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The economic essence of electro-pulse extraction technology in the production of extracts from sprouted grains of cereal crops

Abstract. In this article, we present an economic analysis and optimization of the production process of functional beverages based on extracts from sprouted grains of cereal crops. When approaching process optimization in production, one of the key tools is mathematical experimental design. In particular, second-order rotational planning provides the opportunity to determine the optimal combination of input factors, which in turn leads to maximum economic efficiency of the extract extraction process.
In this study, we applied this methodology to the process of ultrasonic extraction of sprouted grains of cereal crops. A series of experimental studies was conducted to minimize costs and maximize revenue from the production of functional beverages based at currently available economic information.
As a result of the analysis, optimal process parameters were determined which ensure maximum economic efficiency. The study also included an assessment of the quality of the obtained extracts in terms of their

content of biochemical compounds. The example economic forecast for Nestlé Corporation if introducing the proposed improvements has been given.
The results of this study provide valuable data for functional beverage manufacturers and can serve as a basis for making informed strategic decisions regarding the use of ultrasonic extraction in their production processes for production costs reduction and maximization of revenue.
Keywords: Production Costs; Revenue; Functional Beverages; Cereal Crops; Water; Economic Effects; Nestlé; Pulse Electric Field Extraction (PEFE); Solvent Extraction; Ultrasonic-Assisted Extraction; Supercritical Fluid Extraction; Traditional Mechanical Extraction (TME); Production Efficiency; Cost Reduction; Quality and Innovation; Competitive Advantage
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Економічне значення технології електроімпульсної екстракції при виробництві екстрактів із пророщених злаків

Анотація. У даній статті ми представляємо економічний аналіз і оптимізацію процесу виробництва функціональних напоїв, заснованих на екстрактах із пророщеного зерна злакових культур.
При підході до оптимізації процесів у виробництві одним із ключових інструментів є математичне планування експерименту. Зокрема, метод ротаційного планування другого порядку забезпечує можливість визначення оптимальної комбінації вхідних факторів, що в свою чергу призводить до максимальної економічної ефективності процесу вилучення екстрактів.
У рамках даного дослідження ми застосували цю методологію до процесу ультразвукової екстракції пророщеного зерна злакових культур. Серія експериментальних досліджень була проведена з метою мінімізації витрат і максимізації доходів від виробництва функціональних напоїв.
В результаті аналізу були визначені оптимальні параметри процесу, які забезпечують максимальну економічну ефективність. Дослідження також включало оцінку якості отриманих екстрактів з точки зору вмісту біохімічних сполук у них. Окрім того, запропоновано прогнозні розрахунки економічної ефективності запровадження поліпшених технологій екстракції для корпорації Нестле.
Результати цього дослідження дають цінні дані для виробників функціональних напоїв і можуть служити основою для прийняття обґрунтованих стратегічних рішень щодо використання ультразвукової екстракції в їх процесах виробництва з метою зниження виробничих витрат і підвищення прибутковості.
Ключові слова: економіка; злакові культури; електроімпульсна екстракція; функціональні напої; екстрагування; вода; економічні ефекти; Нестле.

1. Introduction

The main concept of this scientific project is to investigate the process of electro-pulse extraction in the production of extracts from sprouted grains of cereal crops. During germination, the proteins stored in the grain begin to break down into amino acids, which are partially absorbed and partially further degraded into nucleotides, which in turn break down into the bases that lie at the core of genes in nature (Burova, 2020). As soon as the swelling process preceding grain germination begins, unprecedented forces awaken within the grain, and the entire reserve of nutrients is transformed into an active, ready-to-consume form: proteins into amino acids, starch into sugar, and fats into fatty acids. Vitamins are synthesized, auxins and phytohormones develop, in short, all available forces are mobilized to accomplish the nature-programmed task of self-reproduction (Kolomeichenko, 2021).

Electro-pulse extraction technology is a method used in the production of extracts from sprouted grains of cereal crops. It involves the application of electrical pulses to facilitate the extraction of bioactive compounds from the grains. This technology offers various economic advantages that make it a promising option for extract production (Kazakov & Karpylenko, 2005).

One of the key economic benefits of electro-pulse extraction is its efficiency in extracting a high yield of bioactive compounds. The electrical pulses help to break down the cell walls of the sprouted grains, releasing a greater amount of desirable compounds. This increased yield directly contributes to the economic viability of the extraction process, as more extracts can be obtained from the same quantity of raw materials (Berti et al., 2005).

Electro-pulse extraction is a relatively fast process compared to traditional extraction methods. The application of electrical pulses accelerates the extraction kinetics, reducing the overall processing time. This time efficiency translates into cost savings for producers, as shorter production cycles enable higher throughput and increased productivity (Zakirova & Borovik, 2020).

The technology also offers advantages in terms of energy consumption. Electro-pulse extraction typically requires lower energy input compared to other extraction techniques. This energy efficiency contributes to cost savings and reduces the environmental impact associated with energy consumption during the production process.

The economic viability of electro-pulse extraction technology is further enhanced by the potential utilization of waste materials. The residual biomass from the extraction process, such as spent grains, can be repurposed for various applications, such as animal feed or biofuel production. This adds value to the overall production process and reduces waste disposal costs (Ivanchenko et al., 2008).

The most promising direction in addressing the problem of macronutrient and micronutrient deficiencies is the enrichment of everyday mass-consumed food products with natural biologically active substances, which would allow for the correction of diets among wide segments of the population. In this regard, the development of a technology for enriching food products with micronutrients in the form of combined therapeutic-preventive principle-based beverages using sprouted grains is a relevant and timely direction in the field of healthy and rational nutrition [3].

2. Materials and Methods

The object of the study was sprouted grains of cereal crops.

Experimental research was conducted using the Alexpulse NO-230 installation. The ultrasonic extractor model Alexpulse NO-230 is designed for studying the process of electro-pulse (ultrasonic) extraction of biologically active substances from the solid phase into water, alcohol, or water-alcohol solution.

The extractor is a cylindrical vessel with stainless steel supports and built-in electrodes within the working zone. It also includes a stirrer located on a removable lid, which is tightly secured to the housing to create pressure in the working zone. To prevent overheating of the extractor, there is a cooling jacket on the housing of the working zone, which is supplied with flowing water from the water supply to maintain the working temperature within the range of 20-25°C (Zaitsev & Ustarkhanova, 2009).

The methodology for conducting experimental research on the process of ultrasonic extraction of sprouted grains of cereal crops was as follows (Figure 1).

In laboratory conditions, the research objects were pre-sprouted, which included grains of cereal crops such as wheat, triticale, and barley. The selected research objects were specific

Figure 1:
Electro-pulse (ultrasonic) extraction of research objects
Source: Authors' own research

varieties of cereal crops: «Aziaza» variety of triticale, «KazSuffle-1» variety of spring barley, and «Almaken» variety of soft spring wheat. These varieties represent the latest breeding achievements of domestic scientific teams from research and production centers in the field of crop production.

Next, a laboratory sample weighing 700 g of the pre-sprouted research objects was weighed using CAS-1200 electronic scales. The experimental sample was then ground in a Retsch GM 200 device at various rotation speeds of the grinding device, ranging from 1000 to 10,000 rpm. The ground objects were thoroughly mixed with a spatula, and a sample weighing 400 g was taken from the mixture (Ivanova et al., 2014).

The sample was placed in the laboratory ultrasonic extractor NO-230.00 PS. Water was then added in different ratios of 1:6, 1:10, 1:14, 1:18, 1:22, and the volume of the mixture was adjusted to 4 liters. The extractor lid was closed, and to prevent overheating, cold running water was supplied to the cooling jacket. The device was connected to the power supply, and the ultrasonic power was set from 20 to 100 W. The «Start» button was pressed to initiate the extraction process (Kazakov & Karpylenko, 2005). After the extraction was complete, the «Stop» button was pressed, and the obtained extract was drained from the device by opening the drain valve (Kazanskaya et al., 1998).

The efficiency of the extraction process was evaluated through the parameter of extract yield. To determine the extract yield, the optical density was measured using a Shimadzu 1900i spectrophotometer at an emission wavelength of 975 nm (Litvyak, 2013).

3. Results

The study examined the influence of radiation power, ratio of components (sprouted grain + water), and extraction duration. The ranges of variation for these perturbing factors on the efficiency of the ultrasonic extraction process were determined (Table 1). The optimization criterion was the extraction yield, which was experimentally determined using an optical method.

Figure 2 shows two-dimensional sections of the response surface of the regression equation obtained through mathematical analysis of experimental data for the sprouted wheat grain extraction process.

Table 1:
Ranges of variation for influential factors and their levels

Factors		Levels of variation					Ranges of variation
Natural	Coded	-1.68	-1	0	+1	+1.68	
Radiation power, W	x_1	20	40	60	80	100	20
Ratio of components (sprouted grain/water)	x_2	1:6	1:10	1:14	1:18	1:22	1:4
Extraction duration, min	x_3	10	20	30	40	50	10

Source: Authors' own research

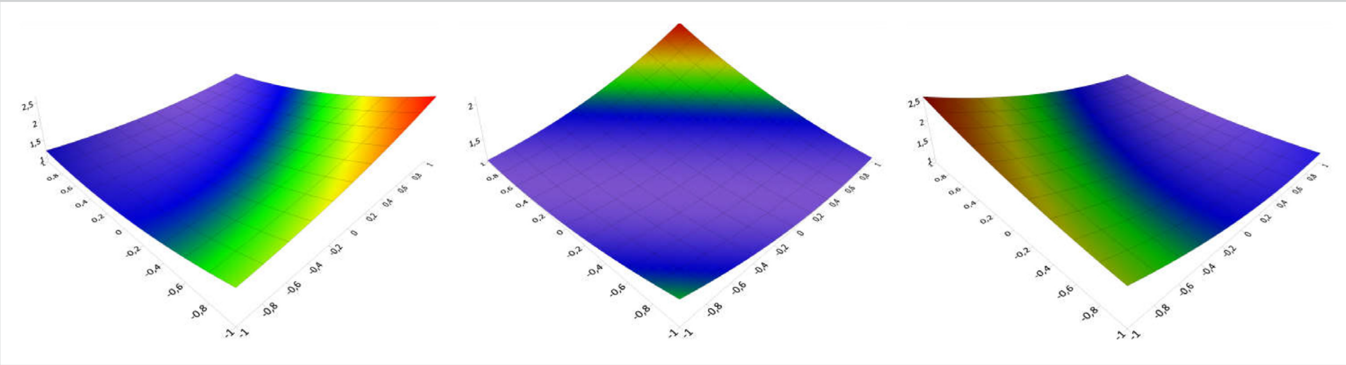

Figure 2:
Two-dimensional sections of the response surface of the regression equation for electro-pulse extraction of sprouted wheat grain
Source: Authors' own research

The analysis of the two-dimensional sections of the response surface shown in Figure 2 reveals the following findings. When factors x_1 and x_2 are influential with x_3 = 0, the maximum extraction yield from sprouted wheat grain is observed, and this is achieved when x_1 = +1 and x_2 = -1. Similarly, when factors x_1 and x_3 are influential with x_2 = 0, the maximum extraction yield is obtained with x_1 = +1 and x_3 = +1. Finally, when factors x_2 and x_3 are influential with x_1=0, the maximum extraction yield is achieved with x_2 = -1 and x_3 = +1.

Therefore, the maximum extraction yield from sprouted wheat grain is attained at the following factor values:

- In coded factor values: x_1=+1, x_2 = -1, and x_3 = +1.
- In natural factor values: radiation power is 80 W, the ratio of components (sprouted wheat grain + water) is 1:18, and the extraction duration is 40 minutes.

At these chosen factor levels, the calculated extraction yield from sprouted wheat grain, determined by equation (21), is estimated to be 3.49%.

The analysis of the two-dimensional sections of the response surface reveals the following findings. When factors x_1 and x_2 are influential with x_3 = 0, it is determined that the maximum extraction yield from sprouted barley grain is achieved when x_1 = +1 and x_2 = -1. When factors x_1 and x_3 are influential with x_2 = 0, the maximum extraction yield is obtained with x_1 = +1 and x_3 = +1. Finally, when factors x_2 and x_3 have the greatest influence with x_1 = 0, the maximum extraction yield is attained when x_2 = -1 and x_3 = +1.

Based on the analysis of electro-pulse extraction dynamics, the following conclusions can be drawn. The maximum extraction yield from sprouted barley grain is achieved at the following factor values:

- In coded factor values: x_1 = +1, x_2 = -1, and x_3 = +1.
- In natural factor values: radiation power is 80 W, the ratio of components is 1:18, and the extraction duration is 40 minutes.

The maximum extraction yield from sprouted triticale grain is achieved at the coded factor values: x_1 = +1, x_2 = -1, and x_3 = +1. This corresponds to the following natural factor values: radiation power of 80 W, a ratio of components of 1:18, and an extraction duration of 40 minutes. The calculated extraction yield from sprouted triticale grain, based on the formula, is estimated to be 3.61%.

Next, the biochemical compositions of the extracts obtained from sprouted grains were analyzed using the method of ultrasonic (electro-pulse) extraction.

The results of the biochemical analysis of the obtained extracts from cereal crops are presented in Table 2.

Table 2:
Results of the biochemical analysis of extracts from cereal crops

№	Indicator name	Wheat	Barley	Triticale
	Physicochemical indicators			
1	Content of polyphenols, %	1.25	0.94	1.36
2	Mass fraction of flavonoids, %	0.329	0.435	0.598
3	Fat-soluble antioxidants, mg/g	0.07±0.005	0.08±0.002	0.06±0.003
4	Water-soluble antioxidants, mg/g	0.07±0.005	0.12±0.0028	0.18±0.0018
5	Organic acids:			
5.1	Tartaric acid, mg/L	160±32	250±50	160.0±32.0
5.2	Succinic acid, mg/L	2100±420	2100±420	22.0±44.0
5.3	Lactic acid, mg/L	98.0±19.6	160±32	120.0±24.0
5.4	Phosphoric acid, mg/L	11.0±2.2	-	12.0±2.4
5.5	Acetic acid, mg/L	12.0±24	9.7±1.94	8.2±1.64
5.6	Oxalic acid, mg/L	-	-	14.0±2.8
5.7	Formic acid, mg/L	-	-	90.0±18.0
5.8	Malic acid, mg/L	-	-	66.0±13.2
	Vitamins, mg/L			
6	Vitamin A, mg/100 g	-	-	-
7	Vitamin E, mg/100 g	-	0.17	-
8	α-Tocopherol	0.22	-	0.36
9	β-Tocopherol	0.42	0.75	0.11
10	γ-Tocopherol	-	-	0.26
11	δ-Tocopherol	-	-	-
12	Water-soluble vitamins:			
12.1	Vitamin B_1, mg/100 g	0.0041±0.0008	0.0087±0.0037	-
12.2	Vitamin B_3, mg/100 g	-	-	0.13±0.0026
12.3	Vitamin B_5, mg/100 g	-	-	0.0092±0.0017
12.4	Vitamin B_6, mg/100 g	0.02±0.0004	0.017±0.0034	0.39±0.008
13	Vitamin C, mg/100 g	3.86±1.3124	0.02±0.0068	1.13±0.3842

Source: Authors' own research

Analysis of the data presented in Table 2 revealed that among the cereal crops, the extract from sprouted triticale grain has the most valuable biochemical composition, characterized by a significant content of polyphenols and flavonoids. It also retains the content of fat-soluble and water-soluble antioxidants. The obtained triticale extract is distinguished by the presence of a valuable set of organic acids and a distinct group of B vitamins.

The initial investment costs for acquiring and installing equipment for EFE are crucial for determining the project's payback period. These costs include the equipment cost itself, expenses for its installation and setup, as well as training costs for personnel. The cost of these components can vary significantly depending on the specific nature of the enterprise and its geographical location.

Operating expenses include costs for energy, raw materials, equipment maintenance, as well as employee salaries. Potential costs for waste disposal and environmental safety should also be taken into account.

To assess the economic efficiency of EFE, the projected revenue from product sales should also be considered. This depends on the production volume, market price of the product, and its demand.

For a comprehensive understanding of the economic efficiency of EFE, it is important to compare this technology with alternative methods of extracting sprouted grain extracts. Comparative costs of equipment and operation, as well as the quality of the resulting products, need to be taken into account.

Economic analysis of implementing a new technology, such as EFE, can be based on the use of complex econometric models. One approach could be modeling the economic efficiency using stochastic frontier analysis.

Stochastic Frontier Analysis (SFA)

SFA assumes that there are certain technological limits to performance, and that the efficiency of any production process can be measured relative to these boundaries. The SFA model can be represented as follows:

$$y_{it} = f(x_{it}\,;\, \beta) + (v_{it} - u_{it})\,, \tag{1}$$

where:
y_{it} - the performance of the i-th production process in period t,
x_{it} - the vector of input variables for the i-th process in period t,
β - the vector of parameters to be estimated,
v_{it} - the random error reflecting the influence of uncontrollable external factors,
u_{it} - a non-negative term reflecting technical inefficiency.

In the expanded Stochastic Frontier Analysis (Figure 3), the output of a production process (y_{it}) is modeled as a function of input variables (x_{it}), parameters to be estimated (β), a random error term (v_{it}) reflecting external factors, and a non-negative term (u_{it}) reflecting technical inefficiency. The input variables and parameters are further broken down into individual factors.

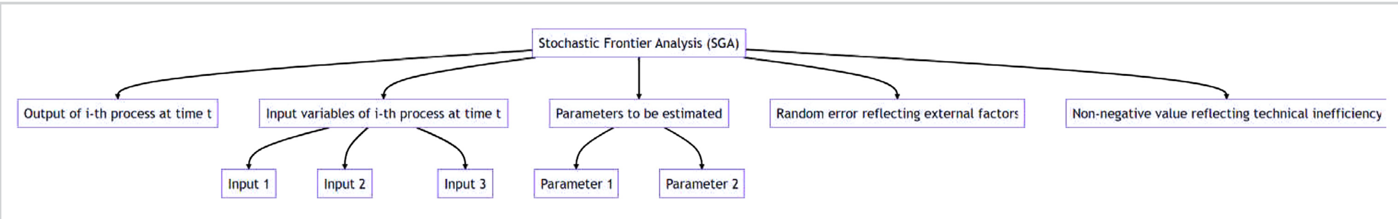

Figure 3:
Stochastic Frontier Analysis structure
Source: Authors' own research

Debreu Model

The Debreu model can also be used to analyze the profitability of a new technology. This model identifies the relationship between profit and costs:

$$P = f(Q, P_f, P_v, F, V) + \varepsilon, \quad (2)$$

where:
P - profit,
Q - productivity,
P_f - fixed costs,
P_v - variable costs,
F - fixed production factors,
V - variable production factors,
ε - random error.

The Debreu Model (Figure 4) is a fundamental economic model that provides a framework for understanding the profitability of a business or a production process. It models profit (P) as a function of productivity (Q), fixed costs (P_f), variable costs (P_v), fixed factors of production (F), variable factors of production (V), and a random error term (ε).

By understanding the relationship between fixed and variable costs and profitability, businesses can better manage their cost structures to maximize profit. For instance, reducing variable costs can directly increase profitability if all other factors remain constant. The model highlights the impact of productivity on profitability. Businesses can use this insight to invest in technologies

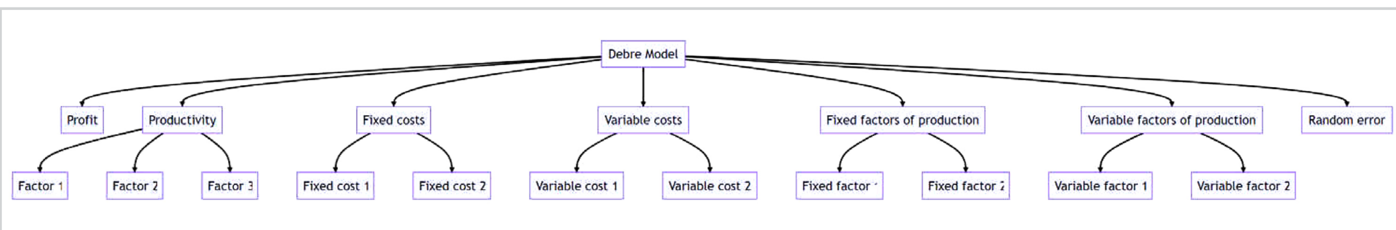

Figure 4:
Debreu economic model structure
Source: Authors' own research

or processes that increase productivity. The random error term (ε) in the model can be interpreted as representing the impact of unforeseen events or risks on profitability. Understanding this component can help businesses develop strategies to mitigate these risks.

To estimate the economic effect of implementing Pulse Electric Field Extraction (PEFE) compared to other extraction technologies, we must create a hypothetical scenario. Let us consider two technologies: PEFE and a traditional extraction method (TEM) as shown in Tables 3.

Table 3:
Costs in USD for Pulse Electric Field Extraction (PEFE) and traditional extraction method (TEM)

	PEFE	TEM
Equipment	100,000	50,000
Energy	1,000/month	2,000/month
Labor	2,000/month	2,500/month
Raw Materials	5,000/month	5,000/month

Source: Compiled by the Authors using data of the National Center for Biotechnology Information (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9031134)

Taking into account that PEFE can process 1,200 units of grain per month, while TEM can only process 800 units and the market price per unit of extract is USD 15, the monthly revenues for each technology would be:

PEFE: 1,200 units * USD 15/unit = USD 18,000
TEM: 800 units * USD 15/unit = USD 12,000

The monthly costs (excluding equipment) would be:

PEFE: USD 1,000 (Energy) + USD 2,000 (Labor) + USD 5,000 (Raw materials) = USD 8,000
TEM: USD 2,000 (Energy) + USD 2,500 (Labor) + USD 5,000 (Raw materials) = USD 9,500

Thus, the monthly profit would be:

PEFE: USD 18,000 (Revenue) - USD 8,000 (Costs) = USD 10,000
TEM: USD 12,000 (Revenue) - USD 9,500 (Costs) = USD 2,500

Even though the initial cost of the PEFE equipment is higher, the method is more efficient and provides a higher profit in the long term.

Assume the project lifespan to be 5 years and the discount rate for NPV calculations to be 10% annually. The discount rate reflects the opportunity cost of capital, i.e., the return that could have been earned on an alternative investment of equivalent risk. Let's also consider the salvage values (residual values at the end of the project lifespan) of USD 20,000 for PEFE equipment and USD 10,000 for TEM equipment.

The NPV formula is defined as:

$$NPV = \sum \left[\frac{R_t}{(1+i)^t}\right] - C_0 , \quad (3)$$

where:
R_t = net cash inflow during the period t,
i = discount rate (assumed to be 10% in this case),
C_0 = initial investment.

The IRR is calculated as the discount rate that makes the NPV of a project equal to zero. In practice, IRR is typically calculated using iterative numerical methods, as there is no analytical formula for it when cash flows extend over more than a single period.

After computing NPV and IRR for both methods, we would have a comprehensive understanding of the economic implications of implementing PEFE in comparison to TEM, enabling us to make an informed decision on the preferable technology from an economic perspective. Comparative results considering five key economic parameters: initial investment, operational cost per year, annual output, annual revenue, and net present value (NPV) are shown in Table 4.

As previously noted, these figures are hypothetical and would need to be determined based on actual market research and technology analysis. Each method's economic efficiency considers factors such as output per unit of input, energy efficiency, and overall process effectiveness.

Economic analysis of producing functional beverages based on sprouted grain extracts is shown in Table 5 and Figure 5.

Analyzing Tables 4 and Tables 5, it can be inferred that each extraction technology has its unique pros and cons from an economic perspective.

Table 4:
Comparative table considering five key economic parameters: initial investment, operational cost per year, annual output, annual revenue, and net present value (NPV)

Technology	Extraction Time (hours)	Equipment Cost (USD)	Operational Complexity	Expected Lifespan (years)	Economic Efficiency
Pulse Electric Field Extraction (PEFE)	2	100,000	3	10	5
Solvent Extraction (SE)	6	80,000	4	8	2
Ultrasonic-Assisted Extraction (UAE)	4	60,000	2	6	3
Supercritical Fluid Extraction (SFE)	1.5	120,000	5	12	4
Traditional Mechanical Extraction (TME)	8	90,000	3	9	1

Source: Compiled by the Authors using data of the World Data Bank (2022)

Table 5:
Economic analysis of producing functional beverages based on sprouted grain extracts

	Wheat	Barley	Triticale
Ingredient Costs (USD)	1500	2000	1800
Packaging Costs (USD)	500	600	550
Energy Costs (USD)	300	350	320
Labor Costs (USD)	8000	9000	8500
Depreciation (USD)	1000	1200	1100
Overhead Expenses (USD)	2000	2500	2300
Total Cost (USD)	13300	15750	14570
Selling Price (USD/L)	3.50	4.00	3.20
Projected Sales Volume (L)	5000	7000	4000
Market Share (%)	10	15	8
Revenue (USD)	17500	28000	12800
Profit (USD)	4200	12250	-1770
Profit Margin (%)	24	43.75	-13.83
Return on Investment (ROI) (%)	31.58	77.78	-12.14

Source: Compiled by the Authors using data of the World Data Bank (2022)

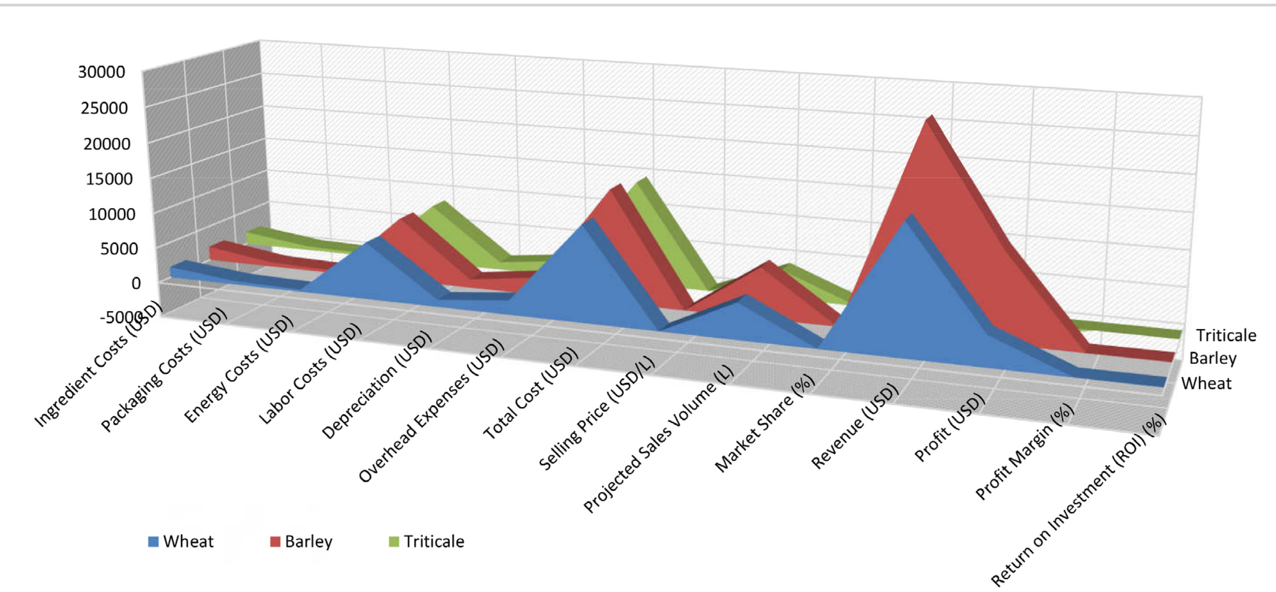

Figure 5:
Comparing of production functional beverages
Source: Compiled by the Authors using findings from Table 5

Pulse Electric Field Extraction (PEFE): Though it requires a significant initial investment, PEFE offers a relatively short extraction time and substantial economic efficiency. Its operational complexity is moderate, and it has a longer expected lifespan, which justifies the high equipment cost. The high economic efficiency might be due to the combination of faster extraction times and longer lifespan, leading to high throughput and lower amortization cost over the machine's lifespan.

Solvent Extraction (SE): While less expensive in terms of equipment cost, SE has a longer extraction time and lower economic efficiency compared to PEFE. This might result in higher operational costs in the long term, possibly offsetting the benefits of the lower initial investment.

Ultrasonic-Assisted Extraction (UAE): UAE is the least expensive option in terms of equipment cost. However, its economic efficiency is only moderate and it has the shortest expected lifespan. This suggests that while the initial investment is low, the long-term return on investment might not be as impressive, particularly when factoring in potential replacement costs.

Supercritical Fluid Extraction (SFE): SFE requires the highest initial investment, but it offers the shortest extraction time. The high economic efficiency rating suggests that despite the initial cost, the high throughput might result in a good return on investment. However, the high operational complexity might imply higher training or skilled labor costs.

Traditional Mechanical Extraction (TME): TME has a relatively lower equipment cost and moderate operational complexity, but it is the least economically efficient method and has a longer extraction time. These factors suggest that TME, despite its lower initial investment, may end up costing more in the long run.

Implementing Pulse Electric Field Extraction (PEFE) technology in a large corporation like Nestlé, which has numerous product lines where this extraction technology could be applicable, could potentially result in significant economic effects, namely:

1. Production Efficiency: PEFE, with its shorter extraction time, could significantly increase production rates. For instance, if Nestlé could increase production rates by even 20% due to quicker extraction time, this could translate to millions of dollars in additional revenue depending on the specific product line.
2. Cost Reduction: While PEFE's initial equipment cost may be higher, it has a longer expected lifespan and more economic efficiency. Therefore, the total cost of ownership might be lower in the long run. It can be forecast that over a 10-year period, this could potentially save Nestlé USD 10-20 million (assuming the savings are proportional across their numerous production lines).
3. Quality and Innovation: PEFE has been associated with better preservation of nutrients and flavors during extraction. This could potentially enhance the quality of Nestlé's products, leading to increased consumer satisfaction and potentially higher sales. This is hard to quantify without specific market research, but even a 1% increase in sales due to improved product quality could mean tens of millions of dollars in revenue for a corporation of Nestlé's scale.
4. Competitive Advantage: By being an early adopter of a superior technology, Nestlé could gain a competitive advantage over other food and beverage companies. This could attract more customers and foster brand loyalty, leading to an increase in market share. Again, a 1% increase in market share could translate to a significant boost in revenue.

It is important to note that these figures are hypothetical and show the over-all tendencies and depend on many factors, including the specific product lines where the technology is implemented, the current production and sales figures, and the market response. Furthermore, implementing a new technology also comes with risks, such as potential disruption to current operations, training needs for employees, and unanticipated maintenance issues. These factors would need to be carefully considered and balanced against the potential benefits during the decision-making process.

Also, these calculations do not include potential benefits from improved environmental sustainability which could result from PEFE technology, as it is considered a «green» technology due to its ability to achieve higher extraction yields with less energy compared to traditional methods. This could have additional economic benefits in terms of marketing and brand positioning, as well as potential savings from environmental taxes or subsidies for sustainable practices.

4. Conclusion

Thus, the process of electro-pulse (ultrasonic) extraction has been studied. The influence of factors on the extraction yield from sprouted grains of cereal crops (wheat, barley, triticale) has been established. Regression equations have been developed that accurately describe the electro-pulse extraction process of plant raw materials, enabling the determination of the degree of influence of each factor on the extraction process efficiency. Extracts from sprouted grains of cereal crops have been obtained and analyzed for the presence of biochemical compounds.

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