Kruhlova Olena
PhD, Associate Professor, Kharkiv State University of Food Technology and Trade
Pohozhykh Mykola
DSc, Professor, Kharkiv State University of Food Technology and Trade
Niemirich Oleksandra
DSc, Associate Professor, National University of Food Technologies
Ustymenko Ihor
PhD, National University of Food Technologies
Havrysh Andrii
PhD, Associate Professor, National University of Food Technologies
Skyrda Olena
PhD, Associate Professor, National University of Food Technologies
Hubenia Viacheslav
PhD, National University of Food Technologies
Liulka Oleksandr
PhD, National University of Food Technologies
Tkachuk Yurii
PhD, National University of Food Technologies
Matiushenko Raisa
National University of Food Technologies
(Kharkiv, Kyiv, Ukraine)

TECHNOLOGY OF DRIED FOOD PRODUCTS AND FOOD PRODUCTS USING IT: EVALUATION OF EFFICIENCY AND IMPLEMENTATION PROSPECTS

Introduction. The current stage of development of the national economy indicates the growing role of scientific developments in ensuring the effective functioning of enterprises, including food producers. The introduction of science-intensive technologies leads to the expansion of existing and creation of new markets and increase production, which ensures the competitiveness of innovative enterprises. Given the place of food industry enterprises in the technological chain, the production of science-intensive food products has a positive impact on the development of food enterprises and other economic activities, stimulating research and investment in related sectors of the economy.

Food industry enterprises belong to the group of the most innovatively active enterprises with significant production volumes. According to the State Statistics Service of Ukraine during 2015-2019 in the total number of innovatively active enterprises by type of economic activity, the share of innovatively active enterprises of the food industry was 16.8…24.6 % [1-4]. One of the promising areas of food production in Ukraine is the production of dried products. Drying is the most natural among other ways of preserving products. According to published data, the volume of the market of the dried product grows annually by 10.0…15.0 % [5], the price of dried products is almost 10 times higher than fresh or frozen [6].

Despite the positive dynamics of production and export of fruits and vegetables during 2018-2019, Ukraine is behind the world leaders in sales of dried products [7, 8].

One of the factors of low growth rates of dried products production and the lack of significant investments in the development of this segment of food production is the low functional and technological potential of existing technologies for drying food products. Based on the results of generalization of the scientific literature on technologies for obtaining dried vegetables, meat, dietary supplements antianemic direction, it is concluded that existing developments are energy-intensive and require special equipment both during drying and storage of dried products [9].

Taking this into account, the team of scientists of National University of Food Technologies (Ukraine) and Kharkiv State University of Food and Trade (Ukraine) set and solved the task of developing DFP technology using mixed heat supply drying (MHS-drying) and substantiation of dried products production using specified technology.

The introduction of scientific developments in the practice of activity actualizes the problem of evaluating their effectiveness in the early stages of development of the innovation process, which determines the features of technology transfer and affects the prospects for their commercialization. For technologies in the field of food production, such an assessment is carried out mainly based on qualitative methods for the price and consumer properties of new products, which ultimately makes it possible to determine its competitiveness compared to similar products.

However, the quality and price characteristics of new food products is only one aspect of the implementation of the developed food technology. Therefore, it is important to substantiate the scientific and methodological foundations of a comprehensive assessment of food technology.

The purpose and objectives of the study. The purpose of the study is to assess the effectiveness and prospects of implementation of the developed technology of dried food products using the use of drying with mixed heat in the practice of economic activity of food industry enterprises. To achieve this goal, scientific and methodological tools are substantiated and a comprehensive assessment of the technology of dried food products using drying with mixed heat supply.

Research methods. To evaluate the developed technology of dried products, the method of multicriteria evaluation is used, which is based on the methods of coefficients, comparative, point evaluation, additive convolution, discounted income, radar method.

The level of potential of scientific development is determined by taking into account the criteria of science-intensive products, scientific and technical efficiency, and investment attractiveness of the implementation of the developed technology in practice. Taking into account the experience in evaluating the effectiveness of scientific developments given in the publications [10-14], the potential of dried food technology when using drying with mixed heat supply (MHS-drying) was evaluated. The sequence of calculations is shown in Figure 5.8.

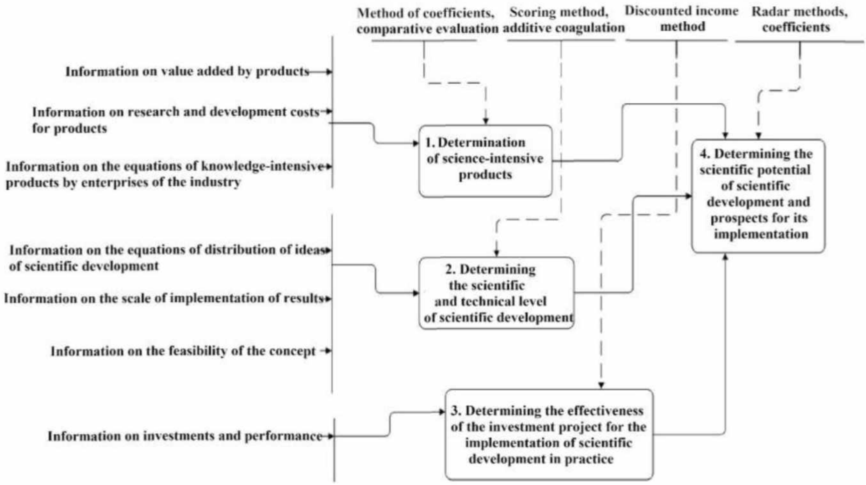

Figure 5.8 The sequence of assessing the potential of the technology of dried food products using drying with mixed heat supply

Estimation of the knowledge intensity of food products.

One of the criteria that determines the prospects of scientific development is the science-intensive products, the level and methodological principles of calculation of which depend on the stage of research (R&D).

Given the cyclical process of research, the stage of development of new technology, characterized by a high level of R&D costs, is replaced by its introduction into production, accompanied by a restructuring of the production complex with subsequent changes in cost characteristics of products.

Given this, the knowledge intensity of the product is determined by certain coefficients, which are calculated taking into account the cost of research, price, profit, value-added per 1 kg of product [13, 14]. The key characteristic during the calculations is the cost of research and development, the value of which relative to the price of the product reflects the level of its knowledge intensity.

Product intensity – a characteristic that reflects the level of research and development costs in the price of products. To determine the knowledge intensity of products, the coefficient of science intensity of products (Кнп) is used, which is calculated by the formula:

$$K_{НП} = \frac{B_{ДР}}{Ц_{П}} \times 100 \quad , \tag{5.1}$$

where: $K_{НП}$ – coefficient of knowledge intensity of products;

$B_{ДР}$ – research and development costs, UAH / t;

$Ц_{П}$ – product price, UAH / t.

The higher the calculated coefficient of the knowledge intensity of products compared to its average value for enterprises of a certain type of economic activity, the higher the quality of innovative development; probability of obtaining products with a high level of added value; investment attractiveness of scientific development. Exceeding the calculated coefficient of the knowledge intensity of its average value for enterprises of a certain type of economic activity indicates an average high level of the knowledge intensity of the i-th product.

Comparison of the coefficient of the knowledge intensity of the i-th product with its average value for enterprises of a certain type of economic activity allows determining the level of science intensity of products. The conclusion on the results of the ratio of these coefficients is as follows: if the coefficient of the knowledge intensity of the i-th product is greater than its average value for enterprises of a certain type of economic activity is diagnosed high, if less – low, if it corresponds to the average value – the average level of science.

Determining the scientific and technical level of scientific development. To determine the scientific and technical level of scientific development, the coefficient of scientific and technical efficiency is used, which is calculated using the method of coefficients and scoring, taking into account the level of distribution, scale of implementation, and feasibility of the scientific concept presented in [11, 12]. Conditions for assessing the scientific and technical level of scientific development are given in Table 5.8.

Table 5.8

Conditions for assessing the scientific and technical level of scientific development

Indicator	Conditions for evaluation		
	1 point	2 point	3 point
The level of dissemination of ideas of scientific development	Theoretical calculations are simple, the experiment was not performed	Low complexity of calculations, verification on a small amount of experimental data	Performing complex theoretical calculations, testing on a large amount of experimental data
The scale of implementation of the results of scientific development	Certain enterprises	Industry, region	World, national economy
Feasibility concept	The concept is confirmed by expert opinions	The concept is confirmed by calculations	The concept is tested in practice

Source: compiled on the basis of [11; 12, p. 11, 13-14]

The formula for calculating the coefficient of scientific and technical efficiency is as follows:

$$K_{HTP} = \frac{\sum_{i=1}^{3} Б_{фi}}{\sum_{i=1}^{3} Б_{\max i}}, \quad (5.2)$$

where: $К_{НТР}$ – indicator of scientific and technical efficiency of development, coefficient;

$Б_{фi}$ – assessment of scientific and technical level of scientific development on the i-th indicator, actual, score;

$Б_{maxi}$ – assessment of scientific and technical level of scientific development on the i-th indicator, maximum, point.

The conclusion on the results of the calculation of the coefficient is as follows: if the values of the coefficient are in the range from 0 to 0.33 diagnosed low, from 0.34 to 0.66 – medium, from 0.67 to 1.0 – high levels of scientific and technical effectiveness of scientific development.

Determining the effectiveness of the investment project for the implementation of scientific development in practice. To assess the effectiveness of the investment project to implement research into practice, the indicators of reduced income and payback period are used. Formulas (5.3) and (5.4) are used to determine the net present value:

$$NPV = \sum \frac{P_t}{(1+r)^t} - I \tag{5.3}$$

$$NPV = \sum_{t=1}^{n} \frac{P_t}{(1+r)^t} - \sum_{j=1}^{m} \frac{I}{(1+i)^j} \tag{5.4}$$

where: NPV – net present income, UAH;

P_t – net cash flow by years, UAH;

r – discount rate, in shares;

t – duration of the settlement period;

I – invested funds, UAH;

j – term of investment of financial resources;

i – projected average inflation.

If the investment project provides a one-time investment to determine the net present value of the formula (5.3) if the investment project involves a consistent investment for several years – formula (5.4).

The criterion for evaluating the effectiveness of the implementation of scientific development in practice is the indicator of the payback period, the formula for determining which is:

$$PP = \frac{I}{P\Pi}, \qquad (5.5)$$

where: $P\Pi$ – the average annual amount of net cash flow for the period of operation project, UAH.

Based on the recommendations for assessing the potential of scientific development as an object of commercialization [11] to assess the effectiveness of the implementation of scientific development in practice, the following conditions are met: if the payback period of investment in the project, from 3 to 5 years – average, from 5 years and lower levels of efficiency of introduction of scientific development in the practice of activity.

Determining the potential of scientific development and prospects for its implementation. To determine the potential of scientific development, the radar method was used [15, pp. 184-185]. The essence of this method is to divide the circle into sectors, the number of which corresponds to the number of indicators that reflect the knowledge, scientific and technical level, and effectiveness of the implementation of scientific developments in practice (Table 5.9).

The formula for calculating the area of the figure is as follows:

$$Sp = \frac{1}{2}\sin\alpha\sum_{k=1}^{n} P_k \times P_{k+1}, \qquad (5.6)$$

where: Sp – potential for scientific development, actual, score;

P_k, P_{k+1} – vector for related indicators on science intensity, scientific and technical level and efficiency of implementation of scientific developments in practice, score;

α – the angle between two adjacent values of the potential vectors;

n – number of evaluation indicators.

Table 5.9

Criteria and indicators for a comprehensive assessment of the potential of scientific developments and prospects for their implementation in practice

Criterion	Indicator
Science-intensive products	Coefficient knowledge intensity of products
Scientific and technical level of scientific development	The level of dissemination of ideas of scientific development
	The scale of implementation the results of scientific development
	Feasibility concept
The effectiveness of the investment project to implement research into practice	Payback period of investments in the project on introduction of scientific development into practice

The level of research development potential is determined by comparing the area of the radar Sp and the estimation circle:

$$K_p = Sp \div S, \quad (5.7)$$

$$S = \pi R^2, \quad (5.8)$$

$$h = \frac{K_{\max} - K_{\min}}{3}, \quad (5.9)$$

where: K_p – integrated indicator of scientific development potential, coefficient;

K_{max}, K_{min} – maximum and minimum value of the integrated indicator of the potential of scientific development, coefficient;

S – the area of the assessment circle within which the radar is built, units;

R – radius of the evaluation circle, units.

As qualitative characteristics of unit indicators were used to characterize the potential of scientific development, the following scale was used to transition from linguistic to quantitative assessment: high value of the indicator corresponds to 3, medium − 2, low − 1 units. Since the radius is taken at the level of 3 units, the area of the evaluation circle will be 28.26 square meters. units; the maximum area of the figure within the evaluation circle − 21.4 square meters. units, minimum − 2.4 square meters. units; the maximum and minimum value of the integrated indicator of the potential of scientific development − 0.76 and 0.08, respectively. In this case, the scale for identifying the potential of scientific development will be as follows (Table 5.10).

Table 5.10

Scale of distribution of values of the integrated indicator to identify the level of potential of scientific development and prospects for its implementation

The value of the integral indicator, K_p	Conclusion
[0,08 ; 0,30]	low level of potential of scientific development, which leads to insignificant prospects for its implementation
[0,31; 0,53]	the average level of potential of scientific development, which determines the average prospects for its implementation
[0,54; 0,76]	high level of potential of scientific development, which determines significant prospects for its implementation

Research results. Evaluation of dried food technology according to the criteria of food science, scientific and technical level, and efficiency of the investment project to implement scientific development in practice allowed to conclude about the high level of efficiency of the developed technology and significant prospects for its implementation in the food industry. The calculations were made using the information on the production and sale of dried products, which includes dried foods from cabbage, zucchini, Jerusalem artichokes, carrots, as well as dried meat products (DMP) and dietary supplements Redgam (DD "Redgem").

According to calculations, the knowledge intensity of dried food products produced by the developed technologies is determined at the level of 1.11…1.18 %, which, according to Eurostat data, 1.5…2.5 times higher than similar characteristics by industry in Ukraine (0.48…0.75 %) [1-4] (Table 5.11).

Table 5.11

Indicators of knowledge intensity of dried food products using the developed technologies

Product	SRW costs, thousand UAH/t	Product price (excluding VAT), thousand UAH/t	Product consumption, %
DFP: of cabbage	0,85	74,80	1,14
of zucchini	0,85	72,65	1,17
of Jerusalem artichoke	0,85	71,90	1,18
of carrots	0,85	76,05	1,12
DMP	3,16	283,40	1,11
DS "Redham"	1,22	105,80	1,15

The high level of potential of scientific developments is also evidenced by the share of value added in the price of products, the absolute values of which are 1.1…1.7 times higher than the corresponding indicators of the processing industry in Ukraine. It is estimated that the share of value added in the volume of sales of dried food products produced by the developed technologies is 21.0…27.8 % (Table 5.12).

Table 5.12

The share of value added in the price of dried food products produced by the developed technologies

Indicator	Sales price product (excluding VAT), thousand UAH/t	The cost of purchasing items of labor and payment for services of third parties, thousand UAH/t	Added value, thousand UAH/t	Share of value added, %
DFP: of cabbage	74,80	55,33	19,47	26,0
of zucchini	72,65	52,45	20,20	27,8
of Jerusalem artichoke	71,90	51,89	20,01	27,8
of carrots	76,05	60,05	16,0	21,0
DMP	283,40	211,44	71,96	25,4
DS "Redham"	105,80	79,77	26,03	24,6

The results of scientific work have a significant potential for use not only in the food industry, but it is also a factor of new technical and organizational solutions in the field of mechanical engineering, production of machinery and equipment for food production, packaging, transport, and warehousing logistics.

Given the increase in value-added at the stages of product creation and promotion to the consumer, the introduction of developed technologies into practice is a prerequisite for the formation of vertically integrated structures of different levels of integration. The multifaceted nature of the results of scientific development determines the objectivity of determining its scientific and technical effectiveness, which is based on assessing the prospects for use, scale, and quality of results [12].

To confirm the scientific and technical effectiveness of the developed technology, objective data on the developed technology of dried food products were used. Thus, as a result of the development of technology of dried food products, the technology of food products of a wide range was improved and adapted with its use for different conditions and capacities of enterprises, which is confirmed by 4 patents of Ukraine for inventions; 7 – on the utility model.

Regulatory documentation has been developed: TUU 15.1-01566330-229:2014 "Dried meat semi-finished product. Specifications"; TU U 15.8-01566330-279: 2012. "Dried vegetable products. Specifications"; TU U 15.1–01566330–226: 2009. "Dietary supplements from the blood of cattle and plant materials. Specifications"; technological maps for food products with DFP. The results of the work were tested, confirmed in production conditions, and implemented in 12 restaurants in Ukraine. In generalized form, the results of the evaluation of the scientific and technical level of scientific development are given in Table 5.13

Table 5.13

The results of the evaluation of scientific and technical level of scientific development

Indicator	Characteristic	Evaluation of scientific development, point	
		Maximum value	Actual value
The level of dissemination of ideas of scientific development	Performing complex theoretical calculations, testing on a large amount of experimental data	3	3
The scale of implementation of the results of scientific development	Branch	3	2
Feasibility concept	The concept is tested in practice	3	3
Total		9	6
K_{HTP}		0,67	

According to calculations, the overall coefficient of scientific and technical effectiveness of scientific development was 0.67 points, which confirms the high potential for further development and commercialization of developed technologies. The maximum values are marked by the characteristics of the dissemination of ideas and feasibility of the concept.

The potential of scientific development is determined in combination with the assessment of its investment attractiveness for implementation in practice. For this purpose, the payback period of the invested funds was used. The calculations were made under the condition of placing the product on the free areas of the functioning enterprise taking into account: the practice of production of dried products [16]; order portfolio; cost and selling prices for products (Table 5.14).

Table 5.14

Information to determine the investment attractiveness of the introduction into production of developed technologies DFP

Indicator	Units of measurement	Value
Price (excluding VAT)		
DFP: of cabbage	UAH / kg	74,80
of zucchini	UAH / kg	72,65
of Jerusalem artichoke	UAH / kg	71,90
of carrots	UAH / kg	76,05
DMP	UAH / kg	283,40
DS "Redham"	UAH / kg	105,80
The cost of production		
DFP: of cabbage	UAH / kg	59,80
of zucchini	UAH / kg	58,10
of Jerusalem artichoke	UAH / kg	57,55
of carrots	UAH / kg	66,10
DMP	UAH / kg	226,70
DS "Redham"	UAH / kg	84,60
Production volume	t/year	180

Additional investments in fixed assets are determined based on the specification of the required equipment and its market price; current assets – based on the standard and average daily needs for raw materials and supplies.

Economic calculations indicate the possibility of implementing a project for the production of SHP with the developed technologies and its attractiveness to the investor (Table 5.15). According to preliminary estimates, the project requires investments of about UAH 4.5 million. The payback period of the project at different levels of capacity utilization is 2.0…2.5 years, at the average load level – 2.3 years.

Thus, based on the conducted researches the high level of investment potential of the developed technologies of SHP and food products with its use or on its basis turns out that is confirmed by indicators of science intensity of production, scientific and technical efficiency, and investment attractiveness of scientific development.

Table 5.15

The main indicators of the enterprise for the forecast period

№	Indexes	Years		
		1 year	2 year	3 year
1	Investments, thousand UAH	4500,0	–	–
2	Discounted income, thousand UAH	2214	1932,1	1706,2
3	Absolute return on investment, thousand UAH	-2286,	-353,9	1352,3
4	Payback period, years	2,3		

For the generalized conclusion concerning the potential of scientific development and prospects of its introduction in practice of activity, the integrated indicator defined based on calculation of the relative area of a radar constructed within an estimation circle is calculated. The initial information and results of calculations are given in table 5.16.

Table 5.16

Integral indicator to identify the level of potential of scientific development and prospects for its implementation

Criterion	Indicator	Qualitative assessment	Mark
Science-intensive products	Coefficient of knowledge intensity of products	high	3
Scientific and technical level of scientific development	The level of dissemination of ideas for scientific development	high	3
	The scale of implementation the results of scientific development	average	2
	Feasibility concept	high	3
The effectiveness of the investment project to implement research into practice	Payback period of investments in the project on introduction of scientific development into practice	low	3
Evaluation circle		28,3	
Radar area		18,3	
Integral indicator		0,65	

According to calculations, this integrated indicator is 0.65 points, which according to the developed evaluation scale (Table 5.10) indicates a high level of potential of the developed technology of dried food products and significant prospects for its implementation in the practice of the food industry enterprises.

Conclusions. The results of the research indicate a high level of innovative potential of the developed technologies. It is established that the introduction of the developed technologies provides a high level of knowledge-intensive products. The knowledge intensity of the production of new dried food products is determined at the level of 1.11…1.18 %, which is 1.5…2.5 times higher than the corresponding indicators for other types of economic activity in Ukraine. Evaluation of scientific and technical effectiveness of the study shows that the obtained scientific results are of high quality and can be applied in many areas, including the development of new solutions in food technology, production of machinery and equipment for food production, packaging, transport, and warehousing logistics. Based on the calculation of investment costs and their payback period, the investment attractiveness of the project for the production of dried food products using the developed technologies were assessed. The low payback period (up to 3 years) proves the feasibility of the project and its attractiveness to the investor. The high level of potential of the developed technology of dried food products and significant prospects for its implementation in the practice of food industry enterprises have been diagnosed.

References:

1. *Scientific and innovative activity of Ukraine. (2016). Kyiv: State Statistics Service of Ukraine*
2. *Scientific and innovative activity of Ukraine. (2017). Kyiv: State Statistics Service of Ukraine*
3. *Scientific and innovative activity of Ukraine. (2018). Kyiv: State Statistics Service of Ukraine*
4. *Scientific and innovative activity of Ukraine. (2019). Kyiv: State Statistics Service of Ukraine*
5. *Drying fruit as a business (2019). Retrieved from https://uasushka.com/ua/sushka-frukt%D1%96v-yak-b%D1%96znes.html*
6. *In Ukraine, named a lucrative niche in vegetable growing (2020). Retrieved from https://dzi.gov.ua/press-centre/news/v-ukrayini-nazvano-nadprybutkovu-nishu-v-ovochivnytstvi/*
7. *Ukraine has set a record for the export of vegetables and fruits (2020). Retrieved from https://www.unian.ua/economics/agro/10859066-ukrajina-vstanovila-rekord-z-eksportu-ovochiv-ta-fruktiv.html*
8. *Sales of dried vegetables and fruits are growing rapidly. (2020). Retrieved from https://agro.guide/prodazhi-sushenykh-ovochiv-ta-fruktiv-intensyvno-zrostaiut-5352/*
9. *Niemirich, O. (2019). Scientific substantiation and development of technology of dried food products and food products with its use. (Doctoral Thesis). National University of Food Technologies. Kyiv*
10. *Methods for determining the economic efficiency of research and*

development costs and their implementation in production. § 218/446. (2001).

11. *Methodical recommendations for the commercialization of developments created as a result of scientific and technical activities. § 18. (2010).*
12. *Karpov, V.A., Koroliov, T.S. & Pidgorny, A.Z. (2005). Methods for evaluating the effectiveness of research work. Odessa: ODEU, rotaprint.*
13. *Yakovlev, A. (2016). Means of determining the effectiveness of the creation and sale of science-intensive products. Economist, 3, 23-25.*
14. *Koshevyi, M.M. (2015). Ensuring the development of science-intensive industries of associations of enterprises. (PhD Thesis). National University of Water Management and Environmental Sciences. Kyiv*
15. *Reshetniak, O. (2008). Modern methods of enterprise management in the service sector. Kharkiv: Factor*
16. *Stock market infrastructure development agency of Ukraine. (2020). Retrieved from https://smida.gov.ua/about*