Trends and COVID-19 Disruptions on Innovation Management Aspects in Fruits and Vegetables Preservation

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Research

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Abstract

The research aimed at analyzing several facets of innovation management in the field of fruit and vegetable preservation. The analysis was based on a review of the trends using the Web of Science database and a questionnaire survey to assess the potential influence of the COVID-19 pandemic on the condition of innovation management in the field of fruits and vegetables preservation. A thorough analysis and evaluation of 256 journal articles retrieved from the Web of Science database were done. The results show that there has been an imbalance in the distribution of researchers by region and that research on fruit and vegetable preservation innovations did not increase until recent years. A total of 18.04% of the papers on the subject that the investigation could locate were generated by Italy and the USA, accounting for around 9.02% of them each. Furthermore, the results showed that, in terms of the demand for innovations and investment level in fruit and vegetable preservation, the COVID-19 innovation disruption had a bigger influence on large-scale firms than on small businesses. It is also worth pointing out that the research findings to now, which have primarily been based on laboratory-scale studies, have not fully taken into account the cost-effectiveness of the suggested preservation technologies. The goal of a cost-effective therapy can only be partially met by the different approaches that have been proposed. If sustainable innovation management in the field of fruits and vegetables preservation is to be achievable on a global scale, an effort must be made to fund more research activities, particularly in the cold and arid and semi-arid regions. Practical considerations dictate that small-scale research that uses readily available and affordable materials be encouraged. This will make it possible to do a logical cost-benefit analysis of a particular technique or strategy for addressing fruit and vegetable preservation.

1.0 Introduction

Fruits and vegetables are a fundamental component of cuisines and are essential for supplying consumers of all ages with fresh, wholesome food worldwide. Dietary sustainability is one of the most significant worldwide concerns of the twenty-first century (Reinhardt et al. 2020). The fruit and vegetable supply chain is significantly impacted by the COVID-19 pandemic in particular. There are new costs and challenges to deal with even while there is a lot being done to ensure the consistency and continuity of supply at points of sale. The inefficiency brought on by the necessary social isolation in orchards and packhouses, increases in logistical expenses as a result of trucks returning empty to their base, increased safety precautions, and delays are only a few of the causes of these new expenditures. Additionally, there are product losses and market pressures. Because these greater costs are not offset by higher returns on sales, pressure is mounting on growers and merchants (OECD 2020). Despite the fact that global agriculture effectively supplies enough calories for the world’s current population, there is a considerable overproduction of high-energy foods, especially sugar, cereals, and oils, and insufficient worldwide production of fruits and vegetables (Bisbis et al. 2018). The transition to healthy diets necessitates the availability and affordability of the required foods for low-income populations. Therefore, increasing the consumption of and production of fruits, and vegetables, and moving toward a diet high in plant protein is the best strategy for a rising population (especially impoverished consumers) to attain a nutritionally
balanced diet, save land, and reduce greenhouse gas emissions (Lau et al. 2021). The consumption of most individuals still does not reach the World Health Organization (WHO) recommendations for a healthy diet, despite the general recognition and preference of consumers for safe, high-quality, nutritious fresh fruits and vegetables and the rise in health awareness (Kumanyika et al. 2020). Additionally, a lot of waste is produced during the production, storage, and processing of fruits and vegetables, and because of their high moisture content and organic matter load, they have the potential to seriously pollute the environment (Porat et al. 2018). As a result, efficient and sustainable processing is crucial to the modernization of the fruits and vegetables system. Because fruits and vegetables are seasonal and only available for a limited time, attempts have been made to preserve the availability of safe fruits and vegetables for longer periods of time, allowing for a more varied diet throughout the entire year (Chavan and Amarowicz 2012; Liu et al. 2020; Sapper and Chiralt 2018; T. Xu et al. 2019). Increased palatability was also a result of traditional processing methods, particularly in terms of texture, stability during transport, and consumer convenience (Swain and Ray 2017).

Additionally, consumer preference has a big impact on how much fruits and vegetables are consumed. In other words, customers make decisions about buying fresh produce based on search (such as color, size, firmness, and flaws), experience (such as taste, texture, and cooking quality), and credibility (such as organic, fair trade, local origin, and pesticide residues) considerations. The future of processed fruits and vegetables products may therefore also need to satisfy consumers' desire for qualities that are natural, nourishing, healthful, and individualized (Kokthi et al. 2021). It is difficult to strike a balance between safety, micronutrient preservation, and energy expenditures in practice even though minimal processing can theoretically boost the nutritious value. Unprocessed fruits and vegetables contain a high number of vital nutrients, such as vitamins and minerals, but it is unclear how much of these elements will be maintained after processing as well as how much of them will be accessible and digested (Slavin and Lloyd 2012). Small local mobile workshops have proliferated, but these regional processing facilities also face numerous political, economic, and cultural obstacles. Due to their high moisture content, perishability, and vulnerability, fresh fruits and vegetables have more severe requirements for stable and secure preservation across the supply chain (Calín-Sánchez et al. 2020; Ferdaus et al. 2020; Tedesco et al. 2021).

To assure product safety, this may, however, result in unnecessary packaging and the misuse of numerous substances in most items, which would produce too much waste and environmental degradation. The best modern fruits and vegetables preservation solutions ought to be adaptable and tailored, resource-efficient, and dependent on seasonality and demand (Mieszczakowska-Frąc et al. 2021). Focusing on technical and financial viability, they should also take into account the needs of customers and the food supply chain in addition to the distinctive and typical expectations of major industries or small and medium-sized fruits and vegetables processors. To handle its complexity and the losses and waste throughout the entire chain, a robust fruits and vegetables chain system needs to be built. For example, better post-harvest preservation of fruits and vegetables, well-utilized and controlled data, well-organized logistics in the supply chain, and cutting-edge processing equipment and technology are all necessary interventions. Thus, perishable fruits and vegetables can be successfully processed and
employed as consumer goods or reliable culinary ingredients (Pirozzi et al. 2021; Teimoury et al. 2013).

Additionally, the study of food processing, particularly the processing of fruits and vegetables, is complex and involves a number of scientific fields, necessitating the dissolution of disciplinary boundaries.

Over the past ten years, there has been a rise in customer demand for high-quality, fresh food products, which has raised interest in the creation of novel food processing technology (Morales-de la Peña et al. 2019). It is also important to understand that food preservation refers to processing done to food to prevent microbial, enzyme, and autooxidative deterioration (Tavman et al. 2019). The main goal of food preservation is to either stop or significantly reduce the activity of pathogenic bacteria. Many preservation methods are now utilized on a global scale, including chemical preservation, canning, dehydration, freeze-drying, salting, pickling, pasteurization, fermentation, and carbonation.

In the Republic of Kazakhstan, stabilizing domestic agricultural production through enhanced productivity and profitability of the agricultural sector’s branches, with effective government supervision, is currently the key priority in ensuring food security (Tireuov et al. 2020). The Republic of Kazakhstan's national interests in the agricultural sector includes: ensuring the required amount of domestic food production and maintaining the state food reserve at a normative level; ensuring the quality of products and sales in accordance with food quality and safety standards; as well as ensuring the required subsistence wage and a decent standard of high-quality, healthy living (Aigarinova et al. 2014). Many research projects aim to keep fruits and vegetables fresh till consumption (Li et al. 2017; Miller et al. 2013; Pinto et al. 2016). Fresh fruit and vegetable quality losses due to inappropriate postharvest technology use typically occur during the cold chain. In order to keep the original quality and stop microbial decomposition, it is also crucial to use the right postharvest preservation techniques, especially when fresh fruit is being shipped to far-off markets (Xing et al. 2019). However, supporting original thought is essential for technological advancement. Unfortunately, the fruit and vegetable preservation sector hasn’t seen a lot of innovation. As a result, the study attempts to examine several aspects of innovation management in the field of fruit and vegetable preservation. The Web of Science database was used for a review of the trends, and a questionnaire survey was used to gauge the possible impact of the COVID-19 pandemic on the state of innovation management in the field of fruit and vegetable preservation. 256 journal articles were taken from the Web of Science database and thoroughly examined and evaluated.

2.0 Materials And Methods

2.1 Case study description

Kazakhstan is bordered by Russia to the northwest and north, China to the east, Kyrgyzstan, Uzbekistan, the Aral Sea, and Turkmenistan to the south, and the Caspian Sea to the southwest. Kazakhstan is the ninth-largest nation in the world and the biggest in Central Asia. Kazakhstan spans roughly 1,820 miles (2,930 kilometers) east to west and 960 miles north to south between its furthest points. Kazakhstan has geographical features that are comparable to those of the other Central Asian nations, despite the fact
that Kazakhstan was not deemed to be a part of Central Asia by authorities in the former Soviet Union. Despite having a framework in place to control innovative activity, Kazakhstan's real innovation-related policies and efforts indicate that this mechanism is far from being effective on a national level as well as at the level of specific industries, regions, and businesses. In order to diversify its resource-based economy and further its socioeconomic growth, Kazakhstan is conscious of the value of innovation. Kazakhstan has put in place crucial elements of a contemporary research and innovation system since the turn of the millennium. This has enhanced scientific research and led to certain technological commercialization triumphs. The ability to innovate will need to be strengthened in order to fully utilize Kazakhstan's assets. Further reforms are needed in order to, among other things, improve the governance of the research and innovation system, strengthen the funding model for universities, intensify and broaden knowledge transfer, and boost the efficacy of innovation incentives and policies, with an emphasis on implementation and evaluation (OECD 2022).

2.2 Data collection from Web of Science Core Collection

The analysis of data from the Web of Science Core Collection, a selective citation index of intellectual and scientific publishing that includes journals, conferences, books, and data compilations, was the focus of the study's first section, as was previously mentioned. The survey included information on 256 published works as of October 24, 2022. The summary of the documents used in the study is given in Table 1.

<table>
<thead>
<tr>
<th>Type of document</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article</td>
<td>153</td>
</tr>
<tr>
<td>Proceeding Paper</td>
<td>75</td>
</tr>
<tr>
<td>Review Article</td>
<td>29</td>
</tr>
<tr>
<td>Book Chapters</td>
<td>16</td>
</tr>
<tr>
<td>Early Access</td>
<td>4</td>
</tr>
<tr>
<td>Editorial Material</td>
<td>1</td>
</tr>
</tbody>
</table>

2.3 Questionnaire survey on the potential disruptions caused by the pandemic

How have the social and economic ramifications of the COVID-19 disruption changed the organization's future focus on innovation and how the COVID-19's social and economic ramifications impacted the amount of cash made available for fostering innovation in the firms were also examined in the study based on a questionnaire survey with a total of 54 enterprises associated to fruits and vegetables.
It is also crucial to emphasize that a questionnaire is a research tool composed of a list of questions used to gather information from respondents during a survey or statistical analysis. In that matter, the companies of the respondents were classified into three groups as observed in Table 2.

Table 2
Survey firm size distribution

<table>
<thead>
<tr>
<th>Firm size</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scale</td>
<td>1–20</td>
</tr>
<tr>
<td>Medium-scale</td>
<td>21–1000</td>
</tr>
<tr>
<td>Large-scale</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>

The study's minimal sample size was determined by calculating the sample size prior to the execution of the study. The phrase "sample size" in research refers to the number of people who are included in a study to adequately reflect the population. This is the overall number of participants in a study, and it is frequently divided into subgroups based on demographics to ensure that the final sample accurately reflects the entire community. One of the most crucial aspects of statistical analysis is choosing the proper sample size. The formula used in the sample size determination is summarized in Eq. 1.

\[
\text{Sample size} = \frac{(z - \text{score})^2 \times \text{StdDev} \times (1 - \text{StdDev})}{(\text{margin of error})^2}
\]

1

It should be noted that the margin of error (confidence interval) indicates how far your data can deviate from the population mean. How closely you should expect a survey result to fall in relation to the actual population value is described by the margin of error. The standard deviation is a measurement of how far a data collection deviates from the mean. It gauges a distribution's absolute variability. The standard deviation and size of the deviation both increase with increasing dispersion or variability. The Z-score, on the other hand, is a statistical measurement that expresses how closely a value relates to the mean of a group of values. Standard deviations from the mean are used to measure Z-score. A Z-score of zero means the data point's score is the same as the mean score.

2.4 Statistical analysis

2.2.1 Data distribution analysis

The data distributions among the specified parameters of interest were evaluated using box and whisker diagrams. Data quartiles, also known as percentiles and averages, were used to evaluate the distribution of the data based on the skewness of the numerical data (Mkilima et al. 2021).

2.2.2 Analysis of Variance
In order to determine the statistical significance levels of the variations in the examined parameters (publications per decade), a single-factor Analysis of Variance (ANOVA) was carried out in this study. This was achieved through utilization of samples from each group of data arranged in decades; whereby, the approach assessed the degree of variation within each group. The significance level was evaluated using the difference between the \( p \) and alpha (0.05) values. Therefore, to determine the significance levels of the differences, the comparison between the \( p \)-value and alpha value was done. In that matter, if the \( p \)-value is greater than the alpha, the null hypothesis is accepted. The \( p \)-value, on the other hand, displays the likelihood of obtaining a result that is more extreme than the experiment's outcome (Gulnur et al. 2023; Meiramkulova et al. 2023).

### 2.2.3 Tukey's honest significance test

The study also used Tukey's Honest Significance Test, a single-step multiple comparison technique and statistical test. It was used to evaluate whether there were any statistically significant deviations from the means of the parameters under consideration (Utepov et al. 2022).

### 2.2.4 Scheffé multiple comparison

Scheffé multiple comparisons, a single-step multiple comparison technique, were employed to evaluate whether the means of the parameters under examination had any statistically significant deviations. This procedure is similar to Tukey's Honest Significance Test (Meiramkulova et al. 2022).

## 3.0 Results

### 3.1 General trends of innovation in the fruits and vegetables preservation sector

In this study, a trend analysis was utilized to acquire a broad overview of the scientific efforts in the area of fruit and vegetable preservation innovation. Despite the general growth of publications, it is also clear from the trend that the tendency is still not consistent and that it varies over time (Fig. 2 (a)). Additionally, based on the search criteria, the Web of Science database does not list any articles on the relevant topic for the years 1996, 1998, and 2001. The highest publishing record is found starting in the year 2020 with 33 indexed articles, and the tendency is seen to be eroding over time from 2021 to 2022, which is an interesting phenomenon. From Fig. 2(b), it can be stated that according to the review, compared to the 1995–2004 and 2005–2014 decades, the innovation activities in the field of fruit and vegetable preservation increased considerably more rapidly over the 2014–2022 timeframe.

### 3.1.1 Evaluation of publication variance using Analysis of Variance (ANOVA)

ANOVA was one of the statistical techniques utilized to assess the publication trend throughout the years from the documents that were retrieved. It is important to note that ANOVA is a method for comparing the
averages of different populations that is based on random, independent samples from each population. It offers a statistical evaluation to evaluate whether population means are equal or not. The parametric test ANOVA makes the assumption that the data will be distributed normally (null hypothesis). A type of statistical test called the F-test figures out the variance-to-mean ratio. The ratio of explained to unexplained variances in an ANOVA is measured using the F-test. ANOVA demands adherence to three suppositions. Samples must be independent, come from a population with a normal distribution, and have equal standard deviations for each group in the F-test. The linear dependence between two variables can be measured using it. Table 2 presents an overview of the ANOVA results. Following the division of the published datasets into decades, the Single-factor Analysis of Variance was applied. Notably, the null hypothesis that there is no difference in the means is rejected when the p-value is less than 0.05, indicating that there is a significant difference. The published data, as shown in Table 3, produced a p-value of \(1.74 \times 10^{-8}\), which is less than 0.05 (alpha-value), making the data variances statistically significant.

<table>
<thead>
<tr>
<th>SUMMARY</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995–2004</td>
<td>10</td>
<td>17</td>
<td>1.7</td>
<td>3.122</td>
</tr>
<tr>
<td>2005–2014</td>
<td>10</td>
<td>77</td>
<td>7.7</td>
<td>10.9</td>
</tr>
<tr>
<td>2015–2022</td>
<td>10</td>
<td>222</td>
<td>22.2</td>
<td>75.511</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2221.667</td>
<td>2</td>
<td>1110.833</td>
<td>37.22077</td>
<td>1.74 \times 10^{-8}</td>
<td>3.354</td>
</tr>
<tr>
<td>Within Groups</td>
<td>805.8</td>
<td>27</td>
<td>29.844</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3027.467</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.2 Evaluation of publication variance using Tukey's honestly significant difference test (Tukey's HSD)

Tukey's honestly significant difference test was used in this study to assess the significance of differences between sample mean values, as was briefly mentioned earlier. All pairwise differences are tested using Tukey's HSD method, which also manages the likelihood of making one or more Type I errors. In addition to the ANOVA, the publishing data were divided by decades and tested using Tukey's honestly significant difference test. The results of Tukey's HSD tests are summarized in Table 4. The decade-by-decade comparison between the datasets from 1995 to 2004 and 2005 to 2014 produced a p-value that is higher than 0.05, indicating that the differences are not statistically significant. While the
comparisons of 1995–2004 to 2015–2022 and 2005–2014 to 2015–2022 both produced p-values less than 0.05, whereby, statistical significance was found for the differences.

### Table 4
Summary of the results from Tukey HSD

<table>
<thead>
<tr>
<th>Treatments pair</th>
<th>Tukey HSD Q statistic</th>
<th>Tukey HSD p-value</th>
<th>Tukey HSD inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995–2004 vs 2015–2022</td>
<td>11.8665</td>
<td>0.001005</td>
<td>** p &lt; 0.01</td>
</tr>
<tr>
<td>2005–2014 vs 2015–2022</td>
<td>8.3934</td>
<td>0.001005</td>
<td>** p &lt; 0.01</td>
</tr>
</tbody>
</table>

### 3.1.3 Evaluation of publication variance using Scheffé method

It is significant to remember that the Scheffé test is a post-hoc statistical test employed in statistical analysis. When a comparison is made inside a data set after an ANOVA test has been performed, the comparison’s parameters are not taken into account during the ANOVA experiment. To ascertain whether individual means differ or whether the average of one group of means differs from the average of another group of means, the Scheffé test can be utilized. The Scheffé test was employed in the study to further explore the significant levels of the variations among the examined decades. Table 5 summarizes the outcomes of the Scheffé test. The decade-by-decade comparison of the datasets from 1995 to 2004 and 2005 to 2014 using the Scheffé method yielded similar results to those of Tukey’s HSD. Whereby, the 1995–2004 to 2015–2022 and 2005–2014 to 2015–2022 comparisons both gave p-values less than 0.05, making the differences statistically significant. However, 1995–2004 vs 2005–2014 produced a p-value of 0.065754, which is higher than 0.05, making the differences statistically insignificant.

### Table 5
Summary of the results from Scheffé analysis

<table>
<thead>
<tr>
<th>Treatments pair</th>
<th>Scheffé TT-statistic</th>
<th>Scheffé p-value</th>
<th>Scheffé inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995–2004 vs 2015–2022</td>
<td>8.3909</td>
<td>$3 \times 10^{-8}$</td>
<td>** p &lt; 0.01</td>
</tr>
<tr>
<td>2005–2014 vs 2015–2022</td>
<td>5.935</td>
<td>$1.27 \times 10^{-5}$</td>
<td>** p &lt; 0.01</td>
</tr>
</tbody>
</table>

### 3.2 Publications per country

According to the Web of Science database, Fig. 3 summarizes the publications from 1995 in the area of fruit and vegetable preservation innovation. Figure 3 shows that the USA and Italy are the top two nations in terms of publications in the field of innovation research in fruit and vegetable preservation methods within the period. Furthermore, we understand that more innovation initiatives are required in developing nations as innovation is a key factor in long-term economic growth and sustainable development. The
direction of innovation is important because technological progress is not neutral and has substantial effects on social, economic, and environmental development.

3.3 Publication language

According to Figure, English continued to be the most often used language in scientific publications since 1995, accounting for 97.66% of all publications on the subject of innovation in fruits and vegetable preservation. With 1.56% of the indexed publications published in French and Portuguese as well as 0.78% in German and Spanish.

3.4 Questionnaire survey for a case of Kazakhstan

3.4.1 External factors affecting innovation in the fruits and vegetables preservation sector

By conceptualizing the creative activities of enterprises as embedded in political, social, organizational, and economic systems, the systems view of innovation emphasizes the significance of the external environment. These outside variables may have an impact on a company’s innovation incentives as well as its innovation efforts, capabilities, and results. External influences may also be the focus of a corporate strategy, a government initiative, or a coordinated social movement by public interest groups. It is possible to measure external influences on businesses’ innovation activities directly or indirectly. Without directly mentioning innovation, indirect measurement gathers data on how external influences affect the firm. In this instance, after data collection, the effects of external factors on innovation are discovered, for instance by econometric analysis. With indirect measurement, data can be gathered for all types of businesses, regardless of how innovative they are. In contrast, direct measuring techniques allow respondents to evaluate the significance and influence of an outside factor on a particular innovation-related characteristic. There isn’t much more research needed to answer these questions. Direct questioning, however, may introduce cognitive biases, or there may not have been enough time for the respondent to assess the impact of an outside issue on the firm’s innovation activities or results. Figure 5(a) shows that readiness to attempt novel ways appears to have a greater impact on small-scale businesses, whereas governance quality appears to have a greater impact on medium-sized businesses. The availability of local expertise, governance quality, and the willingness to explore fresh ways were found to have a greater impact on large-scale enterprises (Fig. 5(c)).

3.4.2 The survey on the impact of COVID-19

According to Fig. 6, 63% of respondents said that medium-sized businesses related to the processing technologies for fruits and vegetables had really low levels of innovation motivation during the COVID-19 era, and 51% of respondents said the same about large-scale businesses. Additionally, small-scale businesses showed a 28% substantially elevated motivation for innovation, which is significantly greater than the 10% from medium-sized businesses and 10% from large-scale businesses.
On the other hand, the study also looked into how COVID-19 affected the financing level of the firms as influenced by the investment level. The summary of the survey results on the effect of COVID-19 on investment levels is shown in Fig. 7. Similar to what can be usually seen, large-scale enterprises saw lower levels of investment than small-scale firms. It is evident that 74% of respondents from large companies indicated extremely low levels of investment during the COVID-19 timeframe. However, compared to 21% of medium-sized enterprises and 5% of large-scale organizations, 42% of respondents from small-scale firms indicated a considerable increase in investment level.

An overview of the findings from the investigation of how COVID-19 typically impacted several innovation-related parameters is shown in Fig. 8 regardless of the size of the impacted firm. Figure 8 shows that the COVID-19 scenario had a significant impact on funding, market availability, shipping of goods, and profit-making in the recent past. It should be noted that the study's definition of "goods transportation" includes any sort of cargo or goods that are transported using vehicles like trucks, cars, trains, ships, and airplanes.

4.0 Discussion

Although innovation management research efforts for the preservation of fruits and vegetables have recently increased, the regional distribution of researchers working on this topic is unbalanced, according to the analysis and examination of the available journal articles in this study. Accordingly, Italy and the USA produced around 18.04% of all the papers on the topic that the study was able to find (about 9.02% each). It should be noted that the market for fresh-cut products in Italy is growing and exhibiting numerous novel characteristics related to the overall market, the regulatory environment, and measures for the valuing of local products (Fusi et al. 2016; M. Merlino et al. 2020; Testa et al. 2021). The highly inventive fresh-cut items have a high degree of variability and/or supply growth with changes in market equilibrium, even over a short period of time (Timpanaro et al. 2015). According to this reasoning, methods that entail enhancing already-available items or allowing for the conversion of conventional products into novel ones in order to provide new features to the markets are included for the benefit of the fresh-cut products segment (Nicola et al. 2006). This dynamism creates certain challenges for measuring the phenomena or context, and in Italy, it places the fresh-cut product industries among the unseen economic sectors, leading to problems with time and space comparisons and data replication (Schiavi et al. 1998). However, institutional organizations and/or market segments that gather and process the findings of direct surveys with the character of continuity for their own objectives are very interested in and highly drawn to the economic importance of the Italian market. These findings, along with socioeconomic and market studies of this market category in Italy, are important insights into fresh-cut product trends and evolutionary potential (Zarbà et al. 2022).

Moreover, according to the review, compared to the 1995–2004 and 2005–2014 decades, the 2014–2022 period had a relatively stronger development in innovation activities in the field of fruits and vegetables preservation. In contrast to other industries, the increase is still insufficient. The phenomenon necessitates the development of more creative solutions in the field. It is important to highlight that, the
way people buy and consume food has significantly changed in recent years. Although there are many factors contributing to these changes, some of the most important ones include contemporary work patterns, the expanding number of families where both couples are employed, income growth, and the increased engagement of women in the labor force (Fredericks and Anderson 2013). Families now have less time to spend in the kitchen, which has increased demand for convenience and ready-to-eat goods (Ankeny et al. 2019). The rapid advancement of food technologies, particularly the expanding usage and production of food additives, has led to changes in family lifestyles such as the eventual abandoning of the virtually daily food purchase habit and prompt meal preparation (Mesías et al. 2021). As was previously said, during the past ten years, interest in the development of novel food processing technologies has developed as a result of rising customer demands for high-quality, fresh food products. Today, a variety of preservation methods are employed extensively over the world, including refrigeration (Aste et al. 2017), freezing (Rahman and Velez-Ruiz 2020), canning (Zheng et al. 2021), dehydration (Ahmed et al. 2016), freeze-drying (Ratti 2001), salting (Guinee and Fox 2017), pickling (Scheinberg et al. 2013), pasteurization (Ramesh 2020), fermentation (Caplice 1999), carbonation (Srivastava et al. 2021), cheese-making (Jiao et al. 2021), and other chemical-based preservation methods (Chen et al. 2021; Sridhar et al. 2021; Zhang et al. 2021).

With 97.66% of all publications covered on the subject written in English, the language continues to be the language of communication in science (Meyerhöffer and Dreesmann 2021). The most effective approach to communicate research findings with scientists around the world is today in English, despite the fact that many nations still publish journals in their native tongue (Silva and Signorini 2021). Of course, having a universal language has many advantages. The results are more accessible to a larger audience, and international scientific exchange is greatly increased. But we must also take the disadvantages into account. Non-native English speakers are clearly at a disadvantage as compared to native speakers when it comes to writing and generating interest in their studies because English is primarily the language of science and technology (Ramírez-Castañeda 2020). It also makes it more difficult to judge a scientific study only on the basis of its findings. Clarity issues might detract from even the most fascinating study.

The findings revealed that while governance quality tends to have a bigger impact on medium-sized organizations, preparedness to try creative approaches appears to have a greater impact on small-scale businesses. It was discovered that large-scale firms were more impacted by the availability of local expertise, the quality of governance, and the desire to try new ideas. Business activities can be influenced both directly and indirectly by society and the environment. It has to be noted that, both the public's reception of innovations and corporate social responsibility programs can be influenced by societal factors (Aghmiuni et al. 2020; Petridis et al. 2020). System-wide innovations, like the transition to a low-carbon economy, can be sparked by more significant societal shifts. Company innovation can also be influenced by how business activities and products affect the environment, such as when companies try to minimize negative consequences through "green" inventions (Brasliņa et al. 2021). As in the case of climate change adaptation, businesses can also participate in innovative operations in reaction to anticipated changes in the natural environment. Programs offered by the government to assist
businesses to entail direct or indirect resource transfers. Support might come in the form of money or in-kind donations. Government agencies may provide this assistance directly or indirectly, for instance, by giving consumers subsidies to buy particular goods (Najib et al. 2021). Companies can gain from government funding that focuses on either company operations (such as spending on R&D or the purchase of new equipment) or the results of such operations (Teng et al. 2020). The revenue streams that resulted from earlier innovation efforts are a good example. Government financing frequently focuses on innovation-related activities and results. Evidence regarding the scope and effects of various forms and levels of governmental assistance for innovation is specifically demanded due to national and international regulations that govern the circumstances under which help can be given to businesses (OECD/Eurostat 2019).

The findings demonstrated that the COVID-19 innovation disruption had a greater impact on large-scale businesses than on small businesses in terms of the need for innovations in fruit and vegetable preservation. Despite the pandemic’s widespread effects on all facets of life, most small businesses in the industrial sector did not experience a decline in their revenues, and most of them did not change their business practices, the extent to which they used open innovation tools, or the extent to which they promoted innovation, according to Harel (Harel 2021), who examined how COVID-19 affected small businesses’ performance and innovation. The findings also imply that small enterprises, which rely mostly on long-term contracts and subcontracting for their revenue, will do better amid economic downturns and uncertainties. This phenomenon is in line with the study’s findings. Also, the findings also indicated that large-scale firms were observed to be more impacted by investments in fruit and vegetable preservation innovations than small-scale ones. This is similar to how the COVID-19 situation has affected the general motivation of fruit and vegetable firms to engage in more innovative activities. The results of this study are in line with those of Jin et al. (Jin et al. 2022), who discovered that COVID-19 has a more detrimental effect on major organizations’ innovation than it does on small and medium-sized businesses, while at the corporate level, state-owned businesses are more negatively impacted by COVID-19 than non-state-owned businesses are.

One of the industries most negatively impacted by the COVID-19 pandemic was air travel, as evidenced by a significant drop in travelers and a high number of aircraft cancellations globally (Suau-Sanchez et al. 2020). Sun et al. (Sun et al. 2020) looked at the changes in international passenger flights from December 16th, 2019, to May 15th, 2020 using Flightradar24 data that covered 150 airlines between 2,751 airports worldwide. They discovered that the number of served origin-destination airport pairs fell by roughly 75% beginning in mid-March 2020, and the number of operational aircraft fell by roughly 2/3. Another industry that was severely impacted by COVID-19 was long-distance rail travel, particularly in Asia and Europe (Rothengatter et al. 2021). In the first half of 2020, the two largest train operators in Europe, Deutsche Bahn (Germany) and SNCF (France), both reported major passenger and financial losses for their rail lines (Mack et al. 2021). Divergent tendencies for various kinds of transportation were seen in road transportation. The COVID-19 epidemic had a considerable impact on water transportation as well. Based on panel data for 14 major Chinese ports between January and October 2020, Xu et al. (L. Xu et al. 2021) discovered that due to the widespread factory closures, the pandemic’s severity, as
determined by the total number of confirmed cases, had a significant negative impact on both import and export cargo throughputs.

Low innovation activity indicators are a result of weak knowledge and technology transfer systems in the economy as well as weak commercialization of the research and development sector, according to Sadyrova et al (Sadyrova et al. 2021). The lack of financial and institutional systems for ensuring innovative and technological development, the underdeveloped system for knowledge and technology transfer, and the weak domestic demand for new technological developments are the most important factors contributing to the decline in technological competitiveness (including that coming from the state itself).

5.0 Conclusion

This study's analysis and review of the available journal articles show that there has been a recent growth in innovation management research activities for the preservation of fruits and vegetables, but that the regional distribution of researchers working on this topic is unbalanced. The findings of the study, which also examined the investigation of the potential impact of COVID-19 on the general aspect of innovation activities in the field of fruits and vegetables preservation, showed that the COVID-19 innovation disruption had a greater impact on large-scale businesses than on small businesses in terms of the need for innovations and investment level in fruit and vegetable preservation. Also, the study observed that the majority of research findings so far have come from small-scale laboratory tests, with little thought given to how cost-effective the suggested treatment options would be. Numerous tests incorporated pricey components and perhaps improbable working circumstances. Pilot-scale research using inexpensive, easily accessible materials should be encouraged for practical goals. As a result, a reasonable cost-benefit analysis of a proposed technology for preservation will be possible. Despite the fact that numerous techniques have been suggested, few of them, when employed alone, could successfully preserve fruits and vegetables. Combination techniques are preferred for enhancing fruit and vegetable preservation performance. As a result, the development of technology for preserving fruits and vegetables must take an integrative approach. To achieve the goal of cost-effective preservation, the best solution must be chosen. Characterization and quality evaluation of the fruits and vegetables are crucial since the cost-effectiveness of a preservation method greatly depends on the physicochemical characteristics and possible intended use of the fruits and vegetables to be preserved. However, only a very little amount of research has been done in these areas up to this point. In order to choose the best ways for preserving fruits and vegetables, it is necessary to make efforts to build evaluation systems for characterization and quality assessment that are universally acknowledged.

Abbreviations

ANOVA - Analysis of variance.

HSD - Honestly significant difference.
OECD - Organisation for Economic Co-operation and Development.

SNCF - The Société nationale des chemins de fer français.

StdDev - Standard deviation.

USA - The United States of America.

WHO - The World Health Organization is a specialized agency of the United Nations.

Declarations

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**References**


**Figures**

![Pie chart](image-url)

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Firms’ distribution in the questionnaire survey

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The score of social factors affecting innovation in the fruits and vegetables preservation sector (a) small scale (b) medium scale (c) large scale
Figure 6

Impact on motivation for innovation
Figure 7

Impact on investment level as influenced by funding
The degree to which COVID-19 has influenced several innovation-related parameters in the fruits and vegetables preservation industry