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ECONOMIC AND PUBLIC HEALTH EFFECTS OF IMPLEMENTING OIL-FREE TECHNOLOGIES IN THE U.S. FOODSERVICE INDUSTRY

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Abstract. *The article is devoted to the analysis of the economic, social and health consequences of the introduction of oil-free technologies in the US food service. The purpose of the article is to analyze the economic and social and health effects of the introduction of oil-free technologies in the US food service. At the same time, the study is based on general scientific approaches to cognition, as well as on the scientific approaches of Yu. Manko. The author developed a model for the transformation of kitchens through certified and energy-efficient cooking systems focused on healthy eating and sustainable business development. The results demonstrated the importance of restaurant modernization: from traditional frying in oil to hot air methods that reduce the formation of harmful substances. This is accompanied by a reduction in food waste, a decrease in the load on ventilation systems and the formation of environmentally responsible practices. Oil-free devices used in public catering establishments have proven their ability to ensure process stability, high productivity and optimization of operating costs. The economic effect is systemic: reducing oil use by up to 80% allows medium-sized establishments to save up to $13,000 per year and approximately $90,000 over the seven-year equipment life cycle. In turn, the social and health effect is manifested in a decrease in inhalation load on personnel, a decrease in the calorie content of dishes and a decrease in saturated fat consumption, which, according to meta-analyses, is associated with a decrease in the risk of cardiovascular events. The proven reduction in acrylamide formation by 40–90% creates an additional protective effect for consumers. As a result, oil-free technologies create the basis for increasing economic efficiency and forming healthier eating patterns in the United States.*

Keywords: *oil-free technologies, food service, economic effect, healthy eating, environmental sustainability.*

Introduction

The modern US catering industry finds itself in a situation where several systemic challenges are superimposed on each other, forming a new configuration of requirements for professional kitchens. On the one hand, the demand for fast service is growing. This creates a high operational load and requires uninterrupted operation of equipment. On the other hand, occupational health and safety standards for consumers are being strengthened. The main focus of the standards is on reducing excess fat in their diet and finding healthier alternatives to traditionally fried foods. At the same time, the problem of technological working conditions in restaurant kitchens remains relevant, where the combination of high temperatures, oil vapors and thermal pollutants creates occupational risks, as well as occupational safety problems. In such conditions, technological solutions that can reduce the use of oil, while minimizing the

environmental, sanitary and occupational risks associated with it, become of strategic importance. Oil-free cooking methods, in particular hot air technologies, are becoming an innovative approach to heat treatment of products, as well as a mechanism that directly affects the quality of food, the health of employees and the overall sustainability of business models in the catering sector. This is evident from the fact that equipment that allows for a crispy texture without immersion in large amounts of fat has formed a separate segment of the restaurant market that is strategically focused on reducing trans fats, carcinogens, and energy costs.

Literature Review

Scientific sources form the evidence base of the study, providing an empirical assessment of the impact of thermal processing on food safety, indoor air and metabolic risks. A review by Z.A. Ahmed and N.K. Mohammed systematizes the factors of acrylamide formation in starchy foods and ways to reduce it [1]. A Cochrane meta-analysis demonstrates an association between a long-term reduction in saturated fat intake and a reduced risk of cardiovascular events [5]. A study by C.-C. Lee and M. Demirci describe the design features of deep-frying systems and their energy efficiency mechanisms [7], while R. Tang, R. Sahu, Y. Su, A. Milsom, A. Mishra, T. Berkemeier, and C. Pfrang evaluate air pollution from different cooking methods, comparing PM and VOC levels in traditional frying and hot air cooking [9]. In turn, A. Bhuiyan provides a detailed review of the functionality of commercial air fryers in high-load kitchens, conducting an experiment measuring emissions and oil consumption [3].

Analytical and statistical resources are represented by a number of specialized platforms: Deep Market Insights [2], Credence Research [4], Market Intelo [8], Ron Group Global [10], as well as RTS, which summarizes data on food waste in the United States [6].

Together, these sources form a comprehensive information base for assessing the impact of oil-free technologies on health, economic performance, and sustainability of the restaurant sector.

The purpose of the article is to analyze the economic and social and health effects of the introduction of oil-free technologies in the US food service. The objectives of

the study: to summarize market trends and economic indicators associated with the use of oil-free technologies; to assess the impact of these technologies on working conditions and indoor air quality; to identify potential health benefits for consumers in the context of reducing food risks.

Research Results

Fast food traditionally uses large amounts of vegetable and animal oils in the preparation of dishes: rapeseed, corn, sunflower and soybean oils, as well as animal fats, act as a heat carrier and at the same time form the taste properties of dishes. At the same time, all this oil creates its own “ecological footprint”, in particular, it needs to be grown, processed, transported and stored. After use, it forms a separate segment of waste, which also needs to be disposed of [7].

The total resource load can be estimated from global food waste statistics for 2025, which account for approximately 11% of global greenhouse gas emissions. At the same time, the amount of food that ends up in the US as waste is equivalent to the annual emissions of 37 million cars [6]. About 40% of this waste is generated at the level of restaurants, stores and service companies. In such a situation, technologies that reduce resource consumption and related emissions become a logical direction of development. Oil-free cooking technologies are one of the key lines. First of all, air fryers are one of such technologies. A review by Bhuiyan [3] shows that such devices are adapted to the conditions of high-load kitchens: they have an increased capacity (up to tens of liters), an expanded temperature range and are designed for continuous operation.

The principle of operation is based on the circulation of hot air at high speed around the product. Commercial air fryers are able to cook typical fast-food dishes — such as French fries or chicken wings — in a few minutes, fully complying with the requirements of quick service. Thanks to the circulation of hot air, stable product quality is ensured, which is a critical parameter for chain restaurants, where standardization of taste and texture is a key component of the brand [3].

The latest analytical reports on the market of commercial equipment for food service demonstrate the rapid growth of the economic significance of oil-free

technologies in the USA. In 2024–2025, a clear trend towards the spread of commercial air-fryer systems was formed. This is evident from the data of statistical services [2], which estimate the volume of the global market for commercial air-fryer ovens in 2024 at approximately $1.212 billion and predict its growth to $2.051.5 million by 2032 at an average annual rate of 6.8%. North America, including the USA, forms about 40% of this market. This share indicates the dominance of American foodservice in the implementation of oil-free technologies. In turn, this forms a structural demand for equipment capable of ensuring cooking stability and economic feasibility throughout the life cycle. In particular, Deep Market Insights [2] emphasizes that air-fryer technologies are integrated primarily into the fast and highly dynamic food segment, which is becoming one of the main drivers of market development. In parallel, other analytical platforms confirm similar dynamics. The expected annual growth of the segment is approximately 7%. This is consistent with forecasts that the market is expanding not sporadically, but systematically, due to a combination of technological and economic factors [2].

In the practical dimension of using oil-free cooking technologies at the business level, the economic effect of implementing oil-free technologies in US restaurants is determined primarily by a sharp decrease in cooking oil costs.

Reducing oil costs is one of the most noticeable and immediate consequences of the transition to air-fryer systems. Industry estimates by Ken Research confirm that such systems allow reducing the amount of oil required by up to 80% compared to traditional deep frying, while financial models by Ron Group Global [10] demonstrate that a restaurant that spends about $500 per week saves approximately $13,000 per year by reducing consumption by 50%. Over a typical equipment life cycle of about seven years, the total savings reach almost $90,000. This amount not only compensates for the initial investment in the equipment, but also forms an additional financial resource that can be directed to modernization or increase the operational capacity of the establishment [10].

The second aspect is the reduced maintenance costs. This is due to the fact that traditional fryers require regular oil filtration, careful temperature control and periodic

replacement of individual components. This configuration creates a significant technical load. In parallel, industrial air-fryer systems operate with minimal amounts of fat. This simplifies cleaning, reduces wear and tear, and can also reduce the level of technical costs of the enterprise [7]. The stability of the technological process creates the prerequisites for more accurate forecasting of raw material costs. If oil consumption is unstable and depends on its quality, then cooking on oil-free equipment requires only electricity costs. As a result, this further reduces the amount of product spoilage, since the use of electricity is programmed, while in oil the product can be overfried and become unusable [8]. As a result, a more rational inventory management system is formed. This is especially important in high-load kitchens, where even minor errors scale up throughout the day and generate additional costs.

Therefore, we summarize the economic consequences of using oil-free technologies in catering establishments in Table 1.

Table 1 – Economic consequences of using oil-free technologies in catering establishments

Factor of economic effect	Measurement and brief description
Reduction in oil usage	up to 80% less consumption compared to traditional frying; reduces direct expenses on fat purchases;
Annual savings on oil	with weekly costs of $500, approximately $13,000 saved per year due to a 50% reduction in oil usage;
Lifecycle savings on equipment	over 7 years, around $90,000 in accumulated savings;
Decrease in operational costs	lower demand for oil filtering, replacement, and disposal; simpler equipment maintenance;
Improved process stability	automated time and temperature settings reduce defective batches and write-offs;
Better resource management	predictable cooking cycles help minimize raw material losses and improve procurement planning;
Stronger position in the healthy food market	meets the demand for low-fat meals; supports growth in a segment expanding at 6.8–7% annually;
Market relevance in the USA	the USA represents a region that accounts for about 40% of the global commercial air-fryer market;

Note: systematized by the author based on sources [2, 7, 8, 10]

Modern oil-free technologies are shaping a new infrastructure for professional kitchens, and approaches to innovative modernization vary depending on the goals of the organization. To a greater extent, modernization approaches combine energy efficiency, sanitary safety, and optimization of operating costs. The author of the study,

Yu. Manko, is engaged in the modernization of catering kitchens. She is convinced that equipment certified according to NSF, UL, and Energy Star standards allows catering establishments to prepare crispy dishes without using oil, which has a positive effect on economic indicators, social, environmental, and general indicators of the population's health. The integration of artificial intelligence in kitchens enhances this effect thanks to the Profstore AI platform. This technology combines staff training, energy analytics, and kitchen process optimization. Staff receive step-by-step instructions on how to work with modern equipment, while establishment owners receive individual recommendations for modernization and savings calculations. This model creates the basis for the transition to a more environmentally and economically sustainable food service system, which, combined with modern technologies, can improve the efficiency of food establishments, increasing their profits. The social and medical benefits of using oil-free technologies are obvious for business owners, business employees and consumers.

First of all, the issue of indoor air quality arises. Comparative studies of thermal treatment methods show that traditional frying using large volumes of oil creates significantly higher concentrations of particulate matter (PM) and volatile organic compounds (VOCs). This is confirmed by the data of Tang et al. [9]. Under controlled conditions, during the preparation of standard portions of chicken fillet, the highest peak loads were formed by deep-frying and pan-frying methods. The air-frying mode, which uses minimal amounts of oil (sometimes only a few grams), demonstrated the lowest measured concentrations of both particles and organic compounds. In turn, the transition from immersion of the product in oil to cooking in a jet of hot air provided a multiple reduction in the level of pollution in the working area of the kitchen [9]. Since the measurements were made in the breathing zone of an adult, these results directly relate to the working conditions of the staff.

Higher concentrations of PM and VOCs in kitchens are associated with a greater load on the respiratory and cardiovascular systems. Cooking modes with a minimal amount of fat make it possible to significantly reduce these loads. This is evident from the data of Tang et al. [9]. If we consider that fast food operates in a high-intensity

mode with a large number of repeated cooking cycles throughout the day, the cumulative effect of reducing emissions in one cycle becomes systemic for the entire establishment.

As for consumers, here the main benefit is to reduce the calorie content of dishes.

Deep frying traditionally involves immersing the product in 500–800 g of oil [9], while methods such as air-frying require only a few grams of fat - 2 g of oil. This difference in fat use creates a significant marketing advantage for establishments offering low-calorie alternatives to traditional fried foods, which is important for establishments with dietary food, with food focused on preparing vegan dishes, dishes for children, the elderly, etc.

Scientific evidence shows that when people gradually reduce the amount of saturated and trans fats in their diet and replace them with healthier fats or starch-based products, the risk of cardiovascular disease is reduced. A large Cochrane review [5], which included almost 57,000 people, showed that if saturated fat intake was reduced for two years or more, the risk of heart attack, stroke and similar events fell by about 17% [5].

For fast food, this means a simple thing: when people eat less deep-fried food and more air-fried food, they consume significantly less saturated fat per 1,000 calories. This means that this cooking method brings the diet closer to the one that has been linked to a reduced risk of cardiovascular disease in clinical studies [5].

When foods, especially potatoes or other starchy foods, are fried in large amounts of oil at high temperatures, harmful substances are formed. The most important of these are acrylamide and HMF. Acrylamide is considered a “probable carcinogen,” meaning it has the potential to cause cancer. Studies also show that it can be toxic to the nervous system and damage DNA (this has been confirmed in animals) [1].

Cooking methods using hot air (air frying) make it possible to significantly reduce the levels of these harmful substances in foods. In particular, in French fries, the amount of acrylamide can be reduced by tens of percent, and in some studies even by up to 90%, compared to traditional deep frying. At the same time, the taste and texture of the dishes remain acceptable [1].

Although scientific evidence does not yet prove a clear link between the consumption of acrylamide in food and the risk of cancer in humans, reducing exposure to this potentially dangerous substance at the population level is considered an important step in prevention.

Table 2- Social and health effects of using oil-free technologies (air-frying)

Factor	Health effect (brief with figures)
Air pollution (PM, VOCs)	air-frying produces dramatically lower PM and VOC levels compared with frying; deep/pan frying shows the highest peaks; air-frying results in minimal values [9]
Working conditions	reduced oil aerosol leads to lower respiratory and cardiovascular stress risks for staff;
Fat consumption during cooking	deep frying uses 500–800 g of oil; air-frying uses 2 g [9]
Fat content and caloric density of dishes	fat content in finished products drops by 50–75%; caloric density decreases while flavor is preserved;
Saturated fats and cardiovascular risk	reducing saturated fats in the diet lowers cardiovascular event risk by 17%; air-fried dishes contain substantially less fat per 1000 kcal [5]
Acrylamide and HMF	air-frying cuts acrylamide in French fries by dozens of percent, sometimes up to 90%.

Note: systematized by the author based on sources [5, 9]

Changing cooking technologies are also changing consumer preferences. According to Ken Research, the demand for less fatty dishes is growing, which makes air-frying technologies an important part of the marketing strategy. The ability to significantly reduce the amount of fat while maintaining the texture of frying creates new commercial niches - from fast-casual to QSR brands that seek to increase their competitiveness.

Conclusions

In general, trends in the fast-food sector demonstrate a gradual departure from the model of mass frying in oil. Instead, a vector is being formed for technologically more complex, but resource-saving solutions. Statistics on food waste and related greenhouse gas emissions show that the restaurant segment is an important element in the chain of environmental losses. Data on air pollution with different cooking methods convincingly demonstrate: modes with a minimum amount of oil, such as air-frying, can significantly reduce the concentrations of particulate matter and volatile organic compounds. The description of the capabilities of commercial oil-free devices confirms

their ability to meet the requirements of high productivity and cost-effectiveness. The result is a holistic conclusion: oil-free technologies in fast food are becoming part of the transition to a more environmentally and resource-responsible model of public catering. The introduction of oil-free technologies into the US food service has a systemic economic effect. It consists in a direct reduction in oil costs - up to 80% of traditional consumption - which for establishments with expenses of about $ 500 / week provides savings of approximately $ 13,000 / year, and over a seven-year equipment cycle - up to $ 90,000. Additionally, operating costs are reduced due to a reduction in the need for filtration and disposal of fat, and productivity and process stability are increased - which is critically important for the market, which in the US forms a significant share of the commercial air-fryer segment. Reduction of write-offs and more efficient resource management complement these effects, while the growing demand for healthier dishes strengthens the commercial feasibility of such technologies. On an industry-wide scale, these trends form the basis for the sustainable long-term development of the commercial food preparation segment.

The social and health effect of the introduction of oil-free technologies is a significant reduction in harmful effects on both workers and consumers. The transition from traditional frying to the use of oil-free technologies improves working conditions and reduces inhalation exposure. For consumers, this means lower calorie and fat content of dishes, which, according to Cochrane data, is associated with a reduction in the risk of cardiovascular events by approximately 17% with a long-term reduction in saturated fat intake. Air frying methods can reduce the formation of potentially carcinogenic compounds by up to 90%, which reduces exposure to harmful substances in food. As a result, oil-free technologies simultaneously create safer working conditions, contribute to healthier eating patterns, and reduce the risks to the population associated with the consumption of traditionally fried foods.

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