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# Using Artificial Intelligence-Based Tools to Improve the Literature Review Process: Pilot Test with the Topic “Hybrid Meat Products”

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**Abstract:** Conducting a literature review is a mandatory initial stage in scientific research on a specific topic. However, this task is becoming much more complicated in certain areas (such as food science and technology) due to the huge increase in the number of scientific publications. Different tools based on artificial intelligence could be very useful for this purpose. This paper addresses this challenge by developing and checking different tools applied to an emerging topic in food science and technology: “hybrid meat products”. The first tool to be applied was based on Natural Language Processing and was used to select and reduce the initial number of papers obtained from a traditional bibliographic search (using common scientific databases such as Web Science and Scopus) from 938 to 178 (a 87% reduction). The second tool was a project based on the interplay between Retrieval-Augmented Generation (RAG) and LLAMA 3, which was used to answer key questions relating to the topic under review (“hybrid meat products”) but limiting the context to the scientific review obtained after applying the first AI tool. This new strategy for reviewing scientific literature could be a major advance on from the traditional literature review procedure, making it faster, more open, more accessible to everyone, more effective, more objective, and more efficient—all of which help to fulfill the principles of open science.

**Keywords:** artificial intelligence; review; natural language processing; hybrid meat products; Retrieval-Augmented Generation



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## 1. Introduction

Artificial intelligence (AI) has enormous potential in several fields, including scientific research, and is continuously growing and developing. Regarding food science and technology, AI applications in farm management, food processing, food quality, food safety, food security, and new product development, among others, have been described and are in constant progress [1]. In the STEM fields (science, technology, engineering, and mathematics), the formal route for scientific communication on these technological advances has been preferably through traditional channels such as scientific journals [2]. In addition, food science and technology has been the disciplinary category with the highest number of publications related to AI in recent years (2012–2022) [1]. However, independently of the research field, one of the aspects where AI tools could be handy would be the scientific literature review about a specific topic. Currently, the volume of papers published in research journals has increased dramatically (for example, in the Journal Citation Report, the number of journals included in the “Food Science and Technology” category has increased from 94 to 173 (in the last 20 years) and the number of items from 9783 to 40,282 [3],

which has turned the bibliographical revision process into such a hard task that, in most cases, it even exceeds the cognitive limits of human processing capacity. In this complex and overloaded scenario, AI can be a powerful tool in facilitating the review of scientific literature, which is also the first step to initiating any research project.

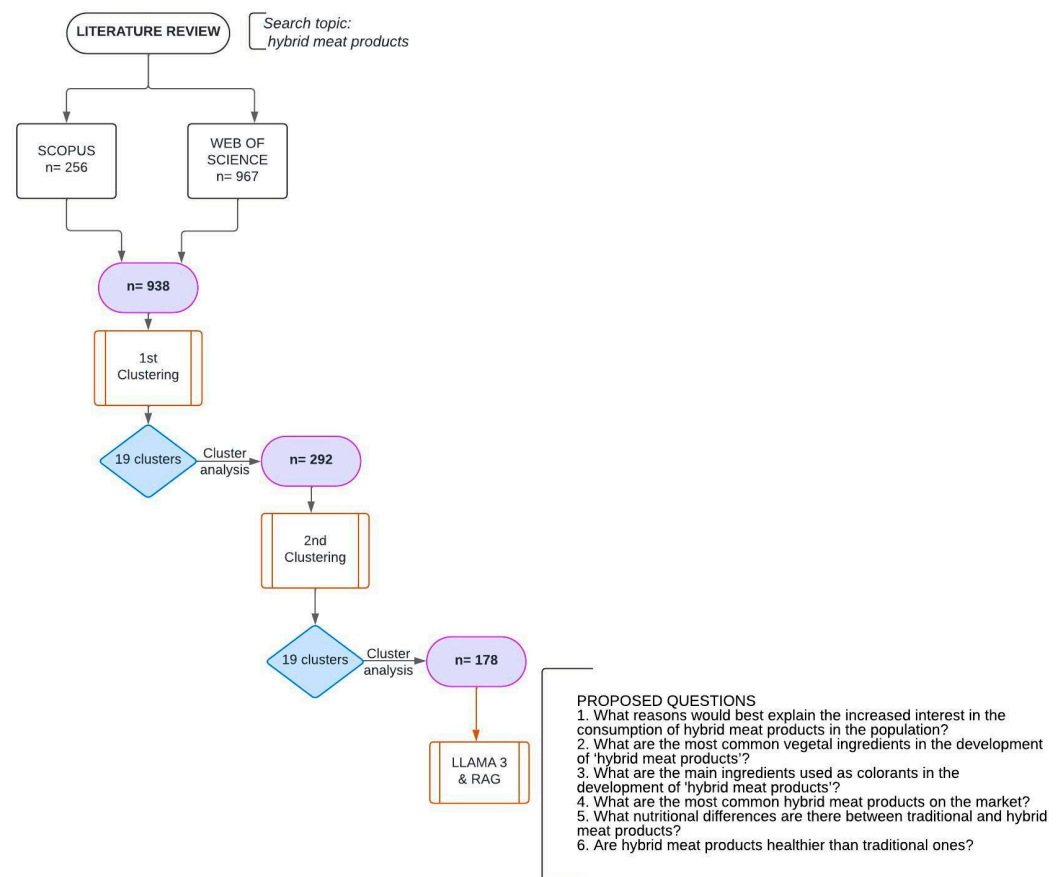
The term “hybrid meat products” was developed in line with the official recommendations for reducing meat consumption based on environmental and ethical issues associated with meat production and issues relating to human health [4]. From this point on, led by the vegan movement, a transition from meat proteins to vegetable proteins began. This was a challenge for the food industry in terms of innovation, technological development, and the procurement of raw materials and spices, among other things, to offer meat analogues and hybrid meat products that meet consumer demands [5,6]. However, a large part of the scientific community and the wider population did not approve this transition and so did not fully adhere to this trend; they claimed that the complete elimination of meat consumption as a source of animal proteins is responsible for inadequate nutrition [7,8], and even that the plant-based meat products on offer have a bad sensory quality [9,10]. Nowadays, it seems the need for meat consumption reduction (rather than elimination) has been widely accepted, and it is in this context that the concept of “hybrid meat products” has emerged [11–13]. With this type of product, part of the meat is replaced by more sustainable vegetable protein sources.

The objective of this work was to apply cheap and widely accessible tools based on AI to analyze and categorize the research literature on a specific topic, not only comprehensively and objectively, but also in a more effective and less time-consuming way. These tools were applied not only to select relevant literature from a massive bibliographic search but also to obtain key insights from relevant papers that could be used to provide a scientific and controlled context for the AI tools to answer key questions on the topic under review. This new approach has been tested in a pilot study on an emerging topic in food science and technology: “hybrid meat products”.

## 2. Methodology

In this section, only a general description of each of the methodological stages that were followed is given; however, each of these stages will receive a more detailed explanation in the following sections when they are described in relation to their application in the pilot study.

The first step in this process was to carry out a bibliographic search using the most relevant scientific bibliographic bases for the specific topic under study. This search provided information on the titles of the papers, their publication year, and their abstract. The second step was to use a Natural Language Processing (NLP) form of AI to automatically assess and categorize all the papers by examining the content of their titles and abstracts. In this case, a recently developed online tool [14] was used, allowing for the clustering of the bibliographic information previously obtained. At the end of this step, a reduced number of selected papers based on their relevance to the topic under study were obtained. The third step was to use AI tools again to analyze the selected papers by answering relevant questions on the study topic. In this case, a project based on the interplay between Retrieval-Augmented Generation (RAG) and LLAMA 3 [15–17] was applied (Figure 1). In the following sections, a more detailed description of all the tools applied, the conditions of application, and the results obtained, as well as an assessment of the effectiveness of the process, will be given.



**Figure 1.** Diagram of the research procedure. n = number of papers; LLAMA3: Large Language Model; RAG: Retrieval Augmented Generation.

### 3. Artificial Intelligence Tools Based on Natural Language Processing to Analyze Bibliographic Literature on the Topic of “Hybrid Meat Products”

As has been previously stated, “hybrid meat products” have received an increasing amount of attention mainly due to a rise in concern on the part of consumers for more sustainable and healthier alternatives to traditional meat products. This increasing interest can be demonstrated by the number of scientific contributions related to the topic “hybrid meat products” that were found using the two big commercial bibliographic databases (Scopus and Web of Science); these databases are also the two most famous in the food science and technology research field. In a basic search using the Scopus database, from 2016 to 2024 selecting as the search topic “hybrid meat products” and “article” and “review” as the document type (without applying any other filter or search restriction), a total of 256 results were obtained. The same search was carried out using the Web of Science database, extending the search period from 2000 to 2024. In this case, the number of papers obtained was 967. The results from these two independent searches were merged into a single file, where repeated items were eliminated. This file contained a total of 938 scientific articles.

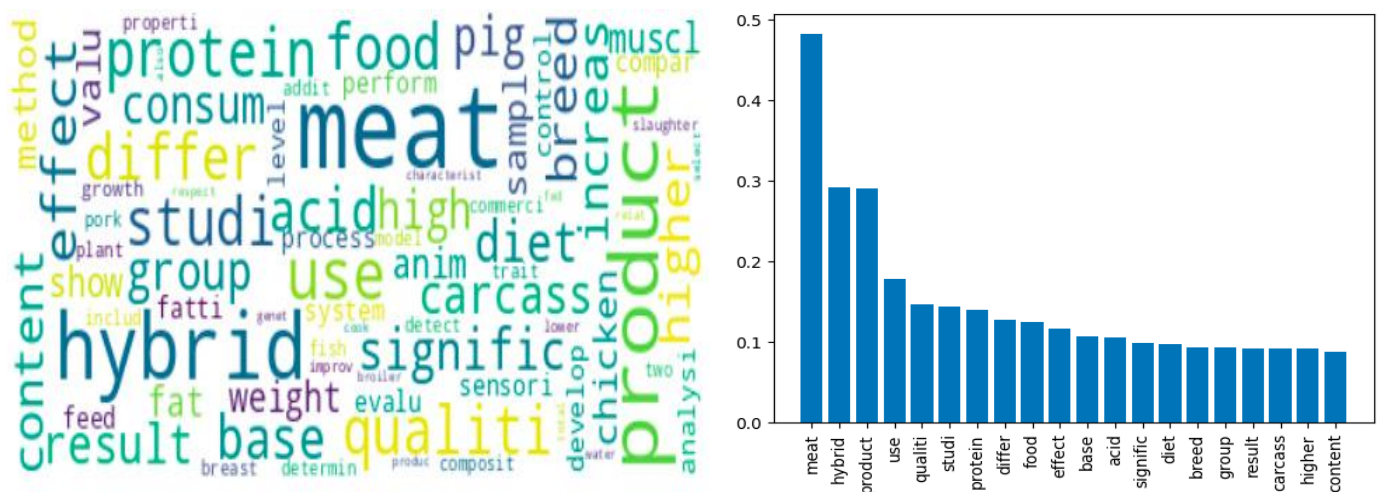
Because of the extensive volume of data acquired and the significant time required for the analysis and categorization of each document, it was decided to utilize AI in the field of NLP to automatically assess and categorize all the papers by examining the content of their titles and abstracts. The advantages of utilizing various NLP tools in the review process are plentiful and evident [18,19]. Many studies have explored the different stages of this process, and there are numerous online tools available to assist researchers in this challenging task. For example, PubMed’s “Similar Articles” feature and other AI-driven literature search engines leverage NLP to suggest related articles based on the content of a given paper, aiding researchers in identifying pertinent literature more efficiently. However,

despite advancements in algorithms and tools, there is a scarcity of studies that employ NLP for conducting reviews on specific topics, such as food science and technology, as our study intends to do. Additionally, most of these new tools lack transparency and do not allow users to interact with the algorithm to guide the review process effectively, making them less appealing to users accustomed to more traditional tools. For all these reasons, it was decided to use a recently developed online tool (which was innovative, objective, easy to use, editable, and adaptable to any topic) that would allow for the clustering (i.e., the grouping of papers according to common characteristics) of such a huge amount of bibliographic information. This tool should also provide other interesting bits of information about the clusters obtained, such as the interrelations between them, their closeness, and their distribution over time, among other things.

The 938 contributions obtained from the initial search (Scopus and Web of Science; Table S1) were processed and analyzed using this new tool (the Jupyter notebook on Google Colab, which is freely available since it was first used for a biology-related topic) (Table S1) [14]. Briefly, the content of the program includes several steps such as a general overview of the file, importing libraries, data description, data preparation, data cleaning, pre-processing of the texts, text analysis, text clustering with K-means, finding the optimal number of clusters, auto-tagging based on cluster centers, plotting clusters, distribution of clusters over the last years, and conclusions. It is from the pre-processing stage of the text that the program begins to provide useful information to be analyzed. This analysis took only 209.12 s to be completed.

### 3.1. Text Visualization

From the analysis of the language contained in the 938 articles, information about the most frequent words was obtained. As expected, the three top words were “meat”, “hybrid”, and “products”. The words “use”, “quality”, “studied”, and “protein” also were found to be among those with the highest relative frequency (Figure 2). All of these confirm that the analysis was in a good way because the main application of “hybrid meat products” is as a source of protein and their use and quality should be studied. This information can also be seen from the word cloud that was generated using the 938 contributions (Figure 2); this textual data visualization allows us to see in a single glance the words with the highest frequency, according to their relative size. This analysis allowed us to understand the data and to verify the preprocessing stage; it enabled us to determine whether more preprocessing was necessary before training the model.

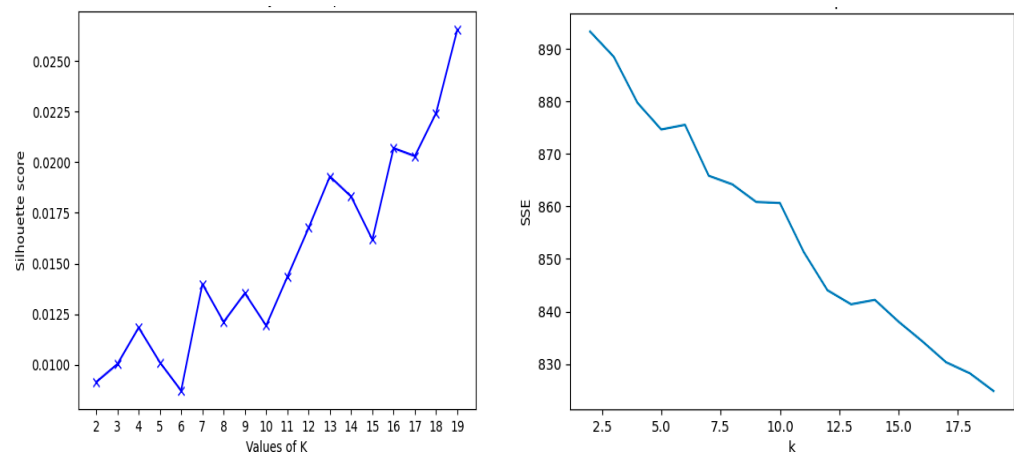


**Figure 2.** Word cloud of the 75 most common words from the 938 articles about “hybrid meat products” and the corresponding frequency bar chart.



### 3.2. Text Clustering with K-Means Model and Finding the Optimal Number of Clusters

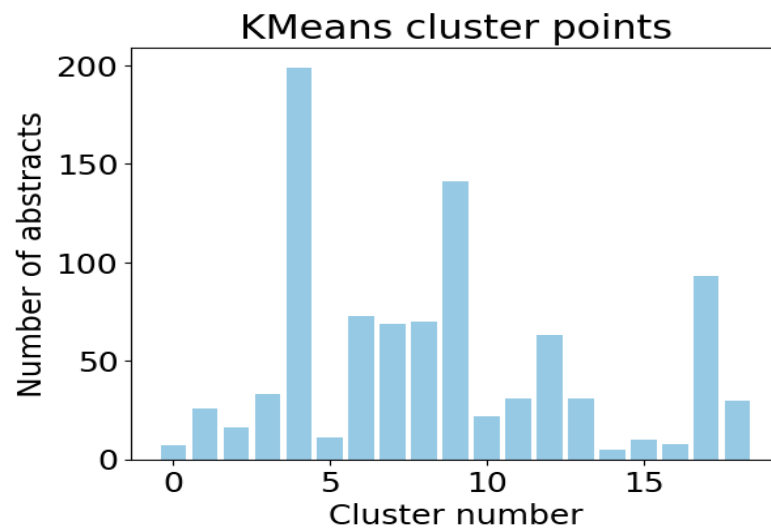
In this step, the articles were clustered based on their textual similarities using language equivalences. There was no prior knowledge concerning the groups of these 938 abstracts. Therefore, to find structure in these unlabeled abstracts, the unsupervised learning technique was applied. To find groups of similar abstracts, the K-means algorithm was used (which is a simple and popular unsupervised clustering algorithm) [20]. This algorithm calculates the distance between the points (in this case the articles' abstracts) and groups nearby points together, indicating that they are similar. A good cluster is one in which the distance between the points within the cluster is smaller than the distance between the points of two different clusters. It is necessary to determine the optimal number of clusters to group the information. For this purpose, two predominant methods were used: the Elbow method and the Average Silhouette method. The Elbow method operates by calculating the within-cluster Sum of Squares (SSE: the total of the squared distances between data points and their cluster center). However, there comes a point where increasing the K will no longer lead to a significant decrease in the SSE, and the rate of decrease will start to slow down. This point is often referred to as the elbow (the point of inflection on the curve) and is generally considered to be an indicator of the appropriate number of clusters [21]. The Average Silhouette score method calculates the silhouette values based on the similarity of the article's language to a determined thematic cluster compared to the rest of the clusters. A higher average silhouette score across all articles suggests that the clustering has been effective in grouping together similar articles [22]. By using these two methods, it was possible to identify the optimal number of clusters (19 clusters) understood as the most appropriate way to organize and categorize the articles based on their content. Figure 3 shows the elbow and silhouette graphs for the selection of 19 as the optimal number of clusters in which the dataset for "hybrid meat products" should be divided (the clusters were numbered from 0 to 18).



**Figure 3.** Silhouette and elbow graphs for the determination of the optimal number of clusters in which the dataset for "hybrid meat products" should be divided.

### 3.3. Autotaging Based on Cluster Centers

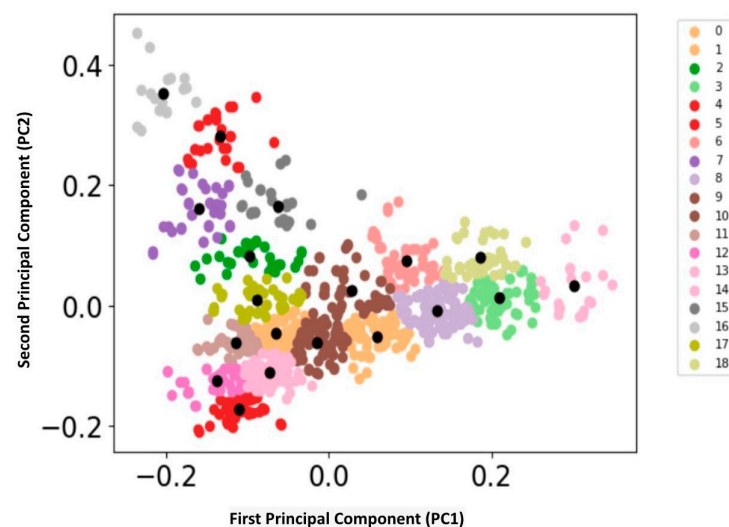
After the clustering has been performed, it is important to identify which paper belongs to which cluster. The K-means algorithm generates cluster labels, which represent the abstracts contained in these clusters. The number of contributions included in a cluster is also important as it gives an idea of its strength; the greater number of papers included, the stronger the cluster is. Figure 4 shows the number of articles included in each of the 19 clusters.



**Figure 4.** Quantitative distribution of the articles in the different clusters.

### 3.4. Plotting Clusters

To visualize the K-Means clustering results with the relationship among the 19 clusters, a Principal Component Analysis (PCA) was applied to reduce the number of dimensions so that it could be visualized using a 2D scatter plot (Figure 5). In the context of clustering in NLP, principal components refer to the axes derived from PCA, a dimensionality reduction technique. These components are essentially new features that capture the most significant variance in the data. The two principal components in clustering NLP data provide a simplified but powerful representation of the most important trends and themes in the data. The first principal component (PC1) captures the primary axis of variation, while the second principal component (PC2) captures the next most significant axis. This allows for more refined and accurate clustering based on the underlying semantic content of the text. In this case, PC1 is the axis along which the data points (documents, words, and sentences) are most spread out. This means that PC1 is the most informative feature in terms of explaining variability in the dataset, while PC2 accounts for variability in the data that is not captured by PC1, providing a new dimension along which to differentiate the data.



**Figure 5.** Scatter plot of the PCA results for the 938 articles included in the datasheet of “hybrid meat products”. Each cluster is represented by a different color; the black points correspond to the centroids of each cluster.

### 3.5. Text Analysis of Each Cluster

At this point, the program had grouped all the papers into 19 clusters, which could be easily analyzed for their respective figure bars of top words (Figure 6) and word clouds (Figure S1).

From this analysis, it was possible to select which of these clusters were highly related to the objective of this review and which were not. For example, clusters 0, 1, and 5 were the only ones where words related to insect proteins appeared (*Tenebrio* and *molitor* in cluster 0, insect in cluster 1, and cricket in cluster 5). To analyze the use of insects as ingredients in meat products was not an aim in this review. Cluster 2 seemed to be related to the use of liver and the study of some contaminants, which is also outside of our objective. Cluster 3 seemed to be related specifically to the packaging and shelf-life of “hybrid meat products” and so it was decided that it was not a key issue in this review. Cluster 4 was based on papers addressing the process, methods, and development of hybrid meat products or their models, and was selected as relevant in this review. The following clusters (from numbers 6 to 16) were considered as outside of the area of interest for this review because they were related to genotype, genetic feed, carcass, energy, biosensors, electrochemistry, plasmids, aquaculture, and microbiology. Cluster 17 met exactly what we were searching for because the 15 top words included were considered relevant for this review. Cluster 18 was also outside of the area of interest for this review because it was only related to DNA analyses and polymerase chain reaction (PCR) techniques to detect adulterations.

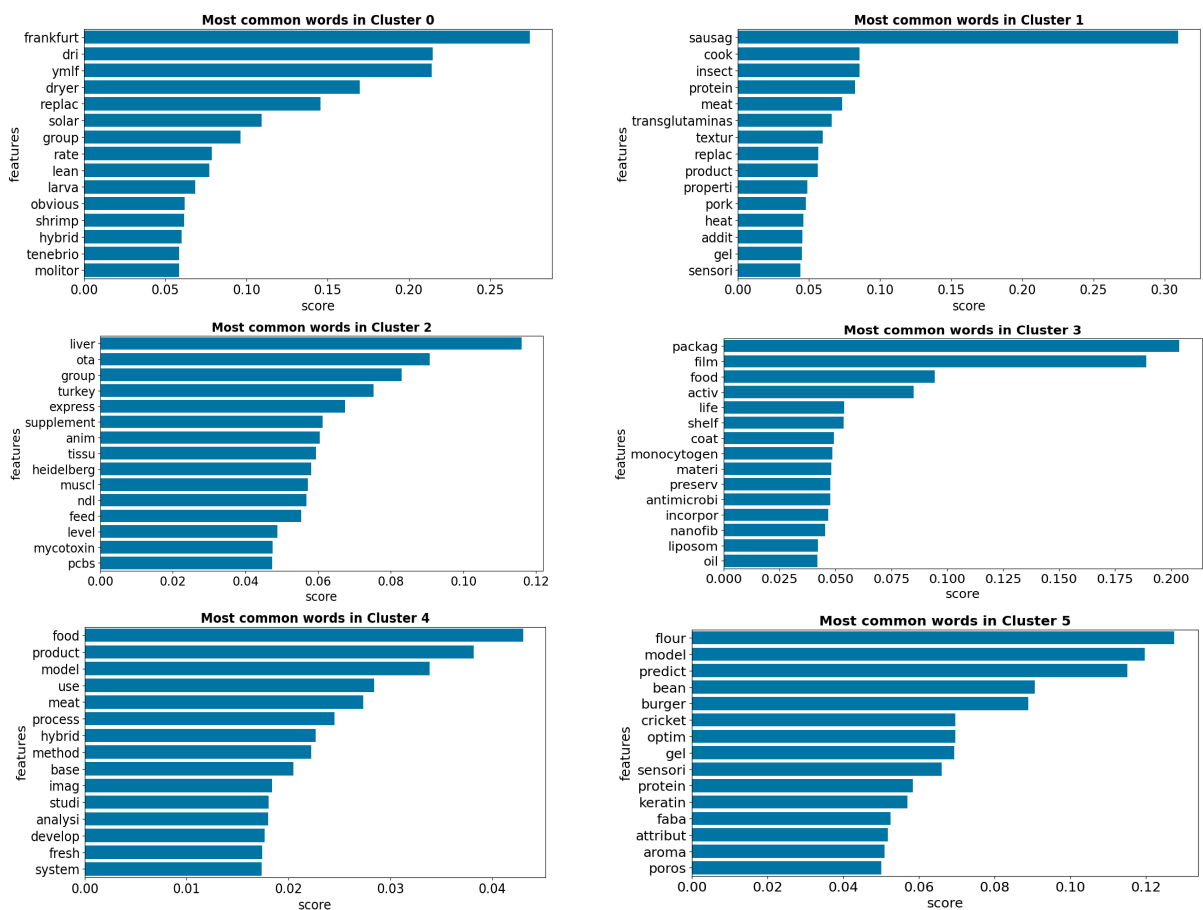


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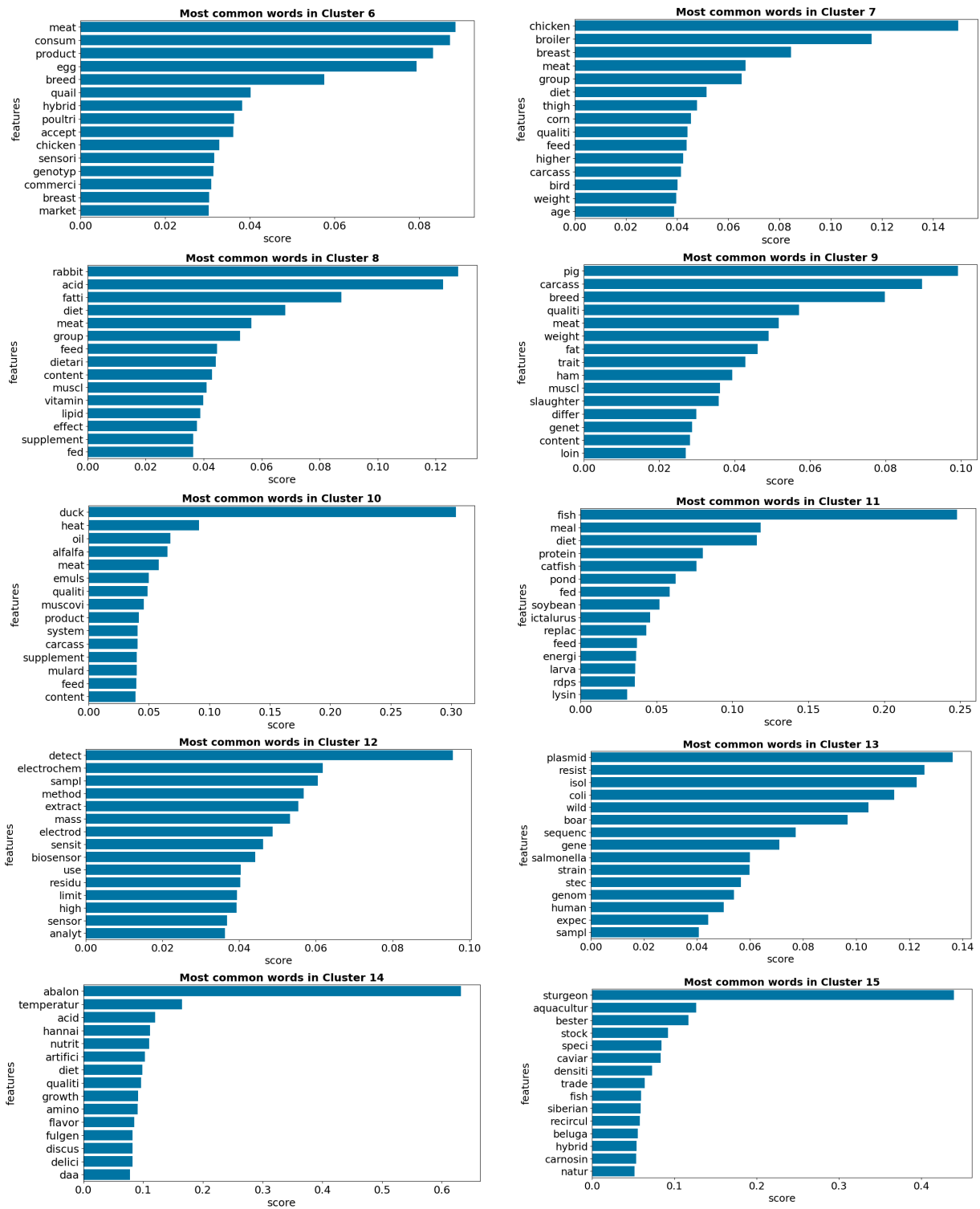
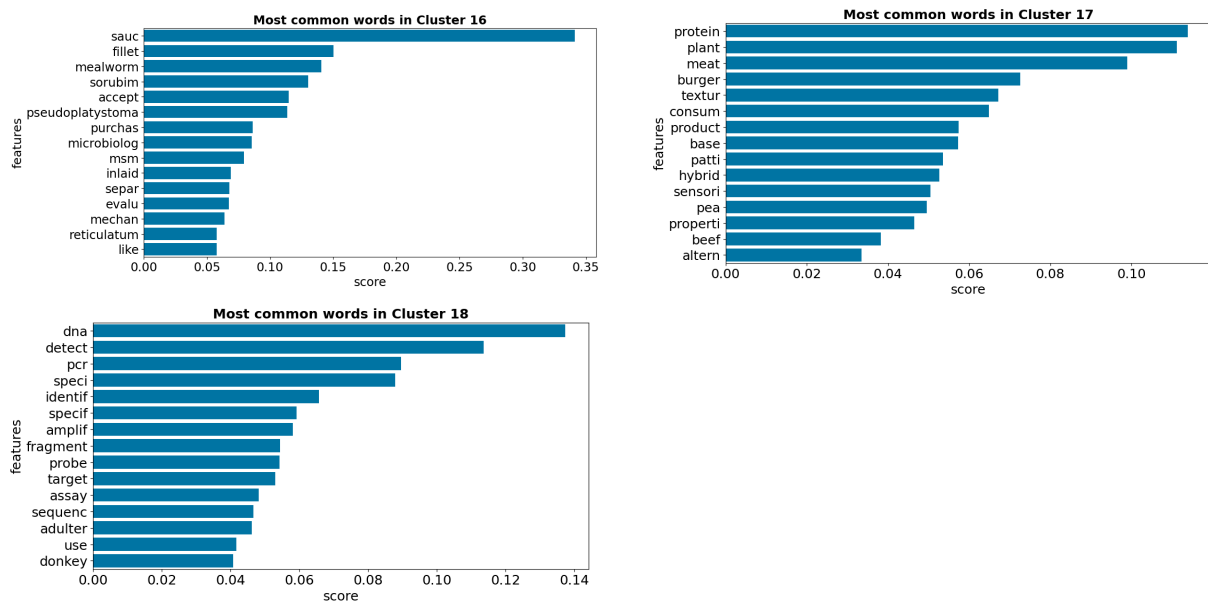


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**Figure 6.** Figure bars for the 15 top words (the highest frequency appearance) for each cluster (19 clusters numbered from 0 to 18 and identified at the top of each figure).

After this quick analysis, based on the top words for each cluster, only two clusters (4 and 17) were selected as relevant for this review. Cluster 4 encompassed a total of 199 contributions, while cluster 17 encompassed 93 contributions, representing 21% and 10%, respectively, of the initial numbers of papers analyzed (Figure 4). Both clusters were among the top three clusters with the highest number of articles, which would indicate that they address the aspects of this topic that have aroused the most interest among the scientific community. When these two clusters are located in the scatter plot from PCA (Figure 5), some useful information can be also observed. Although cluster 4 (red dots) had the highest number of items, the area represented by its red dots was not the largest by far, indicating that its dots are very close together and to their centroid (i.e., they have very little dispersion). This would indicate that this cluster contains very similar or close information about the language or words used in its description. On the other hand, cluster 17 (green dots) shows a higher dispersion than cluster 4 (although it does not show the highest dispersion) and both are separated by a considerable distance, indicating that each one includes different terms and information, which was corroborated but the top word analysis discussed above.

### 3.6. Distribution of Clusters Over the Last 24 Years

Another important piece of information given by the program is the distribution of the clusters over the last 24 years (Figure 7). Here it can be seen that while cluster 4 represents a high level of interest without important variations between 2000–2024, cluster 17 appeared in 2010 and has been increasing in interest over time, reaching a level of interest similar to cluster 4 last year (2022–2023).

### 3.7. Usefulness of This First Analysis and Next Steps

At this point, a 65% reduction in the initial number of articles had been achieved (from the initial 938 papers down to the 292 papers included in clusters 4 and 17). However, this is still a considerable number of papers and is difficult to manage, so the same process was repeated (step by step) for the papers included in these two clusters (the program was run again in a similar way to the first one) (Table S1).

In this case, 19 sub-clusters were obtained as the optimum number, all of which underwent the same analysis described above (based on keywords and word clouds). This allowed us to choose as relevant the sub-clusters 0 (24 papers), 2 (18 papers), 4 (29 papers),

and 5 (107 papers), totaling 178 papers. The accuracy of this selection was corroborated by the fact that they were the only sub-clusters in which the words “hybrid” and “meat” appeared in the top 15 most relevant keywords (Figure 8). The reduction in the number of papers reached in this second analysis was 39%, but this works out at 81% compared to the initial number of papers.

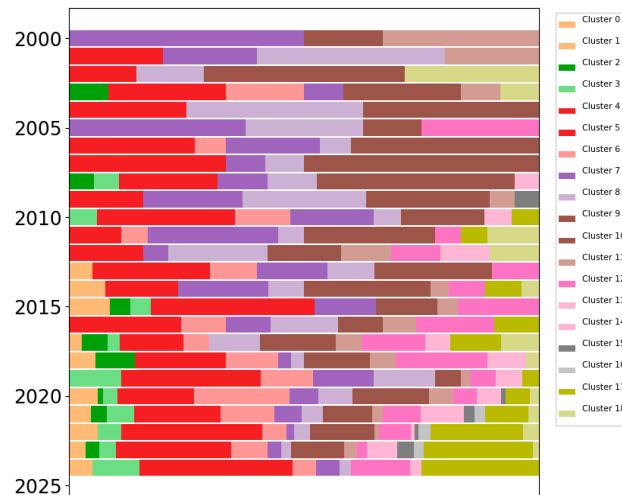


Figure 7. Distribution graph of clusters (19) of articles on “hybrid meat products” by year (2000–2024).

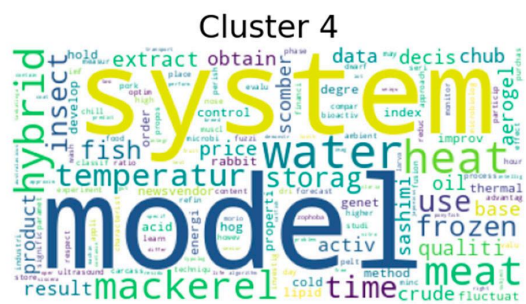
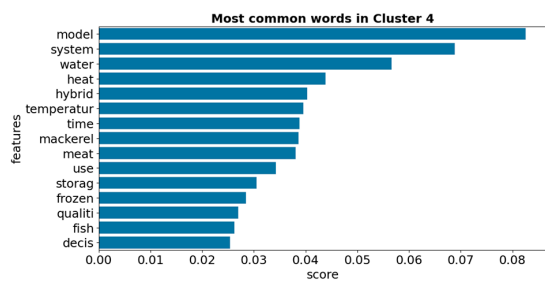
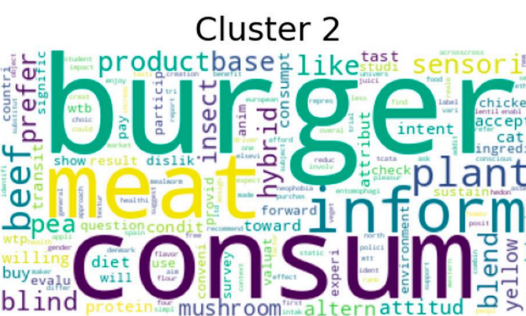
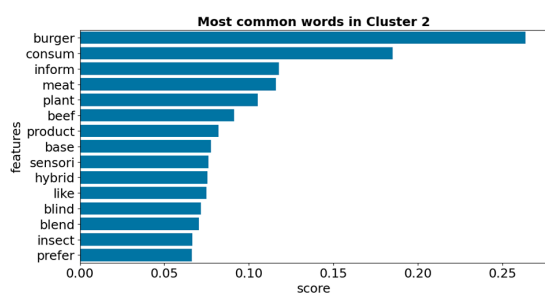
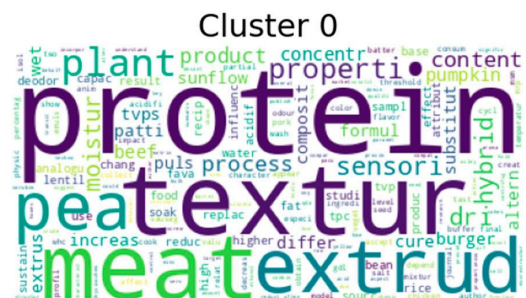
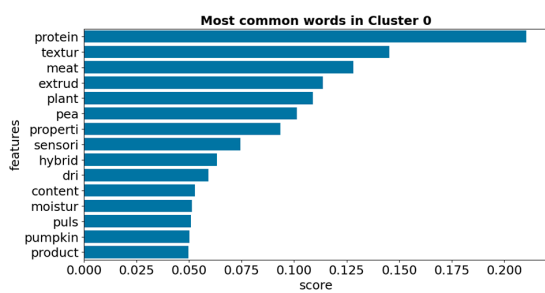
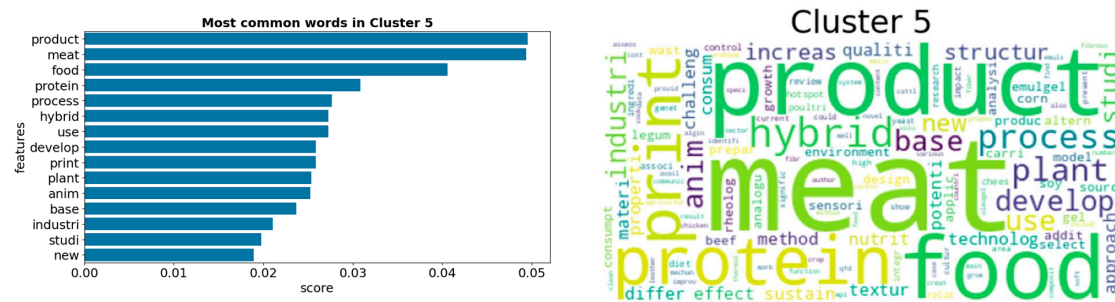


Figure 8. Cont.



**Figure 8.** Bar graph with the relative frequencies of the 15 most abundant words and their corresponding word cloud (of the 75 most common words as a more visual representation of these frequencies) of the selected sub-clusters (0, 2, 4 and 5), after the second round of the program.

In a traditional scientific review process, the next step would be to carefully review each of the papers selected as relevant (178) and detail what each of them has contributed to the different key aspects included in the state of the art. Anyone who has undertaken such a revision is aware of the time and effort involved. However, in this case it was decided to explore what AI tools could be applied to accomplish this task.

#### 4. Using AI to Analyze the Selected Papers by Answering Relevant Questions on the Topic Being Reviewed

For this task, a project based on the interplay between Retrieval-Augmented Generation (RAG) and LLAMA 3 was tested on the “hybrid meat products” issue.

##### 4.1. Understanding This New Project (RAG–LLAMA 3)

So far, a 65% reduction RAG represents a pioneering methodology in NLP. It is a framework engineered to address various NLP tasks, including question-answering, summarization, and conversational agents, involving three primary stages:

- Retrieve: In the initial phase, relevant documents are extracted from a corpus based on the user’s query. Unlike traditional search engines that rely on keyword matching, RAG employs advanced language models for semantic understanding.
- Aggregate: Following retrieval, the information contained within the documents is aggregated. This process involves summarizing the content to distill key insights for, or answers to, the user’s query.
- Generate: Finally, the aggregated information is utilized to generate a coherent response or answer. This may involve paraphrasing, synthesizing new information, or adding context to enrich the response [15].

Several advantages have been reported about the use of RAG in comparison to fine-tuning in certain scenarios related to: the significance and context improvement (RAG enhances the model with relevant context from an extensive corpus of documents, leading to more accurate and contextually appropriate responses); the enhancement of data effectiveness (by obviating the need for the model to encode all external knowledge during pre-training or fine-tuning, RAG permits the use of a substantial amount of external knowledge, reducing the need for extensive task-specific data during fine-tuning, thereby increasing effectiveness); and the effectiveness with long-tail requests (models equipped with RAG excel at managing rare or unseen queries by retrieving pertinent data from external sources to bridge knowledge gaps) [16].

Large Language Models (LLM), such as Meta LLAMA 3 and Generative Pre-trained Transformers (GPT), are typically trained on broad datasets. They are not good at special domain knowledge [20]. Instead of training a new model, using RAG could be a quick and cheap way to achieve a similar outcome. RAG can be used to provide new data to LLMs without retraining them. In addition, with RAG, it is possible to pull data from sources like document repositories, databases, or APIs.

LLAMA 3 is an advanced language model celebrated for its nuanced comprehension and scalability, and it stands out for its processing power and energy efficiency. In logical reasoning and contextual understanding tests, LLAMA 3 often outperforms GPT-4, providing more accurate and contextually relevant answers, which is crucial for applications in scientific and academic environments [17]. For these reasons, LLAMA 3 was selected over GPT for use in tandem with RAG. By synergizing retrieval and generative models, RAG provides detailed and accurate responses to user queries. When integrated with LLAMA 3, RAG attains unprecedented capabilities [16].

#### 4.2. Applying This Project to the “Hybrid Meat Products” Review

To evaluate how effective this tool was, it was decided to launch six questions that were considered very relevant when deciding to review the state of the art of “hybrid meat products”. “Hybrid meat products” is a trending topic in food consumption and in the new food product development industry. The selected questions therefore tried to cover aspects related to the growing interest in their consumption (question 1); the most common ingredients used in their formulation (questions 2 and 3); the most common products already on the market (question 4); and on their differences with traditional meat products (questions 5 and 6). In addition, all these questions were based on the key aspects previously used to select the initial clusters 4 and 17 as the most relevant for the purpose of our review:

What reasons would best explain the increased interest in the consumption of “hybrid meat products” in the population?

1. What are the most common vegetal ingredients in the development of “hybrid meat products”?
2. What are the main ingredients used as colorants in the development of “hybrid meat products”?
3. What are the most common “hybrid meat products” on the market?
4. What nutritional differences are there between traditional and “hybrid meat products”?
5. Are “hybrid meat products” healthier than traditional ones?

Sections 4.2.1–4.2.6 detail the results obtained, the complete transcription of generated text for each question (Table S1) structured as an introduction, the response body, the conclusions, and the references that the program selected as closest to the question, providing the context for the answer. It is important to highlight that this AI tool took 51.31 s to answer each question, including the embedding process.

##### 4.2.1. What Reasons Would Best Explain the Increased Interest in the Consumption of “Hybrid Meat Products” in the Population?

As an introduction to the response, the program stated that the consumption of hybrid meat products has gained significant attention in recent years, with an increasing number of consumers opting for these products. Hybrid meat products are a blend of meat and plant-based ingredients, offering a compromise between traditional meat products and plant-based alternatives.

Seven reasons for increasing interest were provided:

- ✓ Sustainability and environmental concerns: The production of traditional meat products is a significant contributor to greenhouse gas emissions, deforestation, and water pollution. Hybrid meat products offer a more sustainable alternative, with the potential to reduce greenhouse gas emissions by up to 32% [23]. Consumers are becoming increasingly aware of the environmental impact of their food choices, driving the demand for more sustainable options.
- ✓ Health and wellness: Hybrid meat products are often perceived as a healthier alternative to traditional meat products, with reduced saturated fat and cholesterol content. Consumers are seeking healthier options, and hybrid meat products offer a convenient and tasty solution.



- ✓ Flexitarianism and reduced meat consumption: The growing trend of flexitarianism, which involves reducing meat consumption while still consuming some meat, has led to an increased demand for hybrid meat products. These products cater to consumers who want to reduce their meat intake without sacrificing taste and convenience.
- ✓ Innovative and convenient: Hybrid meat products offer a convenient and innovative solution for consumers who want to try new and exciting flavors while still enjoying the familiarity of traditional meat products.
- ✓ Increased availability and affordability: The availability and affordability of hybrid meat products have increased in recent years, making them more accessible to a wider range of consumers.
- ✓ Consumer acceptance and willingness to try: Studies have shown that a significant proportion of consumers are willing to try hybrid meat products, with at least 57% of consumers willing to try and at least 46% willing to buy [24].
- ✓ Technological advancements: The development of new technologies and processing methods has enabled the production of high-quality hybrid meat products that are comparable to traditional meat products in terms of taste, texture, and convenience.

The following paragraph was the conclusion provided for this question: The increased interest in hybrid meat products can be attributed to a combination of factors, including sustainability and environmental concerns, health and wellness, flexitarianism, innovative and convenient products, increased availability and affordability, consumer acceptance, and technological advancements. As consumers become more aware of the environmental and health impacts of their food choices, the demand for hybrid meat products is likely to continue to grow.

#### 4.2.2. What Are the Most Common Vegetal Ingredients in the Development of “Hybrid Meat Products”?

This was the introductory paragraph: Hybrid meat products, which combine traditional meat with plant-based ingredients, have gained popularity in recent years as consumers seek more sustainable and healthier alternatives to traditional meat products. The development of hybrid meat products involves the incorporation of several vegetable ingredients to enhance their nutritional profile, texture, and flavor.

Based on the review of existing literature [12,24–28], the following vegetable ingredients were found to be commonly used in the development of hybrid meat products:

- ✓ Peas: Pea protein, pea isolate, and pea flour were frequently used in hybrid meat products, particularly in combination with meat proteins such as beef, pork, and chicken. Peas are a rich source of protein, fiber, and micronutrients, making them an attractive ingredient for hybrid meat products.
- ✓ Pumpkin: Pumpkin seed protein and pumpkin puree were used in some hybrid meat products, particularly in combination with pork and beef. Pumpkin is a good source of fiber, vitamins, and minerals, and its protein content can help to enhance the nutritional profile of ‘hybrid meat products’.
- ✓ Soy: Soy protein, soy flour, and soy isolate were used in some hybrid meat products, particularly in combination with beef and pork. Soy is a rich source of protein and is often used as a meat extender or substitute in ‘hybrid meat products’.
- ✓ Onions: Onions were used in some hybrid meat products, particularly in combination with beef and pork. Onions are a good source of fiber, vitamins, and minerals, and their flavor and texture can enhance the overall ‘quality of hybrid meat products’.
- ✓ Herbs and spices: Various herbs and spices, such as garlic, were used in some hybrid meat products to enhance their flavor and aroma.
- ✓ The use of vegetable ingredients in hybrid meat products can enhance their nutritional profile, texture, and flavor. Peas, pumpkin, soy, and onions, as well as herbs and spices, are commonly used ingredients in hybrid meat products, and their selection depends on the desired nutritional and sensory properties of the final product. The incorporation of these ingredients can help to reduce the environmental impact of meat



production, improve the nutritional quality of meat products, and provide consumers with more sustainable and healthier alternatives to traditional meat products.

In conclusion, it is mentioned that the development of hybrid meat products involves the incorporation of various vegetable ingredients to enhance their nutritional profile, texture, and flavor. Peas, pumpkin, soy, onions, herbs, and spices are commonly used ingredients in hybrid meat products, and their selection depends on the desired properties of the final product. The use of these ingredients can help to reduce the environmental impact of meat production, improve the nutritional quality of meat products, and provide consumers with more sustainable and healthier alternatives to traditional meat products.

#### 4.2.3. What Are the Main Ingredients Used as Colorants in the Development of “Hybrid Meat Products”?

The response provided included this introductory paragraph: Hybrid meat products, which combine traditional meat with plant-based proteins, have gained popularity in recent years due to their potential to reduce meat consumption and environmental impact. The development of these products requires careful consideration of various factors, including colorants, to ensure appealing and consistent products. This report aims to identify the main ingredients used as colorants in the development of hybrid meat products.

Upon reviewing the provided information [12,25–28], it becomes clear that the focus is on the formulation and properties of hybrid meat products, rather than specific colorants. However, it is possible to infer that the color of these products is influenced by the intrinsic color of the plant proteins used and can significantly impact the final color of hybrid meat products. For example: Pea protein, which is commonly used in hybrid meat products, has a natural yellowish color that can affect the final product color. Soy protein, another popular plant protein, has a slightly yellowish or beige color that can also influence the final product color. Pumpkin seed protein, used in some hybrid meat products, has a natural greenish-yellow color that can contribute to the final product color.

In addition to the intrinsic color of plant proteins, other factors can influence the final color of hybrid meat products, including:

- ✓ Meat content: The proportion of meat in the hybrid product can affect the final color, with higher meat content resulting in a more intense red or pink color.
- ✓ Processing conditions: Temperature, pH, and other processing conditions can impact the final color of the product
- ✓ Additives: Some hybrid meat products may include additional colorants or additives that can affect the final color.

The main conclusions were that while specific colorants are not explicitly mentioned in the provided information, it is clear that the intrinsic color of plant proteins plays a significant role in determining the final color of hybrid meat products. The natural colors of pea protein, soy protein, and pumpkin seed protein, among others, can influence the final product color. Additionally, factors such as meat content, processing conditions, and additives can also impact the final color of hybrid meat.

#### 4.2.4. What Are the Most Common “Hybrid Meat Products” on the Market?

The introduction to the response was that the meat industry is undergoing a significant transformation, driven by consumer demand for more sustainable, healthy, and environmentally friendly products. Hybrid meat products, which combine traditional meat with plant-based ingredients, have emerged as a promising solution. These products offer a compromise between traditional meat and plant-based alternatives, catering to consumers who want to reduce their meat intake without sacrificing taste and convenience.

The following hybrid meat products are among the most common on the market [12,24–26,28]:

- ✓ Beef-Pea Hybrid Burgers: These products combine beef with pea protein, onions, herbs, and spices. They are formulated to have a meat-like texture and flavor, with a nutritional claim on protein or fat.

- ✓ Pork-Pumpkin Seed Hybrid Sausages: These products combine pork meat with texturized pumpkin seed proteins, resulting in a dry-cured sausage with a unique flavor and texture profile.
- ✓ Meat-Pea Hybrid Emulsions: These products blend meat with pea protein, soy protein, or other plant-based ingredients to create a hybrid emulsion with improved nutritional profiles and reduced environmental impact.
- ✓ Beef-Soy Hybrid Meatballs: These products combine beef with soy protein, onions, and spices to create a meatball with a meat-like texture and flavor.
- ✓ In general terms the consumers prefer hybrid meat products with a meat substitution level of 25% to 50%. These products are perceived as healthy, ethical, and environmentally friendly, with a taste and texture similar to traditional meat products. Consumers are willing to try and buy hybrid meat products, with at least 57% of respondents willing to try and 46% willing to buy.

In conclusion, hybrid meat products are a promising solution for consumers who want to reduce their meat intake without sacrificing taste and convenience. The most common hybrid meat products on the market include beef-pea hybrid burgers, pork-pumpkin seed hybrid sausages, meat-pea hybrid emulsions, and beef-soy hybrid meatballs. These products offer a compromise between traditional meat and plant-based alternatives, catering to consumer preferences for healthy, sustainable, and environmentally friendly products.

#### 4.2.5. What Nutritional Differences Are There between Traditional and “Hybrid Meat Products”?

The introductory paragraph was: The meat industry is undergoing a significant transformation with the emergence of hybrid meat products, which combine traditional meat with plant-based ingredients. This shift is driven by growing consumer demand for more sustainable, healthier, and environmentally friendly food options. Hybrid meat products offer a promising solution, but it is essential to understand the nutritional differences between traditional and hybrid meat products. This report provides an in-depth analysis of the nutritional variations between these two types of products.

The main nutritional differences reported were:

- ✓ Protein content: Hybrid meat products typically contain a combination of animal-derived protein (e.g., beef, pork, or chicken) and plant-based protein sources (e.g., pea, soy, or rice protein). The protein content of hybrid products can vary depending on the proportion of plant-based ingredients used. For example, a study on hybrid chicken nuggets found that the protein content decreased by up to 32% when meat protein was replaced with plant-based protein [23]. In contrast, traditional meat products typically contain higher protein levels, with minimal or no plant-based protein content.
- ✓ Fat content: The fat content of hybrid meat products can also differ significantly from traditional meat products. A study on hybrid sausages found that the fat content decreased by up to 70% when meat was replaced with texturized pumpkin seed proteins [26]. This reduction in fat content can be attributed to the lower fat content of plant-based ingredients. In contrast, traditional meat products often have higher fat levels, which can contribute to increased calorie intake and potential health risks.
- ✓ Moisture content: The moisture content of hybrid meat products can also vary depending on the type and proportion of plant-based ingredients used. A study on hybrid meat emulsions found that the moisture content increased when plant-based proteins were added, leading to a more tender and juicy texture [12]. In contrast, traditional meat products often have a lower moisture content, which can result in a drier texture.
- ✓ Micronutrient content: Hybrid meat products can also differ in their micronutrient content compared to traditional meat products. Plant-based ingredients can contribute to higher levels of fiber, vitamins, and minerals, such as potassium, magnesium, and iron [24]. For example, a study on hybrid burgers found that the addition of plant-

based ingredients increased fiber content by up to 50% [7]. In contrast, traditional meat products often have lower levels of these micronutrients.

- ✓ Sensory properties: The sensory properties of hybrid meat products can also differ from traditional meat products. A study on hybrid chicken nuggets found that the addition of plant-based ingredients affected the texture, appearance, and taste of the products [25]. Hybrid products can have a softer, more tender texture and a more neutral flavor profile compared to traditional meat products.

In conclusion, hybrid meat products exhibit distinct nutritional differences compared to traditional meat products. The protein, fat, moisture, and micronutrient content of hybrid products can vary significantly depending on the type and proportion of plant-based ingredients used. These differences can result in a more sustainable, healthier, and environmentally friendly food option. However, it is essential to consider the potential impact of these changes on the sensory properties and overall acceptability of hybrid meat products.

#### 4.2.6. Are Hybrid Meat Products Healthier than Traditional Ones?

The introduction to the response was that the meat industry is undergoing a significant transformation, driven by growing concerns about sustainability, health, and animal welfare. One promising solution is the development of hybrid meat products, which combine traditional meat with plant-based proteins. This innovative approach has sparked interest in the potential health benefits of hybrid meat products compared to traditional ones. This report aims to provide an in-depth analysis of the nutritional properties of hybrid meat products and determine whether they are healthier than traditional meat products.

The main aspects when comparing traditional meat products with hybrids are:

- ✓ Nutritional properties of hybrid meat products: Hybrid meat products are formulated by replacing a portion of meat with plant-based proteins, such as soy, pea, or pumpkin seed proteins. This substitution can lead to significant changes in the nutritional profile of the final product. Studies have shown that hybrid meat products tend to have lower fat content, higher protein content, and improved fatty acid profiles compared to traditional meat products [12]. Additionally, the incorporation of plant-based proteins can increase the fiber and antioxidant content of hybrid meat products [25].
- ✓ Protein quality and digestibility: The protein quality of hybrid meat products is a critical factor in determining their nutritional value. Research has demonstrated that the protein digestibility of hybrid meat products can be affected by the type of plant-based protein used and the processing methods employed [26]. For example, a study found that the *in vitro* protein digestibility of hybrid meat emulsions was lower when rice protein was used, compared to soy or pea proteins [12]. This highlights the importance of selecting suitable plant-based proteins and optimizing processing conditions to ensure optimal protein quality.
- ✓ Sensory and texture properties: The sensory and texture properties of hybrid meat products can also impact their nutritional value. Studies have shown that the texture and appearance of hybrid meat products can be influenced by the type of plant-based protein used and the processing methods employed [25]. For example, a study found that hybrid extrudates with beef and pea protein isolate had a softer and layered texture, while those with beef and milled texturized pea protein concentrate were harder and had smaller fibers [25]. These differences in texture and appearance can affect consumer acceptance and nutritional intake.
- ✓ Consumer acceptance and market potential: The market potential of hybrid meat products is closely tied to consumer acceptance. Research has shown that hybrid meat products can be an effective solution for consumers who want to reduce their meat consumption and environmental impact [13]. However, the success of hybrid meat products in the market depends on factors such as taste, texture, and price. A study found that a meat hybrid with a relatively high share of 30% plant-based proteins

with peas as a protein source and textured vegetable protein as a processing method can still attract consumers [28].

The main conclusions obtained were that hybrid meat products have the potential to be a healthier alternative to traditional meat products. The incorporation of plant-based proteins can lead to improved nutritional profiles, including lower fat content, higher protein content, and increased fiber and antioxidant content. However, the protein quality and digestibility of hybrid meat products can be affected by the type of plant-based protein used and the processing methods employed. Additionally, the sensory and texture properties of hybrid meat products can impact consumer acceptance and nutritional intake. Based on the available evidence, it can be concluded that hybrid meat products have the potential to be a healthier alternative to traditional meat products. However, further research is needed to fully understand the nutritional benefits and limitations of hybrid meat products.

#### *4.3. Discussion about the Suitability, Weakness, and Strengths of These Responses*

The potential of this new tool was evident from the responses obtained. It seems implausible that in such a short period, such well-argued, structured, and evidence-based answers can be obtained (427.91 s on Google Colab to answer six questions, approximately one minute per question; Virtual Machine (VM) in Google Colab offers 12.67 GB of RAM and a temporary Disk Space of 107.72 GB). In addition, it can be assumed that the context in which the information has been obtained to answer the questions is scientifically based because it comes from the literature review carried out on that particular topic. From the general analysis of the responses, several strengths and weaknesses can be identified. The strengths of this system are its ability to process a lot of information quickly, to obtain clear, well-structured answers, cover the key points, be reliable, and express these answers in a very didactic and credible way. On the other hand, its main weakness is that it was not able to attribute the information presented to each of the consulted sources (not all answers incorporate in the text the bibliographical citations from which the information was obtained and in other cases with a low number of references; for example, for question 4.2.1, only two bibliographical references have been cited; for questions 4.2.2, 4.2.3, and 4.2.4, the number of references cited ranged from five to seven but all of them were cited together without a specific distribution along the text).

However, from the individual analysis of each one, it can be seen that the answer obtained to question 4.2.3 (What are the main ingredients used as colorants in the development of hybrid meat products?) does not fully meet the expectations. The question seems to have been misunderstood, which is first confirmed by one of the sentences in the body of the answer “the focus is on the formulation and properties of hybrid meat products, rather than specific colorants”. This was not the purpose of the question and therefore the answer was not correct. The intention was precisely to ask about the colorants used in hybrid meat products to simulate the characteristic reddish colors of traditional meat products. At this point, it was thought that it was perhaps not a fault of the program but that the question that had been asked was not clear or explicit enough. So, it was decided to rephrase the question, trying to be as explicit, clear, and reliable as possible and to compare both answers.

Thus, the initial question, what are the main ingredients used as colorants in the development of hybrid meat products? was rephrased to this one: what are the main ingredients used to obtain the red color in hybrid meat products? In this case, the following answer was obtained.

The introduction in this case was that the hybrid meat products have gained popularity in recent years as a more sustainable and healthier alternative to traditional meat products. One of the key characteristics of hybrid meat products is their red color, which is often achieved through the use of natural ingredients. This report aims to identify the main ingredients used to obtain the red color in hybrid meat products.

The main ingredients used to obtain the red color in hybrid meat products are:



- ✓ **Cochineal carmine:** A natural red colorant. One of the main ingredients used to obtain the red color in hybrid meat products is cochineal carmine, a natural red colorant derived from the cochineal insect. Cochineal carmine is a popular choice for hybrid meat products due to its vibrant red color and stability in various formulations. In a study published in the journal *Current Research in Food Science*, researchers found that cochineal carmine adsorbed on a layered zinc hydroxide salt (ZHN) was an effective natural hybrid dye for mortadella, a type of Italian sausage. The ZHN-carmine hybrid dye was found to produce a more intense red color with lower lightness and higher redness values compared to traditional formulations [29].
- ✓ **Other natural red colorants:** In addition to cochineal carmine, other natural red colorants such as beetroot juice, annatto, and paprika are also used to obtain the red color in hybrid meat products. Beetroot juice, for example, is a popular natural colorant used in meat products due to its vibrant red color and antioxidant properties. Annatto, a natural colorant derived from the seeds of the achiote tree, is also used to impart a red or orange color to hybrid meat products. Paprika, a spice made from ground bell peppers, is another natural red colorant used in hybrid meat products.

So, the conclusion is that the main ingredients used to obtain the red color in hybrid meat products are cochineal carmine, beetroot juice, annatto, and paprika. These natural colorants are preferred over synthetic colorants due to their vibrant colors, stability, and potential health benefits. The use of natural colorants in hybrid meat products is a growing trend in the food industry, driven by consumer demand for healthier and more sustainable food options.

It can be considered that this answer was much more appropriate to the purpose of the question and does give information on those natural colorants that are used in the development of hybrid meat products.

It must be taken into account that it is an Exploratory Literature Review only to show how useful these AI tools could be. To complete the review, the next step would be a traditional review of the selected papers. Furthermore, it can be used to get a quick answer to a specific research question. For example, following one of the questions used here, if work is to be carried out on the development of hybrid meat products and it is necessary to know which are the most commonly used vegetable ingredients in their formulation, this approach would be very practical and suitable.

## 5. Conclusions and Future Trends

There are many applications of artificial intelligence in the field of food science and technology and many advances have been achieved with its application. In the field of literature reviews and due to the increasing availability of scientific information related to the different topics within this area of knowledge, the effectiveness of traditional literature review processes has become more difficult. In this scenario, the development and application of AI-based tools seems to have great scope for action. Some of these tools have been applied on one emerging topic of food science and technology (“hybrid meat products”) with the aim of not only to objectively selecting the most relevant information from a wide range of scientific publications, but also to analyze the selected papers by answering relevant questions on the topic being reviewed. For the first task, a tool based on the Natural Language Processing was implemented and applied. For the second task, a project based on the interplay between Retrieval-Augmented Generation and LLAMA 3 was implemented and tested. The combination of both tools has proven to be very efficient (selecting relevant references in less time) for the scientific review process. It was possible to answer the key question in a very short period of time, and the responses obtained were well-argued (on the actual knowledge about hybrid meat products), structured (following the fulfilment of a logical order of presentation of scientific results), and evidence-based. In addition, it can be assumed that the context in which the information has been obtained to answer the questions is scientifically based because it comes from the literature review carried out on that particular topic. In both cases human support is still needed. In the first



case in order to identify the key words and to select the clusters closest to the specific topic to be reviewed, and in the second case to draft precisely and clearly the relevant questions of the subject and to determine its reliability. Human action is also indispensable for the analysis of the responses obtained as well as their reformulation if necessary. Both tools have been demonstrated to be fully efficient in a real situation using the “hybrid meat products” as a proof of concept. In addition, these tools are freely available to the scientific community and can be checked on other knowledge areas, in line with the principles of open science set out by UNESCO [30] and incorporated into the science policies of most countries in the interest of greater transparency of future research.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/informatics11040072/s1>, Figure S1: Word cloud of the 75 most common words in the 19 clusters (numbered from 0 to 18 and identified as the top of each figure) in which the analyzed bibliography about “hybrid meat products” was categorized (the higher the word size, the higher their frequency); Table S1: Data, AI-based tools and results obtained during the review of hybrid meat products as proof of concept.

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