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The significance of goat milk in enhancing nutrition security: a scientiometric evaluation of research studies from 1966 to 2020

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Abstract

Background The present study aimed to reveal scientific findings on goat milk as an instrument to combat food and nutrition insecurity, while considering the recurrent challenge posed by food dearth and high rise of hunger among susceptible people of numerous nations.

Results A sum of 9206 research outputs were extracted in a BibTeX design for evaluation by means of bibliometric package in R studio software. The generated result included, but not restricted to authors, citations, affiliations, journals and key words. Published research findings on goat milk as related to nutrition security retrieved from web of science (WOS) and Scopus data bases were used with an increase in scientific findings of an annual growth of 14.42% during the period of study. From the result of the study, Spain was rated in first position with a total of publications ($n = 953$), and a massive global scientific influence with the highest article citations ($n = 17,035$). The most commonly referred authors' keywords in this research field were goat/s ($n = 1605$), milk ($n = 920$), dairy goat/s ($n = 372$), fatty acid/s ($n = 307$), cheese ($n = 251$), milk production ($n = 220$), milk consumption ($n = 173$), which all together gave a hint on associated research studies on goat milk and nutrition security.

Conclusions The current study presented a global picture that covers the pool of scientific knowledge on goat milk research and its relevance in nutrition security, while giving a direction for more studies in this research area. It is of utmost importance to stress that the present findings only addressed prime areas of goat milk production as linked to nutrition security research, therefore, it is proposed that novel empirical study and potential research outcomes would give new understanding and insight on goat milk utilization as an avenue to tackle nutrition security issues as new findings emerges.

Keywords Goat milk, Bibliometric analysis, Nutrition security, Benefits, Vulnerable people

Introduction

The world's worst recession and food crises was seen in the last decade after the Great Depression era [74]. Subsequently, the 2019 covid-19 pandemic hits the global world with great surprise leading to food shortage and

scarcity. Also, more than 820 million individuals all over the world are said to be destitute of their daily meal with two (2) billion deprived of adequate and essential micro-nutrients in food [73]. The recent war between Russia and Ukraine has also had its toll on food prices and food scarcity. The quest for more food production globally is targeted to increase by 50% as the world's population rises by approximately ten (10) billion people globally [21]. Despite the immense efforts made by governments around the world and non-governmental organizations (NGOs) in the fight against hunger, the issue of hunger is

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still a topical challenge, especially for people in the developing world [20].

Despite the seemingly up-hill task inherent in reducing hunger among millions of people worldwide, the collective effort of sorting for avenues to ensure that people have food to eat and are food secure cannot be downplayed. One of the means of combating the challenge of malnutrition and food insecurity among vulnerable individuals of several nations is to implement a food production scheme that is sustainable, available and affordable to meet the nutritional demands of people. One aspect of nutrition security also known as food security is referred to the access to good and healthy nutritious food by all individuals [69, 71].

Milk is known to be one of the naturally available food substance that is “nutritional complete” for human consumption and health benefits. Goat milk is highly nutritious because it contains beneficial nutrients such as carbohydrate, protein, fat, micro and macro elements and vitamins among others [50]. Goat milk and its products (yoghurt, butter, cheese, ice cream and other dairy products) form a huge portion/percentage of economic income for some countries because of their high nutritional value for human utilization [27, 43]. Goat milk and its product is reported to be a functional food that is highly beneficial to human health [68]. Milk and milk products offer several nutritional benefits to several vulnerable and food-insecure people globally especially children and adults (Engh et al. [19, 75]. According to the United Nations [70], goat milk can be utilized as an important tool to achieve its 2030 Agenda for Sustainable Development which was adopted in 2016, and its seventeen (17) inter-linked sustainable development goals (SDGs).

Goat milk with fortifications is capable of improving infant, children and adult’s diet and enhance their food security. Milk from goat with their nutritional physiognomies can be ideal replacements to other sources of milk which in turn can promote healthy living for humans [13]. According to Engh et al. [19], goat milk is reported to be nutritionally beneficial to HIV/ AIDS-affected patients. The worth of goat milk has increased worldwide as a result of its high medicinal value for human health [50]. Talking about food insecurity, it also relates to conditions leading to obesity for persons due to consumption of unbalanced diet. Subsequently, goat milk is a readily available source of healthy food to correct the effect of obesity in people [13, 75].

An important aspect of goats when they are used for milk production, is that, they perform better than cows in adverse environmental situations [32]. Likewise, goats can well be utilized for milk purpose during climate change and the corresponding negative effects it can

cause on livestock [32]. The unique attributes of goats make them an excellent choice (by vulnerable people and financially constrained persons) for milk production compared to cattle or other livestock [28, 35]. The relevance of goat milk for human consumption is gaining significant acceptance globally, and this is apparent by the fast growing goat milk market in most nations of the world [37, 45].

Therefore, promoting scholarly research outputs on the production of goat milk to enhance food security and as a tool to lower the increasing rate of hunger globally is worth-the-while. From literature search, and based on the information that is currently available, there is no research work that have evaluated scientific writings on the present subject matter which highlights the importance of goat milk as a vital instrument to enhance food security.

In addition, there are several growing research works done worldwide at a fast pace and it seems nearly impossible to keep to pace with these research works that are being published at a glance. Therefore, a detailed study on essential publications about a particular subject matter is of importance. Reviewing research publications on goat milk as a potential tool for advancing nutrition/food security is significantly important with such studies being done with the use of scientometric indices which will again help to identify hot, current and leading research topics, international collaboration, country contribution, and research directions on the subject matter. Conversely, the current study seeks to assess and analyse research studies on goat production as it relates to food security with the support of bibliometric tool.

The technique mostly adopted to evaluate and explain scientific studies done on a particular research topic is known as bibliometrics or scientometrics, which is not the same as systematic evaluation and literature reviews. The most valid aim of bibliometric/scientometric research studies is to assess trends of studies, foremost research areas, top-cited studies in the field, local, national, and global influence, scientific contributions, and important contributors/authors in a specific research area. For example, studies by Khatun and Ahmed [33] and Ekundayo and Okoh [18], used the scientometric approach to evaluate scientific studies. Bibliometric assessment permits individuals to use the instrumentality quantitative means to measure and predict happenings/trends of scientific studies and citation, largely majoring on published journal papers [51]. Qualitative literature review is a process referred to as a vital aspect in evaluating the degree of maturity of a research field [76].

Bibliometric investigation of scholarly studies uses an approach that utilizes a set of quantitative techniques to quantify, track, and evaluate scientific literatures [60]. It

recognizes the article publications by authors, the most relevant journals, most relevant global and local collaborations, together with the methodologies used and the conclusions gained [16]. However, systematic evaluation gives a summary of any scientific research field in a qualitative manner [44]. Furthermore, bibliometric approach involves a huge volume of bibliographic scholarly resources and it have been used for the analysis of various research themes [5, 18], Journals [29, 41], Nations [42, 49] and others.

The present study was sustained by a scientometric evaluation which supported an existing data in the data collections that was retrieved for this study. Further statistical, data mapping techniques, mathematical computations, and procedures were also adopted to advance the results of this study. Therefore, the key impulse of this study is to assess the global discoveries and trends of scientific outputs on goat milk as a vital tool for promoting food security and reducing hunger, by analytically conversing erudite opinions in the production of goat milk which currently is a growing interest globally and they are the two inter-related research field of the current study.

The current study pin-pointed some high flying areas on the use of goat milk in relation to food security research work, for example, authors, distribution of countries, research outputs, keywords, the world-wide trends of citation, and trending topics on the subject of discussion. The findings from this study has an elaborate viewpoint on disciplinary knowledge bank of goat milk and its consumption as a feasible tool for combating hunger and food insecurity. Outputs from scholarly publications will help to identify prospective areas of research breaches and research dynamics of goat milk production in relation to food security globally. The study will also help to promote and explore scientific outputs that done on goat milk production and recommend some probable future research prospects.

Materials and method

Terms descriptions of analyzed data

The bibliometrix evaluation package used for this study is a technique known for its precision and has been employed in data analysis of articles including as file conversion, similarity normalization network analysis, descriptive evaluation term extraction, matrix building, duplicate matching and merging [2]. The data matrices utilized in this study were retrieved from publication datasets which include authors, words, coupling, collaboration, multiple correspondence, countries, keywords, and references for results like conceptual and co-citation outline analyses. The scientometric pictorial pairing happens between two research publications which for

instance maybe “*a* and *b*” that had their reference lists mentioned at least by one known source [18]. In addition, the aggregate of scientometric graphical pairing that gave rise to research outputs of “*a* and *b*” or co-authorship in collaboration and academic networking indicates the potency of the network and collaborations [2]. A certain network suggests relationships in a scheme as a collection of nodes and networks (Zhang et al. [77]). Scientific researchers’ contributions in a studied field are evaluated according to Lotka’s law; which is an inverse square law that defines how frequently authors publish research publications in their field of research [38].

Data processing and analysis

This study utilized important key functions of bibliometrix R-package to evaluate recollected data for the ensuing descriptive results, citation analysis, authors’ scientific performance. Scientometric research networks (e.g., citation, author keyword, and Keywords-Plus, author, nation links) and scientometric pictorial coupling (keyword co-occurrences and co-citation) were evaluated from scientometric two-ways (bipartite) collaborations of rectangular benchmarks of research articles \times attributes. For example, the formula for a typical scientometric collaboration is given by employing this exact formula;

$$\text{Network (N)} = X \times N^T;$$

Where *X* is a two (2) way network matrix comprising of research publications \times attributes (e.g., nations, keywords, authors, and article citations).

N stands for symmetrical matrix $N=N^T$.

In this study, a graphical concept was employed for all networks using the force-directed Fruchterman algorithms inputted in the networkPlot command of the bibliometrix R-package. Again, all the collaboration links were normalized by utilizing the Salton’s cosine coefficient, proximity indices (association strength), Simpson’s coefficient (inclusion indices), and the Jaccard’s similarity indices among nodes of a collaboration (Arial and Cucurullo, 2017). In addition, the k-means groupings were carried out on keywords to evaluate concepts in goat milk production as an important food security instrument using the function of conceptual outline of the bibliometrix R-package. This function used the Porter’s stemming algorithm [56] to standardize adjusted terms to their exact form.

Data retrieval for scientometric evaluation

This study used scientific research publications on goat milk in relation to food security research outputs. Data from this study were retrieved from two academic data banks namely Web of Science (WOS) and Scopus archive

on 20 April, 2021. These two data archives are home for efficient and reliable top-impact scientific research outputs [39, 58], which were used for the intended objective in this study. The reason for using an advanced search function in Web of Science and Scopus is because both data archives permit the building of an extended and combined search questions [78]. Customarily, with research work relating to scientometric studies, a single data bank can be adopted, this is because scientometric indices and literature plotting are challenging to carry out on articles collected from multiple data archives [66, 67]. Meanwhile, the adoption of a single data archive for retrieval of information for scientometric studies may exclude some important research outputs on a particular research topic which may be needed for evaluation on that research topic [78]. The justification, therefore, for the use of a combined data archive (WOS and Scopus) guarantees 100% inclusion of PubMed research publications in addition to other scientific data archives.

Search strategy utilized for collection of data

In this study, an effective search question that aligns to the related volume of publications was carried out to minimized pseudo-positive findings. This was done by an exhaustive literature review search (so as to familiarize with most of the potential keywords related to the searched research topic) on the intended research topic which in this case is goat milk and food security. The method of searched strategy employed in this study for data collection has also been adopted by several other researchers [18, 22, 34], Idamokoro et al. [29]. The procedure that was adopted in this study in the quest for data gathering was to utilize the title/abstract search technique for keywords linked to "goat milk" and "food security". This could, however, lead to the retrieval of huge sums of articles which may not be relevant in this current study. Specific 'terms' related to goat milk or food security were used to streamline the Title/Abstract search.

Research search question utilized for data collection

The search questions used in this study are as follows:

WOS

9,244 results from Web of Science Core Collection for:

Goat milk* (All Fields).

Refined By: Search within all fields: Hunger* Or Food* Or Nutrient* Or Health* Or Poverty* Or Insecurity Or Household* Or Nutrition* Or Food* Or Security* Or Protein And Source* Or Peptides* Or Fat* Or Mineral And Elements* Or Infants* Or Adults* Or Human* Or Man Or Product* Or Yoghurt*Clear all.

SCOPUS

2,622 document results.

(TITLE (goat AND milk*)) AND (hunger* OR food* OR nutrient* OR health* OR poverty* OR insecurity OR household* OR nutrition* OR food* OR security* OR protein AND source* OR peptides* OR fat* OR mineral AND elements* OR infants* OR adults* OR human* OR man OR product* OR yoghurt*).

Data analysis and processing

The current study evaluated all retrieved data from the two afore-mentioned data archive (Scopus and WOS) by employing the use of RStudio v. 127.0.0.1:5645 software with bibliometrix R-package for scientometric features [2]. All the data retrieved from the archive were moved into R studio and refined into bibliographic data format removing, after which duplicates arising from the two data archives were removed. A diagrammatic illustration of the data retrieval and analysis is presented in Fig. 1. In addition, to evade article duplication obtained from the two data archives, all replicated peer reviewed papers were constrained to only one record in the analysis in this study. For better understanding, the names of authors, author's keywords (DE), and keywords plus (ID) were removed to rightly comprehend the knowledge stratification of this particular research topic (goat milk/food security). Conversely, all data retrieved from the archives were reviewed for irregularities in names, spelling errors and affiliations. For keywords (DE) and keywords-plus (ID), the subject of the current study (goat milk and food security) were given a primary term to terms. In addition, the co-occurrence of a phrase in the keywords-plus (ID set) and keywords (DE set) of authors in the dataset were evaluated as a collection made of the two sets (ID and DE) that converge.

Results

The current study an aggregate of 9206 reported research studies from the year 1966 to 2020 of the study period; with the evaluation features displayed in Table 1. The result for the studied time comprises of 23,339 authors, with 470 single author, 0.394 article publication per author (2.54 authors per research output), a collaboration index of 2.63 and a 4.74 co-authors per research output. Separate from the 470 single authors, all the remaining authors (22,966) had a multi-author research outputs. Furthermore, a sum of 15.08 citations per article was recorded in the course of the current study. In Fig. 2, the result showed a trend in research publications on goat milk with regards to nutrition security having an annual growth index of 14.42%. It could also be seen that there were low research outputs in the total publications

Summarize explanation of data retrieval and analysis

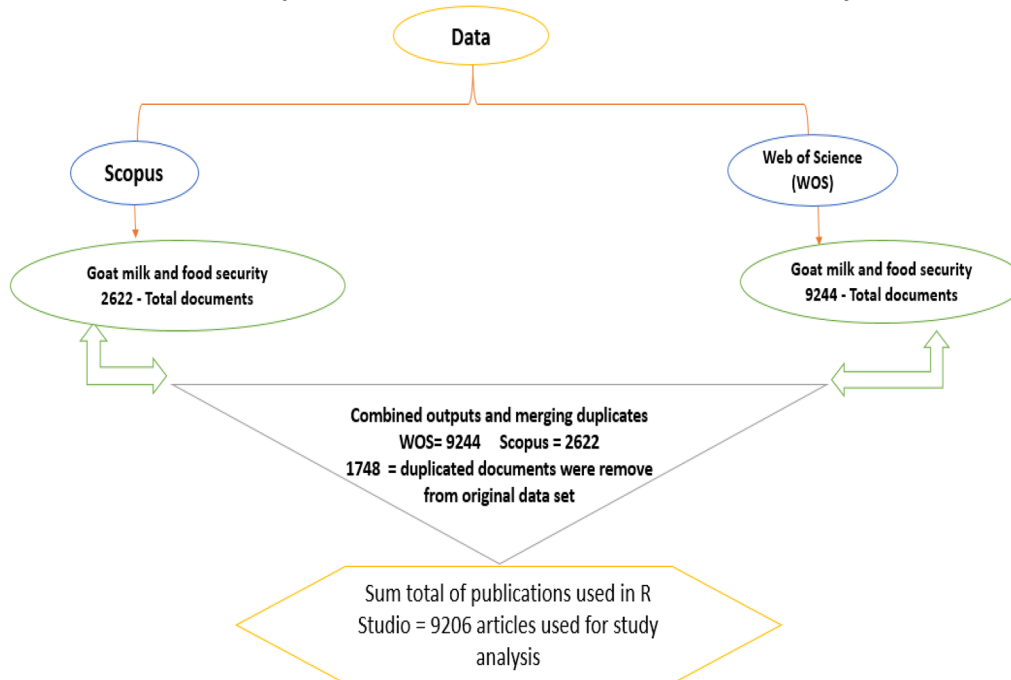


Fig. 1 Diagrammatic presentation showing the inclusion and exclusion criteria for articles selection

between 1966 and 1989. Conversely, the interest in research studies on goat milk gained better momentum as there was a steady upward and sharp increase in trend after 1990 which continued till the year 2020 with an aggregate of over 700 articles in 2020 (Fig. 2). Table 2 shows the findings for the average article citations (AAC) of nations with the most cited research outputs in the field of goat milk production and nutrition security research. Spain (17.87), USA (29.45), France (25.76) and Italy (17.38) top the list of the AAC, respectively.

The research outputs related to goat milk farming, utilization and nutrition security study for the top 20 most productive countries globally is displayed in Table 3. From these top countries, Spain is positioned first in terms of the total number of articles ($n=953$), followed by Italy ($n=807$), China ($n=648$), Brazil ($n=643$) and France ($n=618$), respectively. The frequency of research outputs varied among these top 20 countries from 0.010774 to 0.106958. Likewise, the nations that were ranked in the topmost position in terms of multiple country publications (MCP) and networking include; the Spain which is placed in first position ($n=192$), while USA ($n=139$), China ($n=133$) and Italy ($n=125$) followed in the order of ranking, respectively. Meanwhile, the nations rated in top rankings for single country publications (SCP) of research outputs in the field of goat

milk farming, utilization and nutrition security research are Spain ($n=761$) in the first position, Italy in the second position ($n=682$), and China ($n=515$) place in the third position, respectively (Table 3). From the result in Table 4, the most significant author keywords in the research field of goat milk and nutrition security studies are, the keywords such as goat/s ($n=1605$) was ranked first, followed by, milk ($n=920$) and goat milk ($n=829$) among others.

In Table 5, the global report for the top 20 most well-known authors in the field of goat milk production in relation to nutrition security were presented with the first author by the name H, Chen occupying the first position ($n=77$) based on the number of articles that he has published. Meanwhile, J, Wang was ranked second ($n=72$), followed by J, Luo ($n=61$) and Y, Park ($n=58$) who were placed in the third and fourth position, respectively. In Fig. 3, the result showed global visualization map of networking of nations' collaboration, depicting 50 nations that had at least fifty research outputs. Each node in the network is an individual nation and the diameter of the node relates to the number of articles contributed globally by each nation. The strokes denote the pathways of networking between nations and the thickness of strokes shows the extent of collaboration between the nations, while the 3 different colours (red, green and blue) denote

Table 1 General information of retrieved published documents on goat milk research as a tool for nutrition security from Scopus and WOS data bases

Description	Results
Main information about data	
Timespan	1966:2020
Sources (journals, books, etc)	1609
Documents	9206
Average years from publication	11.9
Average citations per documents	15.08
Average citations per year per doc	1.214
References	25656
Document types	
Article	8121
Article; book chapter	98
Article; data paper	3
Article; proceedings paper	369
Book chapter	25
Conference paper	29
Editorial material	23
Meeting abstract	83
Note	20
Proceedings paper	414
Others (e.g., short survey, book chapter, book reviews etc.)	21
Document contents	
Keywords plus (ID)	12943
Author's keywords (DE)	14183
Authors	
Authors	23339
Author appearances	43617
Authors of single-authored documents	373
Authors of multi-authored documents	22966
Authors collaboration	
Single-authored documents	470
Documents per author	0.394
Authors per document	2.54
Co-Authors per documents	4.74
Collaboration index	2.63

the collaboration cluster of the different nations. Collaboration links ranged from 0 to 198.66. USA had the highest number of collaborations ($n=198.66$); followed by Italy ($n=165.13$), and Spain ($n=117.11$), respectively.

The result in Fig. 4 shows the findings of the word cloud of commonly occurring keywords in goat milk production, utilization and nutrition security studies. Importantly, each keyword size, as shown in the word cloud network (Fig. 4), depicts its strength and occurrence in the research studies related to goat milk goat and nutrition security research work. From Fig. 4, it can also

infer that the nearer the keywords are to each other, the more probable their interrelatedness in the literatures that were retrieved for this study. The word cloud simply depicts the most common words in goat milk production, utilization and nutrition security research, which in turn makes it easy to pin-point the areas of focus in this niche research field.

Table 6 shows the top 20 most cited publications on goat milk and nutrition security based on aggregate citations from 1966 to 2020. The article which was written by Baguisi et al. [3] was placed in the first position with a total citation of 742. The publication that was rated for the second place in ranking was authored by Park et al., [52] with a sum total of citations of 734. Meanwhile, the third and fourth place position had Ross et al. [61] and Chilliard et al. [11] with total citations of 473 and 461, respectively (Table 6). Furthermore, the top 20 journals with the most published articles in the field of goat milk production and nutrition security are listed in Table 7. These journals comprise of Small Ruminant Research, Journal of Dairy Science, Journal of Dairy Research and International Dairy Journal among others. Meanwhile, the Small Ruminant Research journal was ranked first ($n=758$ publications) among the journals with most published research outputs. This was followed by Journal of Dairy Science ($n=650$). Journal of Dairy Research was also ranked third ($n=207$). Conversely, International Dairy Journal was ranked in the fourth position with a sum total of 174 published articles (Table 7).

The top twenty (20) most prolific global research institutions with at least hundred research articles are presented in Table 8. The Northwest A&F University in China ($n=275$) was ranked first position. University of Milan (Italy) and the Autonomous University of Barcelona (Spain) were ranked second ($n=233$). The University of Granada (Spain) was ranked ($n=217$) fourth position, respectively.

Discussions

The current study of goat milk and nutrition security as a tool for improving food nutrition and reducing hunger was assessed between 1966 and 2020. This was done based on findings retrieved from Scopus and WoS data archives. It was observed that the number of research publications on goat milk with respect to nutrition security was relatively low in terms of numbers of outputs between 1966 and 1990. Conversely, the research outputs showed a stable rise from 1990 to 2004 after which there was a rapid increase from 2004 to 2020 resulting into an annual rise of 14.42%. The observed rise in research outputs on goat milk and nutrition security research proposes that more people in the field are developing interest in this niche area. This growing interest may be due to

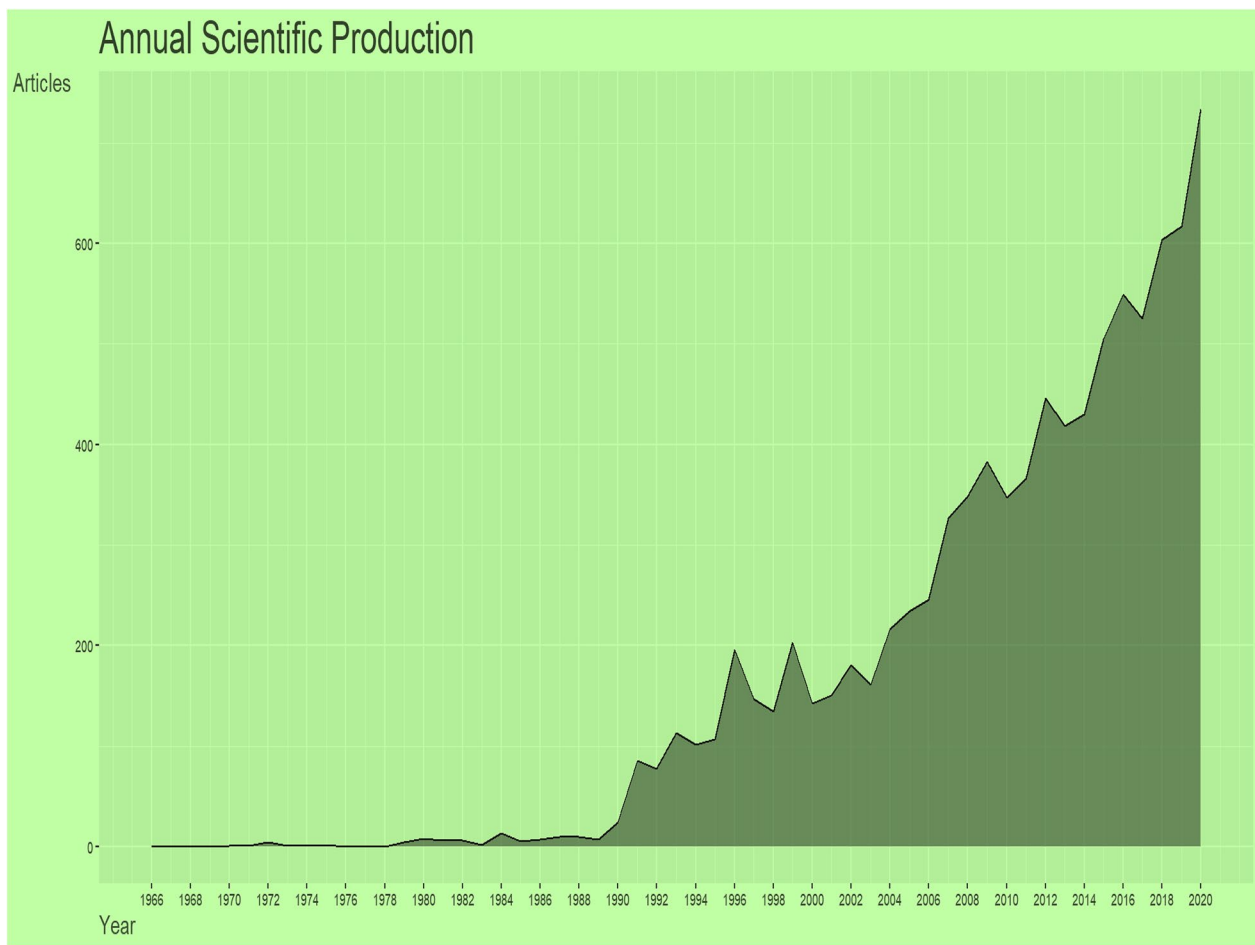


Fig. 2 Annual scientific research outputs (from 1966 to 2020) on goat milk research studies with an annual growth rate of 14.42 %. Goat milk research studies showed a steady upward trends in research articles from 1990 to 2020

the increase search for strategic and workable approach to improve global nutrition/food security through the use of goat milk. As reported by the United Nations [70], goat milk can be used as a vital instrument to achieve its 2030 Agenda for Sustainable Development which was adopted in 2016, and its 17 inter-linked sustainable development goals (SDGs).

Some studies have reported the prospects of utilizing goat milk and its products as food source for people [13, 75]. It has also been reported to be a nutritional enhancer in diet [19]. Goat milk have likewise been used as a means to generate income [27], and as a medium to progress the economic resilience of vulnerable individuals [43, 63]. Goat's milk has been reported to have higher levels of magnesium, calcium, and phosphorus when compared to either cow's or human milk [46]. Again, the fact that many people are sensitive to the proteins found in cow's milk [8, 9], make goat milk a better choice in promoting nutrition security for

vulnerable persons. Cow milk consumption is associated with lactose intolerance which is not common with goat milk consumption, this is because goat milk is naturally low in lactose content [46]. This attribute is also an added advantage of goat milk in its use to advance nutrition security. From the annual scientific production graph in Fig. 2, there was a well-established indication that more research work on the use of goat milk as food will further increase in the future. With the increase in hunger and food mal-nutrition/insecurity in many countries, and especially in developing countries [4], the drive for new scientific knowledge will grow in this research domain.

As was largely expected, it was noticed that several leading authors that promoted research findings on the use of goat milk for nutrition/food security are from developed nations (Spain, Italy, China, Brazil, France, USA). This result was contrary to the findings by Idamokoro and Hosu [29] who reported that the use of

Table 2 The top 20 most cited countries in terms of average article citations (AAC) in the field of goat milk as a tool for nutrition security from 1966 to 2020

S/N	Country	Total citations	Average article citations
1	Spain	17035	17.87
2	USA	16613	29.45
3	France	15925	25.76
4	Italy	14033	17.38
5	China	7344	11.33
6	Brazil	5927	9.21
7	United kingdom	5799	28.01
8	Greece	4217	16.28
9	Turkey	2933	8.65
10	India	2696	7.46
11	Germany	2642	12.52
12	Netherlands	2216	25.18
13	Canada	2142	21.63
14	Poland	1850	7.52
15	Israel	1802	22.81
16	Portugal	1767	18.03
17	Mexico	1741	10.74
18	Australia	1577	17.92
19	Norway	1551	17.42
20	Switzerland	1502	21.76

village chicken to promote food security were from developing nations and especially from Africa.

Subsequently, in line with our result, other related scientometric studies also reported that knowledge promoters/drivers are from developed nations like the UK, USA, Brazil, China, and France [49, 65]. The leading nations with networks on goat milk utilization and nutrition security researches pin-point that most of the collaborating allied were among researches from developed and economically stable nations including Spain, Italy, China, and the USA. Meanwhile, very few nations are from developing countries like Indonesia and Egypt whose countries barely sponsor research funding due to a supposed poor economic status of these nations.

Several notable developed countries including the United States, United Kingdom, Australia, Italy and China among others have often shown dominance in research as reported in several bibliometric publications [6, 7, 24, 30, 67]. In addition, these developed nations tend to network in the area of research with each other thereby neglecting developing nations [49, 65]. Some erstwhile bibliometric studies reported that alliances between developed and developing nations are rare in several scientific studies [18, 49]. Conversely, the promotion of research which involves the networking from both intra- and international institutions between developing and developed countries should be highly encouraged. This collaboration could enhance some more robust

Table 3 The top 20 publications by countries in the field of goat milk research

S/N	Country	Articles	Frequency	SCP	MCP	MCP_ratio
1	Spain	953	0.106958	761	192	0.2015
2	Italy	807	0.090572	682	125	0.1549
3	China	648	0.072727	515	133	0.2052
4	Brazil	643	0.072166	572	71	0.1104
5	France	618	0.06936	526	92	0.1489
6	USA	564	0.0633	425	139	0.2465
7	India	361	0.040516	339	22	0.0609
8	Turkey	339	0.038047	314	25	0.0737
9	Greece	259	0.029068	224	35	0.1351
10	Poland	246	0.027609	227	19	0.0772
11	Germany	211	0.023681	162	49	0.2322
12	United Kingdom	207	0.023232	143	64	0.3092
13	Mexico	162	0.018182	116	46	0.2840
14	Iran	151	0.016947	130	21	0.1391
15	Indonesia	147	0.016498	141	6	0.0408
16	Egypt	125	0.014029	95	30	0.2400
17	Czech Republic	109	0.012233	93	16	0.1468
18	Canada	99	0.011111	67	32	0.3232
19	Portugal	98	0.010999	64	34	0.3469
20	New Zealand	96	0.010774	69	27	0.2812

SCP Single Country Publications, MCP Multiple Country Publications

Table 4 Most relevant words used by authors in the field of goat milk research

S/N	Author keywords (DE)	Occurrence	Keywords-plus (ID)	Occurrence
1	Goat/s	1605	Goat/s	1285
2	Milk	920	Milk	1264
3	Goat milk	829	Sheep	812
4	Dairy goat/s	372	Lactation	529
5	Sheep	316	Cows	502
6	Fatty acid/s	307	Identification	471
7	Cheese	251	Cattle	417
8	Lactation	220	Cheese	400
9	Milk production	220	Quality	361
10	Milk yield	210	Protein	355
11	Milk composition	173	Dairy-cows	352
12	Mastitis	161	Yield	344
13	Somatic cell count	121	Performance	332
14	Mammary gland	110	Goat milk/s	313
15	Proteolysis	109	Growth	278
16	Lactic acid bacteria	108	Products	278
17	Goat cheese	107	Proteins	271
18	Cow	96	Milk-production	270
19	PCR	89	Metabolism	267
20	Composition	88	Conjugated linoleic-acid	264

Table 5 Top 20 well-known authors linked with goat milk and food security research

S/N	Authors	Position	Articles	Articles fractionalized
1	Chen H	1st	77	12.71
2	Wang J	2nd	72	11.08
3	Luo J	3rd	61	8.73
4	Park Y	4th	58	32.15
5	Zhang Y	5th	53	8.00
6	DE	6th	50	6.63
7	Chilliard Y	7th	46	10.80
8	Martin P	8th	45	11.52
9	Caja G	9th	44	8.77
10	Castro N	9th	44	7.64
11	Wang C	10th	42	8.69
12	Wang H	10th	42	6.68
13	Wang Z	11th	41	6.39
14	Costa R	12th	39	6.74
15	Shi H	12th	39	5.56
16	Loor J	13th	37	5.52
17	Prosser C	13th	37	8.89
18	Wang Y	13th	37	4.86
19	Capote J	14th	36	6.12
20	Sauvant D	14th	36	9.65

opportunities in harnessing resources including funds and more man-power to tackle important research questions such as this.

The financial stability/strength of any country is a supporting evidence/factor that stimulates their research precedence and performance (Zhang et al. [76] and [54]. The present global state of hunger, food insecurity, and poverty in several developing nations, should provoke more initiative for more research in this field. This will in turn (goat milk farming and utilization research) be a strategic instrument for nutrition/food security.

Goat milk and their products offer people with a wide-choice of products (milk, cheese, yoghurt, butter) and socio-economic services such as nutrition security. The low-input nature of household/backyard goat farming makes it (milk/products) accessible to vulnerable persons (including young people and women) of several developing nations. The utilization of goat (milk and meat) plays vital roles in the social life of many people in the developing world especially in Africa [53]. Thus, the social and economic significance of goats in terms of what they contribute (milk, meat, skin) to vulnerable people makes them vehicles of development to people in Sub-Saharan Africa [48]. Furthermore, goat milk is used for food and revenue generation in several countries including the Middle East, the Mediterranean, Eastern Europe and some regions of South America [59]. The role of goat milk is significant in ensuring nutrition/food security

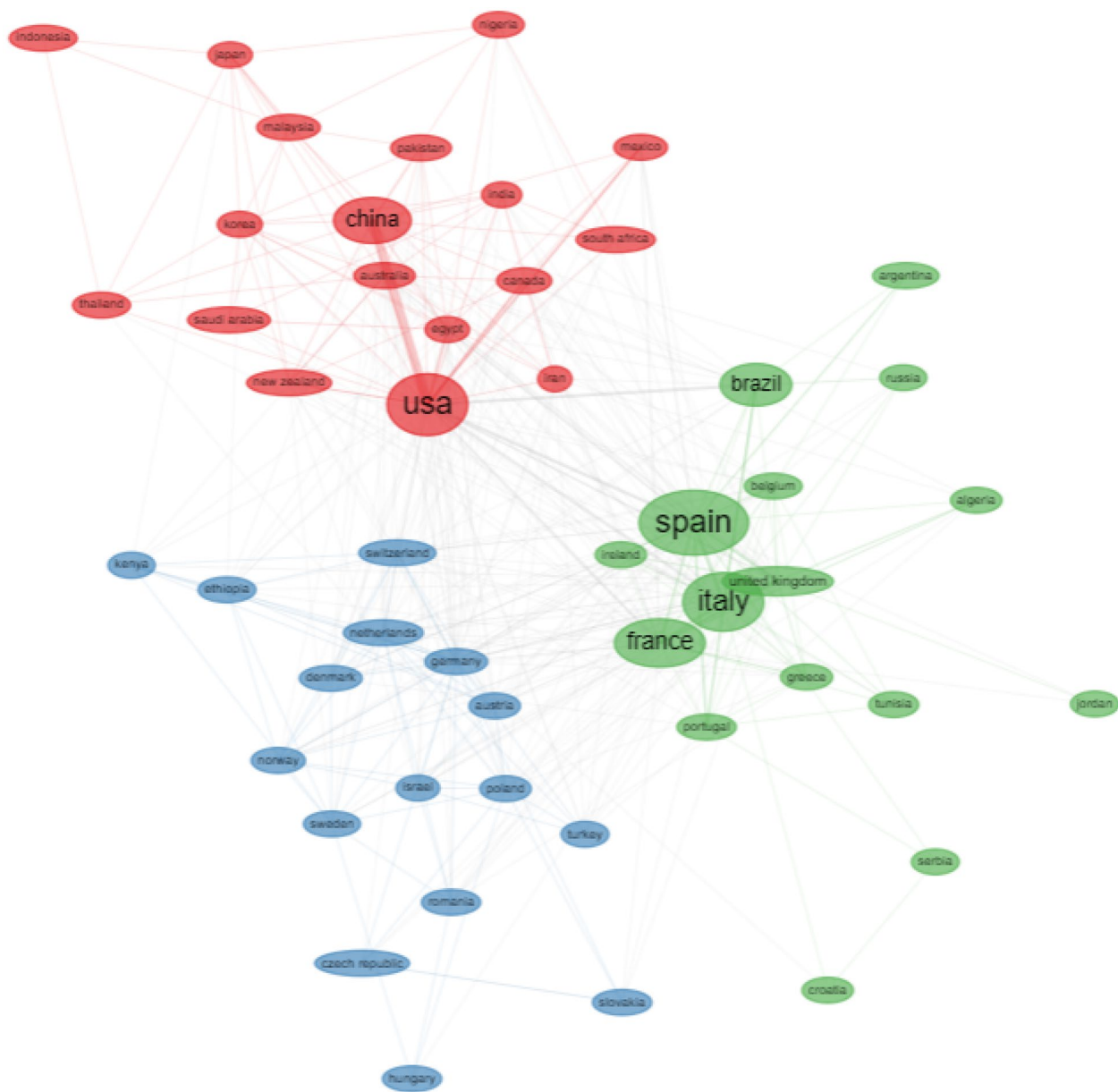


Fig. 3 Collaborative mappings of networks of fifty (50) nations on research done on goat milk with at least ten publications. Apiece node in the network is an individual nation and the diameter of the node corresponds to the number of publications. The strokes denote the paths of networking between nations and the thickness of strokes indicates the degree of collaboration between the nations, while the three (3) different colours seen in this figure represent the collaboration cluster of the nations

of financially struggling households who views them as being the only asset that they possess [62]. Animal protein as an essential nutritional component is vital in the human diet. In a study reported by Neumann et al. [47], it was observed that the inclusion of small quantities of goat milk to a classical diet of children in primary school in Kenya enhanced their performance. The study also reported improved outcomes of the cognitive ability functions/tests and activity rates of the tested children.

Furthermore, the study by Neumann et al. [47], further, reported that, the effect of the consumed milk reduced the problem of stunted growth in the children.

Spain, Italy, China, Brazil, France, USA, and India occupied the top positions of countries that are actively involved in research studies on goat milk as a tool to tackle the challenge of nutrition security with regards to the total sum of research outputs (Table 3). However, nations like Italy, Spain and some European countries



Fig. 4 Word cloud on goat milk and nutrition security studies

may not necessarily use goat milk for combating food insecurity. These afore-mentioned nations are known to be an economically stable nations [30]. The use of goat milk from these nations may be as a means of promoting goat milk products such as cheese which is a very lucrative agricultural industry [40, 55]. India and Turkey (7th and 8th ranked nations in the number of research outputs—Table 3) are among well-known nations that produce and consume goat milk [59]. However, one key purpose for any nation to be listed in such category is well associated to the nations' financial capability to do research and the availability of standard research laboratories in that nation [36, 54, 79].

Conversely, from a general point of view, countries such as the USA, Spain, France and India are known to be leading in the production of goat milk with India taking the lead [48]. This fact suggests their involvements as leading nations in conducting researches on goat milk farming/utilization for sustainable livelihood [76]. Furthermore, the USA is mostly seen as a nation with the most significant partners in global networking and collaborations on promoting sustainable livelihood [76]. The purpose for this, is chiefly because the USA sufficiently recognize the significance of early interventions on the concept of sustainable development

and improved livelihood. This purpose also relates to nutrition/food security, and they (USA) employ all aids/resources within their reach to support people globally, and keenly disseminate information as it relates to findings about the subject matter. Meanwhile, it is important to note that, result observed from the current study also pinpoint that some nations (e.g., Mexico, Iran, Indonesia and Egypt who occupied the 13th, 14th, 15th and 16th positions, respectively) are from developing nations. This suggests an important perspective about the discussed subject matter in addressing nutrition/food insecurity in these countries.

Skepetals and Bampidis ([64]) in their study reported that goat contributes significantly to the production of milk and its products and these (dairy) products are highly acceptable and consumed in numerous low income nations (including Somalia, Kenya, Algeria, Sudan and other Sub-Saharan African countries). This claim further supports the importance of goat milk in promoting nutrition/food security in these nations. With the presence of some developing countries such as Mexico, Iran, Indonesia and Egypt who are placed within the ranks of top research publications (Table 3), this may mirror the challenging questions arising due to food insecurity that is encountered in these nations

Table 6 Top 20 most global cited articles on goat milk and nutrition security research from 1966–2020

S/N	Lead author and year	Journal name	DOI	Total citations	TC per year	Normalized TC
1	Baguisi A, 1999	Nature Biotechnology	NA	742	29.68	31.90
2	Park YW, 2007	Small Ruminant Research	10.1016/j.smallrumres.2006.09.013	734	43.17	27.48
3	Ross GW, 2000	Journal of the American Medical Association	10.1001/jama.283.20.2674	473	19.70	14.78
4	Chilliard Y, 2003	Journal of Dairy Science	10.3168/jds.S0022-0302(03)73761-8	461	21.95	15.44
5	Haenlein GFW, 2004	Small Ruminant Research	10.1016/j.smallrumres.2003.08.010	450	22.50	19.45
6	Evershed RP, 2008	Nature	10.1038/nature07180	319	19.93	15.71
7	Jenness R, 1980	Journal of Dairy Science	10.3168/jds.S0022-0302(80)83125-0	295	6.70	5.55
8	Shingfield KJ, 2010	Animal	10.1017/S1751731110000510	268	19.14	15.65
9	Capuco AV, 2001	Journal of Dairy Science	10.3168/jds.S0022-0302(01)74664-4	264	11.47	7.83
10	Jones JL, 2009	Clinical Infectious Diseases	10.1086/605433	260	17.33	14.49
11	Banskalieva V, 2000,	Small Ruminant Research	10.1016/S0921-4488(00)00128-0	250	10.41	7.81
12	Silanikove N, 2010,	Small Ruminant Research	10.1016/j.smallrumres.2009.12.033	229	16.35	13.37
13	Raynal-Ijutovac K, 2008	Small Ruminant Research	10.1016/j.smallrumres.2008.07.009	229	14.31	11.27
14	Kohn RA, 2005	Journal of Animal Science	NA	220	11.57	8.21
15	Contreras A, 2007	Small Ruminant Research	10.1016/j.smallrumres.2006.09.011	219	12.88	8.20
16	Chilliard Y, 2005	Domestic Animal Endocrinology	10.1016/j.domaniend.2005.02.026	213	11.21	7.95
17	Bouwman AF, 2005	Agricultural Systems	10.1016/j.jagsy.2004.05.006	209	11	7.80
18	Bostick RM, 1999	American Journal of Epidemiology	NA	207	8.28	8.90
19	Ebert KM, 1991	Bio-Technology	10.1038/nbt0991-835	205	6.21	9.40
20	Minervini F, 2003	Applied and Environmental Microbiology	10.1128/AEM.69.9.5297-5305.2003	204	9.71	6.83

and which needs to allow for more research studies on goat milk research.

There were several observed nations with multiple collaboration (MCP) on goat milk farming/utilization as linked to nutrition/food security research topic with Spain, USA, and China having the highest record of multiple collaboration as seen in Table 3. Most nations in the list of top 20 most productive nations have multiple collaborations (Table 3). This may suggest the fact that the present research subject matter (goat milk production/utilization with respect to nutrition/food security) has grown significant popularity. It also shown that the subject matter has gained global attention with a yearly growth rate of 14.42% (Fig. 3). Furthermore, from the observation noticed, it is likely and projected that more nations of the world will be involved in multiple country collaborations as noticed from the present yearly growth rate of scientific research articles produced in recent years in this area of research.

Interestingly, there was position displacements in the rankings among the 20 topmost nations who were ranked to be the most active nations in the field of goat milk production and nutrition/food security when

research publications were evaluated by adopting the criteria of total citation (TC) per nation (Tables 2 and 3). This obvious observation is not new as similar findings has also been conveyed in other scientometric research work by other authors [18, 49]. The reason for this position displacement in article rankings when using the aggregate sum of citations to review country/author's publications may depict its unreliability as an effective instrument to measure productivity of nations in that respect. Fricke et al. [23], in their findings reported that, the rate of citation of a given nation does not necessarily reflect article outputs of that nation or any specific author for that matter. The reason for this observation as stated by Fricke et al. [23], is due to the fact that, the fewer the number of research articles used for assessment in scientometric/bibliometric studies, the more the impact of a few regularly cited articles. In some scenarios, a lot of authors have engaged in self-citations, while other authors provide inaccurate citations when presenting their research findings. This act by authors often yield to false qualitative and quantitative metrics of the aggregate citations of a certain author or nation [18].

Table 7 The topmost 20 journals that have reported relevant research in the field of goat milk and food security from 1966 to 2020

Journal Sources	Articles	Ranking
Small Ruminant Research	758	1st
Journal of Dairy Science	650	2nd
Journal of Dairy Research	207	3rd
International Dairy Journal	174	4th
Food Chemistry	132	5th
Milchwissenschaft- Milk Science International	108	6th
Journal of Agricultural and Food Chemistry	101	7th
Tropical Animal Health and Production	101	7th
Italian Journal of Animal Science	92	8th
International Journal of Dairy Technology	90	9th
Revista Brasileira de Zootecnia-Brazilian Journal of Animal Science	86	10th
Journal of Animal Science	79	11th
Indian Journal of Animal Sciences	78	12th
LWT- Food Science and Technology	73	13th
Animals	72	14th
Mljekarstvo	71	15th
Journal of Food Protection	66	16th
Animal	65	17th
Asian-Australasian Journal of Animal Sciences	65	17th
International Journal of Food Microbiology	65	17th

The most regularly noticed keywords and research areas associated with goat milk and nutrition/food security research work depict the topic hotspot during the survey period of this study. These keywords include, goat milk, dairy goats, goat production, fatty acid, cheese, milk yield, milk composition among others (Table 4 and Fig. 4). In addition, these keywords are all indicative to promoting researches and interventions that will tackle the issues/problems of food insecurity and hunger that appears to be a major challenge of most populations in several nations. Likewise, the keywords and research areas postulated from this study divulged some of the efforts made by scientists to encourage research work on the use of goat milk as a potential research instrument for solving the hunger needs and mal-nutrition status of food in-secured populations. The keywords are also a pointer to attain an understanding of the future viewpoint of the practical intervention strategies for addressing food insecurity. In summary, it is key to note that, keywords tend to encapsulate the subjects of a scientific research field, and it assist to focus and refine the key concepts of the studied subject matter [10].

From the result that was observed in the top 20 journals that featured prominently in studies on goat milk and nutrition/food security research, journals including Small Ruminant Research, Journal of Dairy Science, Journal of Dairy Research, International Dairy Journal and Food Chemistry stood out clearly (Table 7). These

Table 8 The topmost productive institutes on goat milk research studies with over 100 article publications

S/N	Affiliations	Countries	Articles	Ratings
1	Northwest A&F University	China	275	1st
2	University of Milan	Italy	235	2nd
3	Autonomous University of Barcelona	Spain	233	3rd
4	University of Granada	Spain	217	4th
5	Agricultural University of Athens	Greece	205	5th
6	University of California, Davis	USA	190	6th
7	The University of Córdoba	Spain	188	7th
8	Federal University of Paraíba	Brazil	186	8th
9	The University of Sassari	Italy	174	9th
10	The Aristotle University of Thessaloniki	Greece	140	10th
11	The University of São Paulo	Brazil	137	11th
12	The Federal University of Viçosa	Brazil	134	12th
13	The University of Murcia	Spain	134	12th
14	The University of Illinois	USA	128	13th
15	The Polytechnic University of Valencia	Spain	127	14th
16	Institute of Animal Science	Czech Republic	119	15th
17	The Islamic Azad University	Iran	114	16th
18	Langston University	USA	107	17th
19	University of Zagreb	Croatia	107	17th
20	Norwegian University of Life Sciences	Norway	106	18th

journal out-lets are popularly known to divulge scientific information that are related to small-stock and livestock farming with the goal of enhancing food production and nutrition security [1, 14, 15]. More publication out-lets should be open to support the calls from the Food and Agricultural Organization and the United Nations [21, 70] on contemporary topical matters and research fields related to this studies. This will boost livestock production and nutrition security as a result of the present global challenges of hunger and poverty, which has also increased in number due to the ongoing Ukraine and Russia war.

Importantly, from the perspectives obtained in the research publications of many of the authors (the top 20 most cited papers in the present study—Table 6), there are several take home messages/improved innovations that have been employed over the years. This improved innovations further buttress the relevance of goat milk as a significant tool to boost nutrition/food security (including; [12, 17, 26, 57, 63]. Firstly, is the use of enhanced intervention techniques such as the successful production of transgenic goats that expressed a heterologous protein in milk which can help to improve milk quality for human consumption [17]. From that study, it was reported that an enzymatically active LAtPA which is the production of a glycosylation variant of human tPA (LAtPA—longer acting tissue plasminogen activator) was identified in the milk obtained from goat. This study is a clear modern strategy of improving studies done on goat to improve its product (milk quality). On the matters of improving goat milk yield for individuals or companies involved in medium to large scale goat milk production, several modern techniques (e.g., implementation of good management guidelines, eat dip disinfection and selective dry-off therapy) have been employed to reduce/totally eliminate the incidence of milk pathogens [12]. These improved modern techniques in turn promote better milk quality for human consumption [12].

From the health and nutritional perspectives, Haenlein [26] reported that little unbiased medical research to provide evidence and nutritional facts about goat milk has been conducted. Conversely, this research perspectives is very much needed to reduce discrimination against goats and substantiate the many anecdotal experiences about the medical benefits from goat milk consumption, which abound in trade adverts/publications and the popular press. Some of the further highlighted views about goat milk in the study by Haenlein [26] who reported the improvement and prospects of goat milk for better utilization to both the developed and developing countries include,

- a. Goat milk can be utilized to feed more malnourished and starving persons in the developing nations as compared to cow milk;
- b. Goat milk can be used to treat people affected by cow milk allergies and gastro-intestinal problems/disorders, which is an essential section in many populations of developed nations;
- c. Goat milk has been used to fill the gastronomic requirements of connoisseur consumers, which is a rising market sector in many developed nations.

Furthermore, the research by Raynal-Ljutovac et al. [57] and Silanikove et al. [63] offers an encompassing, all-inclusive intervention and policy tactic for organized approach that should be adopted to increase the production of goat milk for human utilization. The findings of these authors in turn will help to mitigate the issue of global hunger and improve nutrition/food and hunger in people.

Base on the global networking and cooperation ties, according to Glänzel and Schubert [25], researchers often adopt some phrases such as ‘international co-publication’ or ‘international articles’ to choose research papers through the collaboration of scientists from diverse nations. The present study (Fig. 3) showed global networking and cooperation ties for 50 nations that were engaged in goat milk and nutrition/food security research. In Fig. 3, nodes signified nations inside the network (the dimension/size of one node signifying the aggregate of published research papers). However, the strokes between the nodes depicts networking/collaboration among collaborating countries (the thickness of a strokes depicting the amount of global co-published research publications). Evaluating scientometric studies, it is notable that the leading research countries often form a cordial allied with other nations on research niche that is of common importance among them [76]. Majority of the countries of the world derive fulfilment to network with other nations in some research area to generate robust mutual interest in the field of science and knowledge sharing. Research networking among countries has an irrefutable positive and important influence on published findings (Glänzel, [25, 72]. As observed in the present result, Spain, Italy, China and the United States of America had academic institutions that possessed the majority of co-author acquaintances in international co-authorship in the field of goat milk production/utilization and nutrition/food security research. Similar findings have also showed that these nations are a leading academic destination for global networking and co-authorship in other research niche areas (Ekundayo and Okoh, [18]; [31].

Overall, more studies on the use of goat milk to address the problem of hunger, mal-nutrition and nutrition/food security are worth researching. A scientometric study couple with a meta-analysis or a descriptive review in goat milk production and nutrition/food security investigation may also be of valuable essence in the archive of scientific wealth of knowledge.

To date, the current paper looks to be the first scientometric study that reported the research publications that are peer-reviewed on goat milk as related to food/nutrition security at a world level. Notwithstanding, it is safe to be mindful of the fact that there might be some limitations to the current study which may include and not limited to;

- i. Missing peer-reviewed publications that might not have been retrieved in the evaluation of goat milk and food security research or its associated key words during the retrieval of data from WOS and Scopus.
- ii. Furthermore, short-comings may have surfaced from this study since publications on goat milk as related to food security research that were in non-indexed journals were not added, and thus, would not have been available in WOS and Scopus archives.
- iii. The present study may also be constrained because the retrieved data (articles) from WOS and Scopus were solely discussed based on the significance of raw goat milk (as liquid) as linked to nutrition security and not necessarily on goat milk products such as cheese which could also be a possibility in some studies done in some economically stable nations such as Spain and Italy.

Conclusion

The current scientometric evaluation of this study revealed a significant upsurge in the utilization of goat milk as a prospective tool to enhance nutrition/food security. The findings from the study showed greater research outputs from high-income countries as compared to their low- and middle-income counterparts. Likewise, there was limited collaboration with developing nations as compared to the develop ones based on the WOS and Scopus data archives. The high research outputs in several developed nations on the current research topic showed the fact that more developing nations are the ones faced with challenges relating to hunger, malnutrition and food insecurity and its related issues like poverty. Notwithstanding there was a substantial progress illustrating the use of goat milk as instrument for food security and hunger alleviation over the past decades.

However, a lot of questions remained to fully address their (goat milk production and consumption) sustainability as a standard measure/practice to tackle the multi-dimensional challenges of food security, malnutrition, and hunger alleviation in several nations globally and especially in developing nations.

Future perspectives of the utilization of goat milk to enhance nutrition/food security

The use of goat for milk (as food) can be greatly improved significantly with appropriate measures in addressing management and the use of best practices to upsurge goat milk production for food especially in developing countries. There is so much affluence of information and knowledge bank related to goat milk production. This information which when employed together with practicable local and cost-effective intervention programmes such as nutrition (from naturally available nutritious food waste), housing and/or management, and/or genetically improved goat breeds) will help to improve goat milk production in many countries.

For instance, the breeding of high milk producing goats can be crossed with local ones for a better improved progeny that will produce substantial amount of milk. To expedite a high adoption of new strategies and technologies in goat milk production for nations that have more financially constrained people, cost-effective interventions is needed to be considered in the application of goat farming and production. Additionally, with appropriate assistance and support from all stakeholders such as government, research institutes and international support groups, improved interventions and adoption of innovative goat milk farming has the potential to meaningfully and sustainably increase milk production (for food and income generation). Importantly, it should be clarified that to protect the health of consumers of goat milk and its products, microbial contamination of the milk should be avoided at all cost and this can be done by employing efficient sanitary and hygienic procedures in the processing and conserving of the milk and its products. In addition, it is suggested that thorough research work should be done to improve more dairy products obtained from goat milk so as to allow for wider acceptance by consumers.

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