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A Research Agenda for Colostrum Supplement Manufacturing: Insights from a Scoping Review

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Abstract*—Bovine Colostrum (BC) is the first milk cows produce after giving birth. BC contains essential nutrients required by neonates. These nutrients may be potentially beneficial to humans. This review aims to establish the nature of the published evidence, thereby detailing the use of bovine colostrum in supplement manufacturing. This scoping review focuses on evidence in the literature related to the manufacturing process, efficacy or efficiency, and nutritional composition of bovine colostrum supplements. The Scopus database was searched to identify all relevant full-text literature published in English. The methodology used to conduct this scoping review is the JBI method. The scoping review follows the Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Reviews (PRISMA-Scr) reporting method. Bibliometric analyses were conducted on the included publications. An R-based software package called bibliometrix was used to perform the Bibliometric analyses. The findings from the studies revealed that there has been an increase in annual scientific production on the topic, highlighting an increase in interest in the subject. The thematic map generated using bibliometrix software using the author's keywords revealed that some of the keywords were in the motor themes quadrant, indicating higher relevance and coherence of the research topics. The review's findings also revealed high research output from developed countries and low research output from developing countries. The results indicate thatEgypt produced the highest research output in the selected publications on the African continent, with four documents on the topic. The research fields that made the largest contribution to the topic under review were medicine, agriculture, and nursing, with 29.4%, 21.2%, and 18.2% contributions, respectively. The results indicate that the countries with the highest frequency of collaboration in the selected literature are the US, the UK, and Australia. Insights from the scoping review were used to develop a Research Agenda to address the research gaps within the research area. Quality Standards, Market Trends, Research Contributions, Nutritional Benefits, Feasibility Studies, and Business Models were the areas proposed for further research to address knowledge gaps in the Bovine Colostrum research field.*

Index Terms—*Colostrum, Supplements, Nutrition, Health, Scoping Review.*

I. INTRODUCTION

The cattle industry is asignificant contributor to food production worldwide. Foods such as meat, milk, and cheese, among other dairy products, are consumed daily. Thus, it is necessary to enhance sustainability in practices within the cattle industry. Bovine colostrum (BC) is the milk dairy animals

produce after giving birth[1]. BC contains many bioactive compounds such as carbohydrates, minerals, fats, proteins, and vitamins[2]. Bioactive compounds have a particular biological activity with human health implications[3]. BC contains critical nutrients human and animal neonates require, such as proteins, immunoglobulins, minerals, and antimicrobials.

BC is a promising nutraceutical food substance[4]. Nutraceutical is a term used to describe food substances that can be used in treating and preventing diseases[5]. It combines two words: nutrition and pharmaceutical[5]. Increasing knowledge supports the view that bovine colostrum can be used to prevent and treat various diseases in humans. Bovine Colostrum is a potential source of immunity for humans and has been shown to promote the growth of tissues and immune functions in neonates[5]. Bovine Colostrum can thus be used to help to promote health and well-being. The composition of all the significant nutrients is higher in bovine colostrum than in regular bovine milk (BM)[2]. Table 1 outlines some of the significant health benefits of Bovine Colostrum on human health [2].

The health benefits of BC are prevention and treatmentof viral influenza[6], the promotion of wound healing[5, 7], the prevention of subclinical leaky gut syndrome[8, 9], the prevention of the occurrence of cardiovascular diseases[5] among many other benefits.

II. METHODS

This review will make use of the JBI method for scoping reviews [10] which was initially proposed by Arksey and O Malley[11]. The framework provides an explicit set of steps that allow studies to be reproducible and enhance the rigor of the methodology[11]. This scoping review will be reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews checklist (PRISMA-SCR) [12].

The focus of this research is to explore the current literature on the topic of Bovine Colostrum Supplement manufacturing. The following review question was formulated:

What current literature has been published on Bovine Colostrum as a nutritional supplement?

The sub-questions of the review are as follows:

a. What are the nutritional components of bovine colostrum?
b. What is the efficacy of bovine colostrum as a nutritional supplement?
c. How can nutritional supplements be manufactured from bovine colostrum?

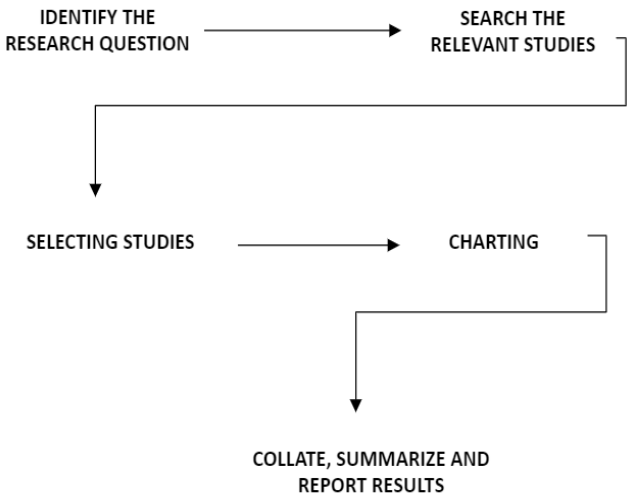

Figure 1Arksey and O'Malley Methodology for Scoping Reviews[11]

A. The PCC Framework

The PCC framework was used to define the criteria for selecting the literature.

Participants
The types of participants will not be the basis for inclusion in this review. All articles about the potential use of bovine colostrum in supplement manufacturing will be considered for inclusion.
Context
This Scoping Review is an international review, and articles
published globally will be considered for inclusion. The articles will be included irrespective of geographical location.
Concept
This review considered articles discussing the use of bovine colostrum in supplement manufacturing. It will provide a way of mapping the literature on the Bovine Colostrum sector. It will primarily focus on bovine colostrum's nutrient composition, effectiveness as a nutritional supplement in humans, and manufacturing processes.

B. Search Strategy
The review will aim to find published studies that contain specific keywords in their titles and abstracts. The search terms were developed with the assistance of a Librarian. The keywords found in these articles will be utilized to create a complete search strategy. The search terms will be obtained from relevant articles' titles, abstracts, and indexes. The total searches will be done in the Scopus database. The reason for the sole use of Scopus is that it is a database with many publications [13]. The identified articles or literature will be considered for inclusion. This review will include studies published in English. Published journal articles and reviews from the year 2000 onwards will be considered. This will allow for the most recent literature as evidence to be considered for the review. Table 2 outlines the search string and terms used in the review, the search results, and the date the search was conducted.

Table 1 Several Benefits of BC[2]

CONDITION	**HEALTH BENEFIT**
Respiratory tract	Athletes are more susceptible to the infection of the respiratory tract due to intense exercise for prolonged periods.[2]. BC can help prevent infection of the upper respiratory tract (URTI). [6]
Gastrointestinal tract disorders	BC reducessymptoms of gastrointestinal tract disorder by regulating the immune system's activity.[2].
Cardiovascular diseases	BC may be beneficial in helping to prevent the occurrence of cardiovascular diseases[5].
Leaky gut syndrome	BC can help prevent subclinical leaky gut syndrome in patients[8, 9].
Wound healing	Nutritional Components in BC can promote wound healing[5, 7].
Viral Influenza	BC can prevent and treat influenza when taken orally [6].

C. Study Selection
When the search has been initialized and the results obtained, the articles in the search results will be considered for inclusion. The journal articles that will be received will be screened using the specifications highlighted in the inclusion process. The titles and abstracts from the relevant studies will be screened for potential inclusion in the study.
D. Data Extraction, Analysis and Presentation
The search results data will be extracted from the Scopus database and exported as an RIS file into the

EndNote reference manager for initial title and abstract screening of the literature. After the initial literature screening, the remaining articles are considered for full-text screening. The full-text versions of the articles are then retrieved (using available resources) where possible. All the retrieved publications will be considered for inclusion.

E. Report Inclusion

The Scopus database search used the search string shown in Table 2. The scoping review was reported using the PRISMA-Scr methodology, as shown in Figure 2. The search produced 529 search results, and 11 articles were selected from reference lists. Initially, 20 files that were not published in the English language were excluded. Subsequently, only journal articles and reviews were then considered, and 48 other types of publications were excluded. The titles and abstracts of the 473 publications that remained were screened for inclusion in the scoping reviews. Of the 473 publications, 273 were excluded, while 200 were considered for retrieval. Full texts of the 200 records were then considered for inclusion. Subsequently, 136 articles were included in the review after the screening process. The selection of the articles was based on relevance to answering the review questions within the scope of the review as outlined by the inclusion criteria.

III. Results and Discussion

Bibliometric methodology can be defined as the analysis of bibliometric data using numeric techniques[13]. It is also a statistical technique for examining the research output for scientific or scholarly publications.[14].This review used the bibliometrix R-package called biblioshiny for bibliometric analyses, which is named bibliometrix. Bibliometrix is an open-source R package that can be used for science mapping [15].

Science mapping or bibliographic mapping aims to display the fundamental elements of scientific research [16]. The bibliometrix software package provides a group of tools for quantitative research[15]. Bibliometrics can be utilized to examine the rate of scientific production numerically[17].Figure 3, generated using the Bibliometrix software, displays the annual scientific production of included reports/literature. The quantity of scientific output fluctuated between 2000 and 2012. Science output increased gradually between 2012 and 2023, with the highest-ever production in 2022 in the selected period. This trend shows the general increase in interest in the topic under review.

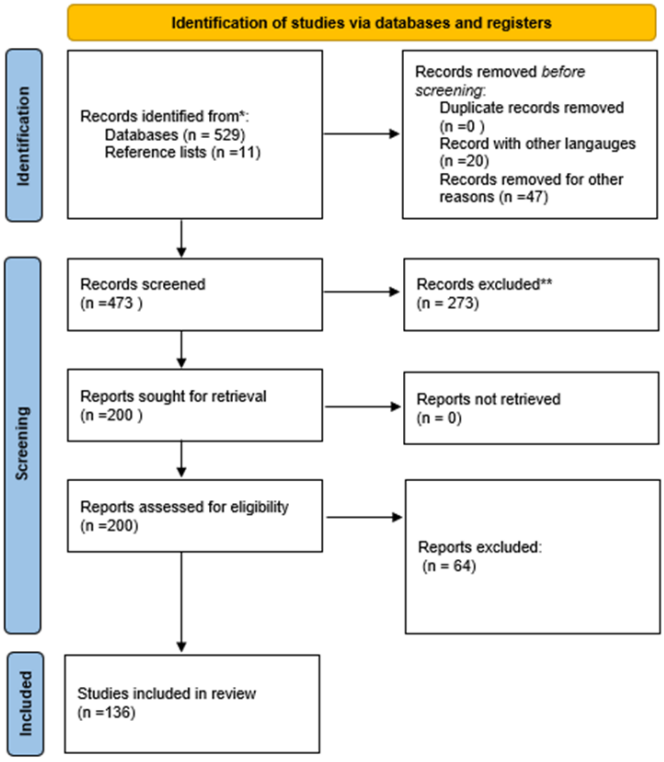

Figure 2Search Results, Screening Process, and Included publications (PRISMA-Scr) [18]

Table 2Search terms used in Scopus database search

DATABASE	SEARCH STRING	SEARCH RESULTS on 21/04/24
Scopus	(TITLE-ABS-KEY ((cattle OR bovine OR cow OR calves) AND colostrum AND supplement AND humans) OR TITLE-ABS-KEY (health AND benefits AND of AND (bovine OR cow OR cattle) AND colostrum AND in AND humans) OR TITLE-ABS-KEY (bovine AND colostrum AND clinical AND trials AND in AND humans) OR TITLE-ABS-KEY ((bovine OR cattle OR cow OR calves) AND colostrum AND randomized AND control AND trials AND in AND humans) OR TITLE-ABS-KEY ((bovine OR cow OR cattle OR calves) AND colostrum AND nutritional AND composition) OR TITLE-ABS-KEY ((bovine OR cattle OR cow OR calves) AND colostrum AND supplements AND (manufacturing OR processing)) OR TITLE-ABS-KEY (colostrum AND (athletic AND performance) OR (antigrowth AND factors) OR (wounds AND healing) OR (antimicrobial AND properties) OR (gastrointestinal AND health) AND humans))	529

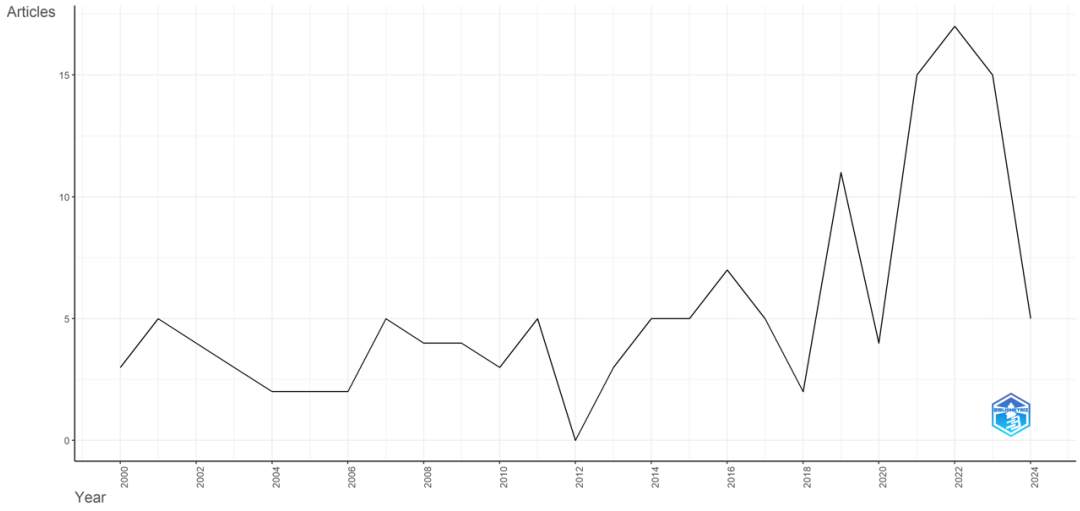

Figure 3 Annual Scientific Production[15]

Figure 4 indicates the subject areas that contributed to the research area. The pie chart shows that the medical field contributed the most research in the included publications. The major contributors are medicine, agriculture, nursing, immunology, pharmacology, biology, and chemistry. Engineering, social sciences, and neuroscience made the lowest contribution, 2%, in the reports included. The Annual Scientific Production is from a diverse set of knowledge areas, and it can be noted that this research area is interdisciplinary.

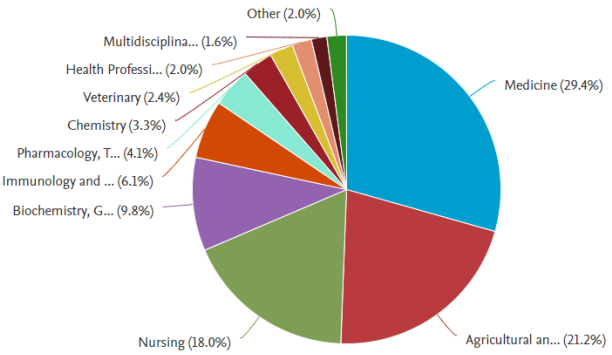

Figure 4 Subject areas of included reports(generated using Scopus)

Figure 5 shows that African countries' research contributions in this research area have been limited compared to other countries such as the USA, the UK, and Australia. Egypt has the highest quantity of publication literature in the research area, followed by South Africa and Zambia. Egypt had 2 publications in the research area under review. In contrast, the other countries had one publication each in the selected studies.

The co-occurrence map by bibliographic data displayed in Figure 6 was generated using the VOSviewer software. The map also shows how often the keyword appears and other keywords in the included publications. The co-occurrence was generated using the author's keywords and words, which had a minimum of 3 occurrences and were included in the map.

The map was developed using the full counting technique, meaning all terms' occurrences were considered. The co-occurrence map indicates the connections between the keywords.

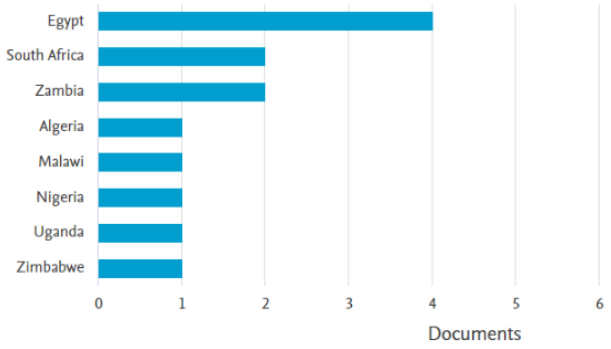

Figure 5 Documents by African Countries in the Research Area[15]

The weight of a keyword or item is an indicator of its importance [21]. The weight can be used to understand the overall strength of the connections [21]. Items with higher weights are more visible or noticeable than smaller ones [21]. The map shows that the term colostrum was one of the terms that appeared most frequently in all the articles, and it appeared in conjunction with most of the terms in the co-occurrence map. The term bovine colostrum appeared along with several words in the included studies, such as supplementation, gut permeability, nutrition, amino acids, human health, functional foods, immunoglobulins, immune system, bioactive proteins, gastrointestinal infection, inflammatory bowel syndrome, and diarrhoea, among other words. These linkages indicate the connections between the bovine colostrum and the abovementioned keywords. The linked keywords are the research areas or topics related to bovine colostrum. The co-occurrence map indicates the connections between the keywords.

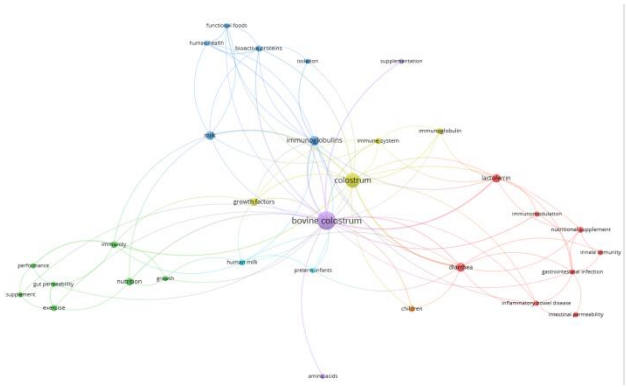

Figure 6 Term co-occurrence map based on bibliographic data. (developed using VOSviewer software)

The country collaboration map in Figure 7 indicates the research collaboration between countries or regions. The United States of America, the United Kingdom, Australia, Poland, New Zealand, and Denmark have the highest frequency of collaboration with other countries in the bovine colostrum supplement manufacturing research area. The USA, UK, and Australia also have the highest research contribution in this research area, they took part in 19, 16, and 16 research publications, respectively. There has been some collaboration in this research area on the African continent, but there is little collaboration among the included studies. Figure 5 shows that African countries' research contributions in this area have been limited compared to other countries such as the USA, the UK, and Australia.

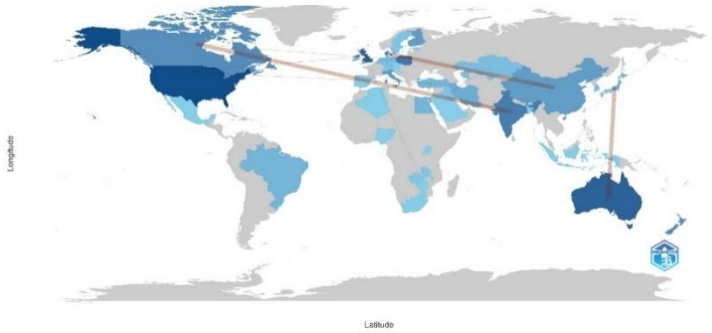

Figure 7 Countries' Collaboration Map[15]

Figure 8 is the thematic map of the included publications. The thematic map was developed using the R-based bibliometrix software called biblioshiny [15]. The theme consists of four quadrants: motor themes, niche themes, and emerging themes; motor, niche, emerging, and basic themes. Basic themes in the thematic map are found in the fourth quadrant, and these topics have a high centrality and low density[19]. The high centrality indicates that the topics in these quadrants have value to the field, and the low density indicates low coherence[19]. Motor themes contain topics with high centrality, meaning that the issues are essential to the field, and high density means an elevated level of coherence of the keywords. Due to their low centrality, niche themes topics have lower importance or value in their respective fields[19]. The topics in niche themes also have high density and cohesion of the keywords[19]. Emerging themes have low centrality and low density, as shown in Figure 6.

The thematic map provides insights into research areas that are still emerging, motor or developed, basic and niche themes. The thematic map in Figure 6 was created using author keywords, indicating that most of the author's keywords are in the fourth quadrant. Some keywords in the motor themes quadrant are exercise, gut permeability, supplementation, lactoferrin, immunoglobulin, colostrum, diarrhoea, and milk. These topics or keywords have high relevance and high density, indicating the amount of research on the subject and its significance. The map suggests the fundamental concepts within the research area, such as nutrition, growth, gastrointestinal tract, performance, and supplements. The map also highlights emerging or declining themes or topics, either gaining or declining interest. Themes in this quadrant are children, amino acids, and hyperimmune bovine colostrum. These keywords indicate the emerging themes or topics in the Bovine Colostrum supplement manufacturing area. The author's keywords with the highest occurrences are bovine colostrum, colostrum, immunoglobulins, diarrhoea, milk lactoferrin, growth factor, and nutrition. The niche themes also outline the niche quadrant, which indicates specific research areas within the Bovine Colostrum industry.

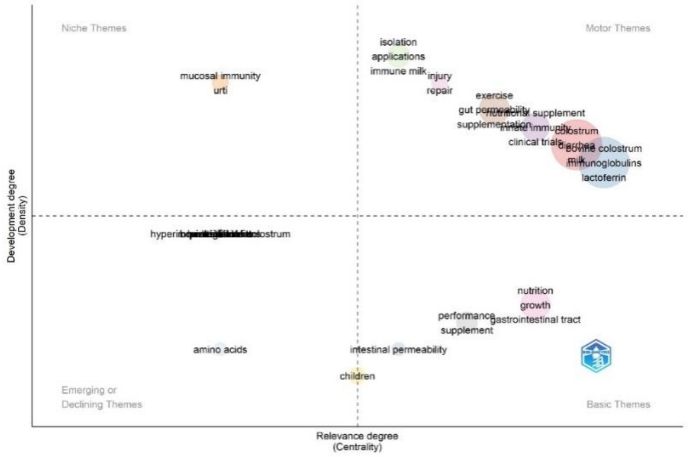

Figure 8 Thematic Map generated using the Author's keywords [15]

A. Nutritional components of Bovine colostrum

BC is an abundant source of bioactive compounds such as immunoglobulins, growth factors, amino acids, antimicrobials, and many other compounds [2]. Several articles highlighted the nutritional composition of BC. Table3 shows the quantities of major constituents in BC. As shown in Table 3, BC is an essential source of essential nutrients. All the major nutrients are higher in BC than in bovine milk except for Lactose, which is higher in BM than in BC. The factors that affect the composition of BC are breed, feed or nutrition, parity, and time the colostrum is collected after giving birth, among other factors[20].

B. Efficacy of bovine colostrum

Several studies in the included reports have documented the numerous health benefits of bovine colostrum as a supplement. Some of the review articles in the included reports aggregate some of the clinical trials that have been done on the use of bovine colostrum. Review articles by Gurberti et al. [21] and Bagwe-Parab et al (2021)[22], provide an analysis of the clinical trials that different authors have documented. These articles provide evidence about some of the interventions that have yielded some results that support the view of Bovine Colostrum as a nutraceutical substance. For example, an article by Jones et al. (2014) documented a clinical trial that had 53 male participants and had a duration of 12 weeks; a decrease in URI incidence was noted as well, and the number of URI days was reduced. In the trial, no effects were pointed out on the severity of URI episodes. Table 4 lists critical trials, the number of participants, the intervention matrix, the study design, and results. The table shows that BC may possess some health benefits.

C. Manufacturing processes for bovine colostrum supplement

A significant challenge with producing products made from BC is the production of high-quality products that are free fromcontaminants[23, 24]. Bovine colostrum contains many constituents, some of which are pathogenic bacteria.[25]. Pathogens in milk and its products have been documented to significantly contributeto foodborne diseases caused by pathogens in industrialized countries[25].Consuming raw bovine colostrum, which contains pathogenic bacteria, can increase a person's chances of developing an illness.[2]. It is thus essential to process the BC before it is consumed. The treatment or processing should be sufficient to treat any disease-causing pathogens[25]. The processing should not, however, diminish the bioactive compounds that give BC its health benefits[2]. The problem is that most bioactive compounds are not stable under heat treatment[2]. Thermal processing is the most widely used in the dairy industry[26]. Heat treatment is one of the standard methods in the literature to inactivate disease-causing pathogens in the colostrum. Farm hygiene practices are essential to preserve the quality of the BC[25]. Microorganism contamination can occur at any stage during the handling of the BC, such as during milking, storage, transportation, and processing [25].Fasse et al. (2021) proposed a process for industrial processing BC that produces a product free from pathogens and safe for human consumption.

The factors that affect the quality of bovine colostrum are the hygiene levels of the milking process, milking equipmentcleanliness, equipment design, the health status of the cow, temperatures during

packaging, temperatures during storage, and temperatures during transportation and the heat treatment process.*[27, 28]*.

Figure 8 outlines three main types of heat treatment steps: low-temperature long-time (LTLT), Low-Temperature Short-Time (LTST), and High-Temperature Short-Time (HTST). The LTST would require an additional step in which the colostrum is treated at temperatures between 58-68^{o}C for about 15 to 30 seconds[25]. Pasteurization focuses on the inactivation of bacteria.

A study by Gosch et al. (2014) [29] proposed a series of process steps that can be utilized to reduce the bacterial count in BC. The novel process involves a combined Microfiltration (MF at pore sizes of 1.4µm and 0.8µm) combined with High-Pressure Processing (HPP at 400 to 500MPa for 10min)[29]. Both MF and HPP produced BC with a very low bacterial count[29].When BC was processed using HPP at 500MPa, the immunoglobulin IgG was reduced to between 19 and 30% of the original content. The percentage reduction of the IgG was between 27 and 64% of the original content. The study proposed that the novel process resulted in less IgG inactivation than the conventional heat treatment[30].

Board, et al. (2021)[30] proposed a novel process that combined microfiltration(MF) followed by ultrafiltration(UF) of the skim colostrum and colostrum whey. The permeate from the MF was concentrated using ultrafiltration to produce retentates of skim colostrum and colostrum whey with fold factors of 2.03 and 2,38, respectively[30]. The study resulted in colostrum production with a high concentration of immunoglobulin. Time, Gradient, and Temperature (TGT) for retentates of skim colostrum and colostrum whey were found to be 72.2 and 74.5^{o}C, respectively, using the temperature sweep.

Figure 9, which was adapted from Poonia [2]shows the different routes that can be utilized to make BC supplements and related products. The BC can be processed using either the thermal or non-thermal routes. Different types of routes produce different product qualities because the various processes affect the number of constituents retained in the final product.

IV.DISCUSSION AND CONCLUSION

The scoping review aimed to map literature relating to the topic. 136 studies were selected, providing relevant literature aligned with the research questions. The scoping study also found that there has been limited research on bovine colostrum supplement manufacturing in Africa. Several studies in the included literature documented the presence of bioactive components in the BC that provide it the capability of functioning as a health supplement.

It can be noted that BC composition varies with several factors, such as environment, breed of cows, sources/type of water, farming practices, or pasture. Therefore, research in all regions is necessary. The study also identified from the literature that various supplements are being manufactured in various parts of the world.

The bibliometric analysis highlighted that interest in this research topic has grown significantly over the past couple of years. Many studies (including clinical trials) in the included literature provide significant evidence that BC contains bioactive compounds and other nutrients that have numerous health benefits for humans. A research gap was noted in the BC supplement manufacturing area. The study did not identify any research output on business model development for manufacturing bovine colostrum supplements.

This scoping review paper proposes a research agenda for further BC Supplement Manufacturing field research, as shown in Table 5. This includes the development of standards in the field, such as optimum BC storage conditions, quality standards, and processing techniques. Also, a holistic view of the whole value chain of bovine colostrum could assist with identifying knowledge gaps and providing areas of improvement in the research area. Further, a business model can be developed to provide information on the possibility of sustainable manufacturing of BC supplements. This could provide necessary information to investors who might want to invest in a business venture on the African continent, where the potential of bovine colostrum has been untapped.

Other authors in the literature included in the scoping review indicate some research gaps that must be addressed. For example, Costa et al. (2023) suggests that there has been limited research in academic

literature on the size of the market in the Bovine Colostrum supplement manufacturing field. Future research could be done to provide these figures for market trends and the size of BC supplement manufacturing.

Table 3 Nutritional Profile of Bovine Colostrum from Poonia(2022)[2]

Components	**Mature Milk**	**Bovine Colostrum**	**References**
Fat (%)	3.6-4.0	6-7	[31]
Lactose	4.7-5.0	2-3	[32]
Proteins Proteins (%) Albumin (%) Casein (%)	 3.1-3.2 0.4-0.5 2.5-2.6	 14-16 1.7-3.49 4.8-5.0	[33, 34]
Immunoglobulins Immunoglobulins (mg/mL) IgA(g/L) IgG1(g/L) IgG2(g/L) IgM(g/L)	 0.4-0.9 0.04-0.06 0.31-0.4 0.03-0.08 0.03-0.06	 42-90 3.2-6.2 34.0-87.0 1.6-6.0 3.7-6.1	[2, 5, 35]
Minerals Sodium(g/kg) Calcium(g/kg) Potassium (g/kg) Magnesium(g/kg) Phosphorus(g/kg) Zinc(mg/kg)	 Approx. 0.4 1.2-1.3 1.5-1.7 0.11-0.13 0.9-1.2 3.0-6.0	 0.7-1.1 2.6-4.7 1.4-2.8 0.4-0.7 Approx. 4.5 11.6-38.1	[35]
Vitamins Vitamin A(µg/100mL) Tocophenol(E)(µg/g) Thiamin(B1) (µg/mL) Niacin(B3)(µg/mL) Riboflavin(B2)(µg/mL) Vitamin(IU/g fat)	 34-35 0.06 0.4-0.5 0.8-0.9 1.5-1.7 0.41	 25.0-26.0 2.92-5.63 0.58-0.9 0.34-0.96 4.55-4.83 0.89-1.81	[35, 36]
Antimicrobials Lysozyme(mg/L) Lactoferrin(g/L) Lactoperoxidase (g/L) Growth Hormone(mg/L) Insulin-like growth factor-1 (µg/L)	 0.07-0.6 0.1-0.3 13-30 <0.03 200–600	 0.14-0.7 1.5-5.0 11.0-45.0 <Img 50-2000	 [37] [37] [36] [22] [32]

Table 4 BC Clinical trialsfrom Gurbeti et al. (2021) and Bagwe-Parab et al.[21, 22]

Use	Authors/ Reference	Number of Participants	Intervention Matrix	Results
BC as a sporting supplement	[38]	53 male participants	BC (Neovite ® UK)	A decrease in the incidence of URI, URI days, and salivary bacterial load.
	[39]	16 competitive male athletes	Freeze-dried whole BC obtained within 2 hrs of calf delivery	A decrease in sugar absorption and zonulin concentration
	[40]	34 active males	BC plus water plus training program	Decrease in immune sensitivity after prolonged exercise.
	[41]	10 males who have undergone extensive training	Intact Bovine CPC before and during a 5-day cycling race.	An increase in the maintenance of testosterone concentration. An increase in cortisol concentration.
BC as a paediatricdietary supplement	Gurbeti, et al (2021) [21] Barakat, et al (2019)[42]	160 paediatrics with acute diarrhoea	ImmuGuard sachets	A decrease in the frequency of diarrhoea and vomiting was noted. The duration of the diarrhoea also decreases.
	Meinich Juhl, S, et al (2018)[43]	40 paediatric participants	BC powder	An increase in protein in the participants
	Rathe, M, et al. (2020)[44]	62 Paediatric participants with	Spray-dried BC powder	Oral mucositis decreases in severity
BC supplementation in adults	Duff, W. R, et al. (2014) [45]	40 adults 15 males 25 females	Spray-dried BC plus training program	An increased leg press and increased bone resorption
Immunodeficiency diarrhoea	Florén et al., 2006 [46] Kaducu et al., 2011[47]	84 adults	ColoPlus/ placebo	Stool frequency per day wasreduced by 79%, while self-reported fatigue decreased by 85%. CD4 count increased by 14%.
Acute Infectious	Menchetti, et	160 children	BC in sachet	A decrease in the

bacteria	al [48]Barakat,et al(2020)[49]			frequency of vomiting and diarrhoea.

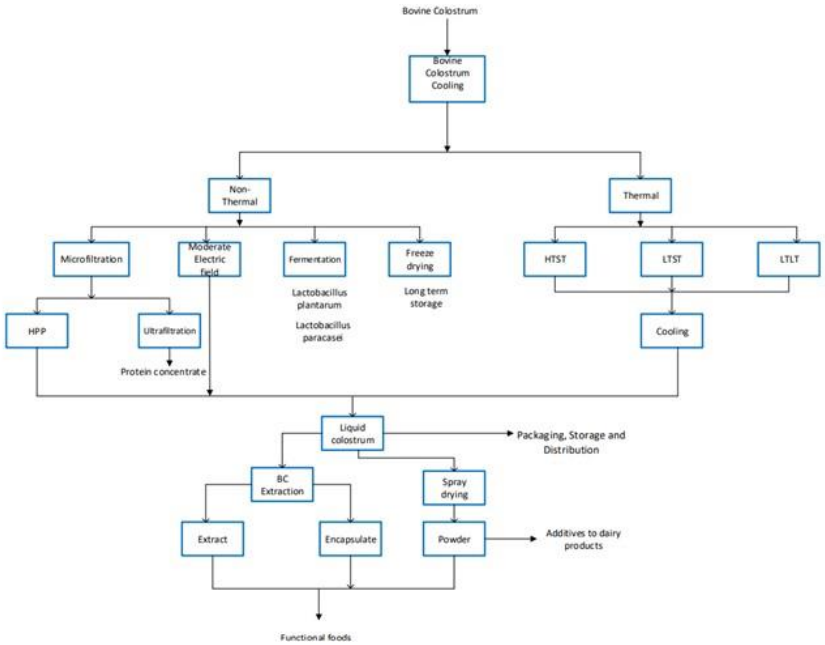

Figure 9Processing of Bovine Colostrum adapted from Poonia (2022)[2]

Research Area	**Research Themes**
Quality Standards	Determination of quality standards of BC supplement manufacturing in terms of • nutritional composition of essential constituents in products such as immunoglobulins, vitamins, etc • development of optimum storage and transportation conditions within a broader supply chain model that results in BC with optimum nutritional value. • manufacturing processing standards that retain the most amount of BC constituents.
Market Trends	• Market research on global BC Market trends
Research Contributions	• This Scoping Review indicates increased interest in the BC Manufacturing research field. Research contributions came mostly from the developed world and less from developing countries. • Certain factors differ between geographical locations, such as nutritional components. This research proposes further research within the African context to provide more geographic-specific information to interested stakeholders.

Nutritional Benefits	• More extensive research on bovine colostrum supplement manufacturing nutritional benefits
Feasibility Studies	• Conducting feasibility studies (technical, operational, legal, market, and resource), particularly within the African Continent
Business Model	• Development of a business model from initial feasibility assessments to provide essential information to potential investors or potential funders about how a BC supplement manufacturing company can be developed to function and capture value.

Table 5 Research Agenda adapted from Grobbelaar et al. (2017)[50]

REFERENCES

1. Rathe, M., et al., *Clinical applications of bovine colostrum therapy: a systematic review.* Nutr Rev, 2014. **72**(4): p. 237-54.
2. Poonia, A., *Bioactive compounds, nutritional profile and health benefits of colostrum: a review.* Food Production, Processing and Nutrition, 2022. **4**(1).
3. Agnieszka Zgoła-Grześkowiak and T. Grześkowiak, *Introduction: Bioactive Compounds and Elements in Human Nutrition*, in *Analytical Methods in the Determination of Bioactive Compounds and Elements in Food*, Magdalena Jeszka-Skowron, et al., Editors. 2021. p. 1-9.
4. Siddhi Bagwe, et al., *Bovine colostrum: an emerging nutraceutical.* Journal of Complementary and Integrative Medicine, 2015.
5. Bagwe, S., et al., *Bovine colostrum: An emerging nutraceutical.* Journal of Complementary and Integrative Medicine, 2015. **12**(3): p. 175-185.
6. Batista da Silva Galdino, A., et al., *Bovine colostrum: benefits for the human respiratory system and potential contributions for clinical management of COVID-19.* Food and Agricultural Immunology, 2021. **32**(1): p. 143-162.
7. Doillon, C.J., et al., *Modulatory effect of a complex fraction derived from colostrum on fibroblast contractibility and consequences on repair tissue.* International Wound Journal, 2011. **8**(3): p. 280-290.
8. Rawal, P., V. Gupta, and B.R. Thapa, *Role of colostrum in gastrointestinal infections.* Indian Journal of Pediatrics, 2008. **75**(9): p. 917-921.
9. Thapa, B.R., *Health factors in colostrum.* Indian Journal of Pediatrics, 2005. **72**(7): p. 579-581.
10. Aromataris, E., et al., *JBI Manual for Evidence Synthesis*, JBI, Editor. 2024.
11. Arksey, H. and L. O'malley, *Scoping studies: towards a methodological framework.* International journal of social research methodology, 2005. **8**(1): p. 19-32.
12. Tricco, A.C., et al., *PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation.* Annals of internal medicine, 2018. **169**(7): p. 467-473.
13. Donthu, N., et al., *How to conduct a bibliometric analysis: An overview and guidelines.* Journal of business research, 2021. **133**: p. 285-296.
14. Radha, L. and J. Arumugam, *The research output of bibliometrics using bibliometrix R package and VOS viewer.* Shanlax International Journal of Arts, Science and Humanities, 2021. **9**(2): p. 44-49.
15. Aria, M. and C. Cuccurullo, *bibliometrix: An R-tool for comprehensive science mapping analysis.* Journal of informetrics, 2017. **11**(4): p. 959-975.
16. Cobo, M.J., et al., *Science mapping software tools: Review, analysis, and cooperative study among tools.* Journal of the American Society for information Science and Technology, 2011. **62**(7): p. 1382-1402.
17. Derviş, H., *Bibliometric analysis using bibliometrix an R package.* Journal of scientometric research, 2019. **8**(3): p. 156-160.
18. Page, M.J., et al., *The PRISMA 2020 statement: an updated guideline for reporting systematic reviews.* Bmj, 2021. **372**.

19. Kuipers, S., A. Van Der Wilt, and J. Wolbers, *Pandemic publishing: A bibliometric review of COVID-19 research in the crisis and disaster literature.* Risk, Hazards & Crisis in Public Policy, 2022. **13**(4): p. 302-321.
20. Ramani, A., S. Taherabbas, and S. Manik, *Bovine colostrum as a promising nutraceutical: a systematic review.* Sustainable Food Technology, 2024.
21. Guberti, M., et al., *Bovine colostrum applications in sick and healthy people: A systematic review.* Nutrients, 2021. **13**(7).
22. Bagwe-Parab, S., et al., *Therapeutic Applications of Human and Bovine Colostrum in the Treatment of Gastrointestinal Diseases and Distinctive Cancer Types: The Current Evidence.* Frontiers in Pharmacology, 2020. **11**.
23. Sotudeh, S., et al., *Effects of spray-drying, freeze-drying and pasteurization on microbiological quality and IgG level of bovine colostrum.* Journal of food quality and hazards control, 2018. **5**(2): p. 54-60.
24. Phipps, A., et al., *Survey of bovine colostrum quality and hygiene on northern Victorian dairy farms.* Journal of Dairy Science, 2016. **99**(11): p. 8981-8990.
25. Fasse, S., et al., *Bovine Colostrum for Human Consumption—Improving Microbial Quality and Maintaining Bioactive Characteristics through Processing.* Dairy, 2021. **2**(4): p. 556-575.
26. Borad, S.G. and A.K. Singh, *Colostrum immunoglobulins: Processing, preservation and application aspects.* International Dairy Journal, 2018. **85**: p. 201-210.
27. Zealand, F.S.A.N. *Primary Production and Processing (PPP) Standards*. 2020 27/04/2024 [cited 2024 28/04]; Available from: https://www.foodstandards.gov.au/business/primary-production-and-processing.
28. Zealand, F.S.A.N. *Food Safety Hub*. 2019 [cited 2024 28/04]; Available from: https://www.foodstandards.gov.au/foodsafety/Pages/default.aspx.
29. Gosch, T., et al., *A combination of microfiltration and high pressure treatment for the elimination of bacteria in bovine colostrum.* International Dairy Journal, 2014. **34**(1): p. 41-46.
30. Borad, S., et al., *Optimization of spray drying of colostrum protein ingredients–A rheological approach.* Journal of Food Engineering, 2021. **288**: p. 110247.
31. Zou, X., et al., *Composition and microstructure of colostrum and mature bovine milk fat globule membrane.* Food Chemistry, 2015. **185**: p. 362-370.
32. McGrath, B.A., et al., *Composition and properties of bovine colostrum: a review.* Dairy Science & Technology, 2015. **96**(2): p. 133-158.
33. Playford, R.J. and M.J. Weiser, *Bovine colostrum: Its constituents and uses.* Nutrients, 2021. **13**(1): p. 1-24.
34. Samarütel, J., et al., *Quarter variation and correlations of colostrum albumin, immunoglobulin G1 and G2 in dairy cows.* Journal of dairy research, 2016. **83**(2): p. 209-218.
35. Godden, S., *Colostrum management for dairy calves.* Veterinary Clinics of North America: Food Animal Practice, 2008. **24**(1): p. 19-39.
36. Arslan, A., et al., *Bovine colostrum and its potential for human health and nutrition.* Frontiers in Nutrition, 2021. **8**: p. 651721.
37. Boudry, C., et al., *Bovine colostrum as a natural growth promoter for newly weaned piglets: a review.* Biotechnologie, Agronomie, Société et Environnement, 2008. **12**(2).
38. Jones, A.W., et al., *Effects of bovine colostrum supplementation on upper respiratory illness in active males.* Brain, behavior, and immunity, 2014. **39**: p. 194-203.
39. Hałasa, M., et al., *Oral supplementation with bovine colostrum decreases intestinal permeability and stool concentrations of zonulin in athletes.* Nutrients, 2017. **9**(4): p. 370.
40. Davison, G., et al., *Oral bovine colostrum supplementation does not increase circulating insulin-like growth factor-1 concentration in healthy adults: Results from short-and long-term administration studies.* European journal of nutrition, 2020. **59**: p. 1473-1479.
41. Shing, C., et al., *A pilot study: bovine colostrum supplementation and hormonal and autonomic responses to competitive cycling.* The Journal of Sports Medicine and Physical Fitness, 2013. **53**(5): p. 490-501.

42. Barakat, S.H., et al., *Bovine colostrum in the treatment of acute diarrhea in children: A double-blinded randomized controlled trial.* Journal of Tropical Pediatrics, 2019. **66**(1): p. 46-55.
43. Eslamian, G., et al., *Effects of early enteral bovine colostrum supplementation on intestinal permeability in critically ill patients: A randomized, double-blind, placebo-controlled study.* Nutrition, 2019. **60**: p. 106-111.
44. Rathe, M., et al., *Bovine colostrum against chemotherapy-induced gastrointestinal toxicity in children with acute lymphoblastic leukemia: a randomized, double-blind, placebo-controlled trial.* Journal of Parenteral and Enteral Nutrition, 2020. **44**(2): p. 337-347.
45. Duff, W.R., et al., *The effect of bovine colostrum supplementation in older adults during resistance training.* International journal of sport nutrition and exercise metabolism, 2014. **24**(3): p. 276-285.
46. Florén, C.-H., et al., *ColoPlus, a new product based on bovine colostrum, alleviates HIV-associated diarrhoea.* Scandinavian journal of gastroenterology, 2006. **41**(6): p. 682-686.
47. Kaducu, F.O., et al., *Effect of bovine colostrum-based food supplement in the treatment of HIV-associated diarrhea in Northern Uganda: A randomized controlled trial.* Indian Journal of Gastroenterology, 2011. **30**(6): p. 270-276.
48. Menchetti, L., et al., *Potential benefits of colostrum in gastrointestinal diseases.* Frontiers in Bioscience, 2016. **8**(2): p. 331-351.
49. Barakat, S.H., et al., *Bovine colostrum in the treatment of acute diarrhea in children: A double-blinded randomized controlled trial.* Journal of Tropical Pediatrics, 2020. **66**(1): p. 46-55.
50. Grobbelaar, S., R. Tijssen, and M. Dijksterhuis, *University-driven inclusive innovations in the Western Cape of South Africa: Towards a research framework of innovation regimes.* African Journal of Science, Technology, Innovation and Development, 2017. **9**(1): p. 7-19.