accumulated income exceeds the accumulated costs. [Figure 2](#) and [Figure 3](#) show that this moment corresponds to the eleventh quarter, which means that after three years, the project will start to be profitable.



**Figure 2:** Accumulated costs and income, over the first 4 years



**Figure 3:** Net Cash-Flow and PV Net Cash-Flow over the first 4 years

In assessing the feasibility of a project, determining the IRR and the NVP is essential since these are some of the best indicators to ensure the good development of a project. Thus, it is clear that *HaliTeddies* has an economic interest and meets all the conditions to be viable, being acceptable to carry out the planned investment.

## 5. Conclusions

In this work, the different stages of designing *HaliTeddies* were explored, including Needs, Ideas, Selection, Manufacture, and Economic Analysis. It was evident that this innovative, national product of natural origin was considered the best idea to mitigate halitosis, an increasing problem due to the use of facemasks during the COVID-19 global pandemic. Although breath malodour has been emphasized due to the temporary context, the problem will continue to be present in society after normality is resumed.

The carnosic acid extracted from rosemary and added to this vegan supplement should efficiently combat halitosis. Its atypical form makes it a very appealing product for the chosen target market (14- to 49- year-olds).

The economic analysis carried out made it possible to obtain certain economic parameters, namely the ROI, which presents a value of 93.8 % after four years, the NVP with a value of 2.7 million euros, an IRR of 43.1 %, and a payback period time of three years. Therefore, this analysis showed that the business case for the valorization of rosemary extraction components with the case product *HaliTeddies* is a profitable and viable business.

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