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Visão Geral da Pesquisa sobre Armazenagem de Grãos (Milho e Soja)

An Overview of Research on Grain Storage (Maize and Soybean)

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ABSTRACT

Research related to grain storage spans to a wide range of aspects. It is a relevant topic for many sectors of the value chain. Studies have been developed to reduce grain losses in terms of food security and food safety. This comprises the need for innovation in terms of technology and logistics. Surprisingly, major players on grain production and exportation, such as Brazil, still struggle to guarantee the proper static storage capacity recommended by The United Nations (FAO). Because grain storage is crucial in the global food supply chain, we aimed to deliver descriptive statistics, identifying trends in literature that may deliver valuable diagnosis and nurture innovative research on the field. Our approach was based on performing quantitative and qualitative appreciation of the scientific production on grain storage between 2008 and 2017. A step by step protocol was made available to allow traceability of all criteria adopted during the workflow. The methodological procedures enabled clustering of scientific production according to the similarity of content and discrimination of scientific production according to several criteria (i.e., peer reviewed journals, universities, countries). Also, an explicit demonstration of networking among academics enabled the identification of pathways and alternative strategies towards innovation in the field. Overall, bibliometric and content analysis of the published manuscripts revealed trends, gaps and legible perspectives for academics interested in the field of grain storage.

Keywords: Food Safety. Post Harvest. Post-Harvest Losses. Grain Quality. Agribusiness.

RESUMO

A pesquisa relacionada ao armazenamento de grãos abrange uma ampla gama de aspectos. É um tópico relevante para muitos setores da cadeia de valor. Estudos foram desenvolvidos para reduzir as perdas de grãos em termos de segurança alimentar e alimentos seguros. Isso inclui a necessidade de inovação em termos de tecnologia e logística. Surpreendentemente, os principais atores na produção e exportação de grãos, como o Brasil, ainda lutam para garantir a capacidade de armazenamento estático adequada recomendada pela Organização das Nações Unidas (FAO). Como o armazenamento de grãos é crucial na cadeia global de suprimento de alimentos, nosso objetivo foi fornecer estatísticas descritivas, identificando tendências na literatura que possam fornecer diagnósticos valiosos e fomentar pesquisas inovadoras no campo. Nossa abordagem foi baseada na avaliação quantitativa e qualitativa da produção científica sobre armazenamento de grãos entre 2008 e 2017. Um protocolo passo a passo foi disponibilizado para permitir a rastreabilidade de todos os critérios adotados durante o fluxo de trabalho. Os procedimentos metodológicos permitiram agrupar a produção científica de acordo com a similaridade do conteúdo e a discriminação da produção científica de acordo com vários critérios (ou seja, revistas revisadas por pares, universidades, países). Além disso, uma demonstração explícita de rede entre acadêmicos permitiu a identificação de caminhos e estratégias alternativas para a inovação no campo. No geral, a análise bibliométrica e de conteúdo dos manuscritos publicados revelou tendências, lacunas e perspectivas legíveis para acadêmicos interessados no campo de armazenamento de grãos.

Palavras-chave: Segurança Alimentar. Pós-Colheita. Perdas Pós-Colheita. Qualidade de Grãos. Agronegócio.

1 INTRODUÇÃO

In modern agribusiness, demands for new technologies are continuous. Some innovations are designed to tackle factors that hinder food production and food quality. In terms of productivity, increasing the control of losses in the supply chain and improving safety margins has become crucial (CRUVINEL *et al.*, 2016). This is the case of grain storage. For some time, the grain sector has been considered as a particular ecosystem because of the magnitude and importance to human survival (ODUM, 1989; DUNKEL, 1992). This resembles what has been defined as the techno-sphere or the agro-industrial landscapes (NAVEH, 2000).

Research related to grain storage covers a wide range of aspects. There are tricky aspects to manage because grain storage occurs at different stages and distribution takes place in many ways. (PARMAR; JAIN, 2016; WILLIAMS *et al.*, 2017).

Studies have been developed to reduce grain losses prior or post-harvest (JAYAS, 2012; MLAMBO *et al.*, 2017). Comparisons and evaluation of grain storage techniques, including solar energy (WANG *et al.*, 2012), non-chemical alternatives to control grain pests (ADEBO; OLADELE, 2014) and smart interfaces that can improve control and management during storage (ZHANG *et al.*, 2014) are cited in literature. Some real-time on-line monitoring systems have been discussed to decrease uncertainty of market availability, food security and food safety (ZHANG *et al.,* 2014). Research on grain storage has also been contextualized on alleviation of food waste and the promotion of sustainability (GAO *et al.*, 2016; DOWELL *et al.*, 2017; MENDOZA *et al.*, 2017). In terms of maintaining grain quality, the moisture content, the insect infestation and toxin contamination are some of the most usual reasons for improving grain storage (DANSO *et al.*, 2017; LIKHAYO *et al.*, 2016; KRSKA *et al.* 2016).

No doubt, grain commodities are prominent in the economy of many countries. Currently, Brazil and USA are the leading countries on exportation of maize and soya (USDA, 2017). Together with China, these countries produce the greatest amount of maize. Surprisingly, Brazil has a deficit on the static storage capacity of about 70 million tons based on the recommendation of the Food and Agriculture Organization (FAO) of the United Nations that a country's static storage capacity should be equal to 1.2 times its annual output.

In a local and global perspective, demands to meet the standards for good storage and address the static storage situation have become critical. In fact, this may hinder the agricultural potential of grain exportation in many countries (HARA, 2009; EMBRAPA, 2017). In several developing countries, silo facilities are frequently inappropriate (due to poor hygiene, inadequate grain drying, improper transport, and other issues related to grain logistics) (EMBRAPA, 2017).

Because grain storage is such an important issue in the global food supply chain, several studies have contributed to the topic with various possibilities of application. Some straight up review on literature content on grain storage related topics have been developed, i.e. Kaleta and Gornicki (2013), but not looking at the statistics of available literature. We aimed to deliver some descriptive statistics, identifying trends and opportunities for scientific publications on grain storage (soya and maize). The research was performed by developing qualitative and quantitative appreciation of the scientific publications on grain storage over the last decade.

2 METHODOLOGICAL PROCEDURES

2.1 Workflow (a step-by-step protocol)

The definition of the research protocol, the analysis of articles and the summary of results were based on procedures and principles found in Martens *et al.* (2013), Hoffmann *et al.* (2015), Ferenhof and Fernandes (2016; 2013) and Struecker and Hoffmann (2017).

The workflow consisted of two trials. Each trial was characterized according to step-by-step procedures. Details encompassing all steps (split in two different trials) are given. The first trial was developed to sample articles from literature and develop quality control. The starting point of the first trial was to fix a collection of key-words sorted to develop wide-range sampling of articles in different databases (peer-reviewed articles). Each combination of key-words was nicknamed and configured as a unique scenario. Every scenario (searches) encompassed two sorts of databases: Brazilian databases (using Portuguese key-words) and Non-Brazilian databases (English key-words). During sampling events, Excel sheets were built by saving information of each sample (article). A classification criterion (separate columns) were developed to sort the articles in the data set. Prior to sampling, we arbitrarily fixed the definition of a time interval related to the year of publication.

After building the wide-range data sets the first trial proceeded to some steps of quality control (QC). The first step of QC was to develop selection/disposal of articles (trimming) by discarding all articles that were not related to the storage of maize or soya. This was done manually by reading titles and abstracts. The second step of QC was to identify and eliminate any overlapping. Overlapping was defined as repetition of articles due to the indexing of manuscripts in more than one database, or because identical articles were observed (false replicates) using a different collection of key-words (scenarios). All scanning procedures (QC) were handmade and were developed to tackle redundancies or super estimation. Articles were sorted in the Excel sheets using information such as author, title, key-words, etc. Columns were also added in the data sheets to allow detail on: methodology; the scientific question; most relevant conclusions (interpretation based on systematic reading and teamwork dynamics). More specifically, teamwork consisted of reading the abstracts and identifying the main objectives, methods and conclusions. When these were not made clear, the entire manuscript was accessed, mainly by one collaborator. The first author was responsible for accessing all necessary articles and for arranging articles according to similarity of content. A second author of the team was always responsible for developing a closer evaluation of at least 15 articles at a time and verifying the arrangements of articles in categories. This was essential to establish consensus between collaborators in terms of summary of content and category baptism (naming categories and subcategories according to content). Labelling all manuscripts helped to sort out the ones referring to exploratory approaches, experiments and questionnaire techniques. The management of all the sheets related to Brazilian or non-Brazilian databases were similar. The third step of QC was to identify all articles that failed to meet the criteria of research. This is usually a classification output offered in the digital databases and may be done according to convenience. The last step of QC was the selection/discarding of manuscripts according to the key-words. Selected articles should present key-words referring to storage.

The second trial of the workflow consisted of building a graphical author network scheme, building a graphical word-cloud, and developing qualitative clustering and re-clustering of the articles selected to compose the novel dataset. This configured a mixture of principles and procedures, defined as bibliometrics, systematic review and content analysis. Bibliometrics highlighted the general statistics and details of the scientific publications, including geographical or institutional information. The on-line software Tagul (Word Cloud Art) helped to develop the word-cloud, based on the key-words present in all the articles that passed QC. The Ucinet for Windows: Software for Social Network Analysis (2002) helped to arrange the network scheme.

Systematic Review and Content Analysis aimed to facilitate appreciation and a critical overview of the dataset. A double-step teamwork approach enabled the appreciation of the same dataset in two different methods. The first method consisted on grouping articles in categories. The criteria was the similarity of titles and abstracts (see results, Frame 1, Frame 2). One category was chosen (category which allocated the higher number of articles) to zoom-in and identify possible subgrouping. Baptism procedures (naming of categories and subcategories) were based on content (*a posteriori)* (BARDIN, 2010; TEZA *et al*., 2016) rather than fixing names prior to exploratory analysis. Hence, baptism procedures were restricted to the first method of appreciating the dataset (in the second method, the names of the categories had already been established). The alternative method of looking at the data was done by selecting at least three or four categories (at least 60% of the novel data set) and writing down short notes or words to describe and address the content of articles allocated in each chosen category. Overall, the first method of looking at the data set enabled summary of articles into categories and subcategorization of the major category. The second method consisted of zooming-in on some of the major categories and making briefs descriptions of the content. Most of the procedures consisted of teamwork dynamics. The goal was to develop qualitative organization of articles and content, and to deliver table and graphic outputs that could facilitate interpretation and inferences regarding the state of the art, trends or even gaps in the field of interest.

2.2 Workflow and quality control (QC)

The collection of key-words (scenarios) used to sample articles in Brazilian and non-Brazilian datasets are presented in Table 1 and Table 2, respectively. An arbitrary time-interval was fixed by the authors to sample publications only between 2008 and 2017, which was a group consensus. The sampling events occurred between October and November, 2017.

Overall, 565 articles were sampled in order to build a wide-range dataset. Subsequently, fine scanning (QC) enabled the disposal of 208 articles, for not being related to soya or maize. Subsequently, 115 articles were discarded because of overlapping between scenarios (identical articles sampled with different key-words), remaining 242 articles in the dataset. From these, 68 were discarded due to overlapping between databases, remaining 174 articles in the dataset. Further, 63 articles were discarded for not meeting the research area (third step of the protocol). All articles assigned to the agricultural area were selected, remaining 111 articles. From these, 38 articles presented key-words with no relation to storage and were discarded (forth step of the protocol). At the end, 73 articles were kept in the dataset for the purpose of subsequent analysis.

Table 1 –Sampled articles* using collections of keywords in Brazilian databases

SCENARIOS	SCIELO	SPELL	TOTAL
1 - (armazenagem) AND (grãos)	9	1	**10**
2 - (pós-colheita) AND (grãos)	2	0	**2**
3 - (sistema de armazenagem) AND (grãos)	0	0	**0**
4 - (armazenamento) AND (grãos)	10	0	**10**
5 - (armazenagem) AND (viabilidade)	1	0	**1**
6 - (armazenagem) AND (investimento)	0	1	**1**
	22	**2**	**24**

Source: Prepared by the authors based on data from Scielo and Spell (2017). *numbers after adjusting for scenario overlapping, prior to adjustments for database overlapping; armazenagem = storage; grãos = grain; pós-colheita = post harvest; sistema de armazenagem = storage system; armazenamento = storage; viabilidade = viability; investimento = investment.

Table 2 – Sampled articles* using collections of keywords in non-Brazilian databases

SCENARIOS	SCOPUS	WEB OF SCIENCE	SCIENCE DIRECT	TOTAL
1 - "grain storage" AND "technology"	44	11	5	**60**
2 - "post harvest" AND "technology" AND "grain"	23	10	1	**34**
3 - "grain storage" AND "adoption"	2	2	0	**4**
4 - "post harvest" AND "adoption" AND "grain"	2	1	0	**3**
5 - "grain storage" AND "food security"	9	7	7	**23**
6 - "post harvest" AND "food security" AND "grain"	11	11	0	**22**
7 - "grain storage" AND "food safety"	3	3	0	**6**
8 - "post harvest" AND "food safety" AND "grain"	1	1	0	**2**
9 - "grain storage" AND "grain protection"	1	2	2	**5**
10 - "post harvest" AND "grain protection"	4	3	0	**7**
11 - "grain storage" AND "optimization"	4	2	1	**7**
12 - "post harvest" AND "grain" AND "optimization"	3	4	0	**7**
13 - "grain storage" AND "post harvest losses"	0	0	0	**0**
14 - "grain storage" AND "feasibility"	2	2	2	**6**
15 - "post harvest" AND "grain" AND "feasibility"	2	2	0	**4**
16 - "grain storage" AND "NPV"	0	0	0	**0**
17 - "grain storage" AND "IRR"	0	0	0	**0**
18 - "post harvest" AND "NPV"	0	2	0	**2**
19 - "post harvest" AND "IRR"	0	0	0	**0**
20 - "grain storage" AND "decision making"	3	2	0	**5**
21 - "post harvest" AND "decision making" AND "grain"	1	5	0	**6**
22 - "grain storage" AND "impacts"	7	1	0	**8**
23 - "post harvest" AND "impacts" AND "grain"	5	2	0	**7**
	127	**73**	**18**	**218**

Source: Prepared by the authors based on data from *Scopus, Web of Science and Science Direct* (2017). *numbers after adjusting for scenario overlapping, prior to adjustments for database overlapping.

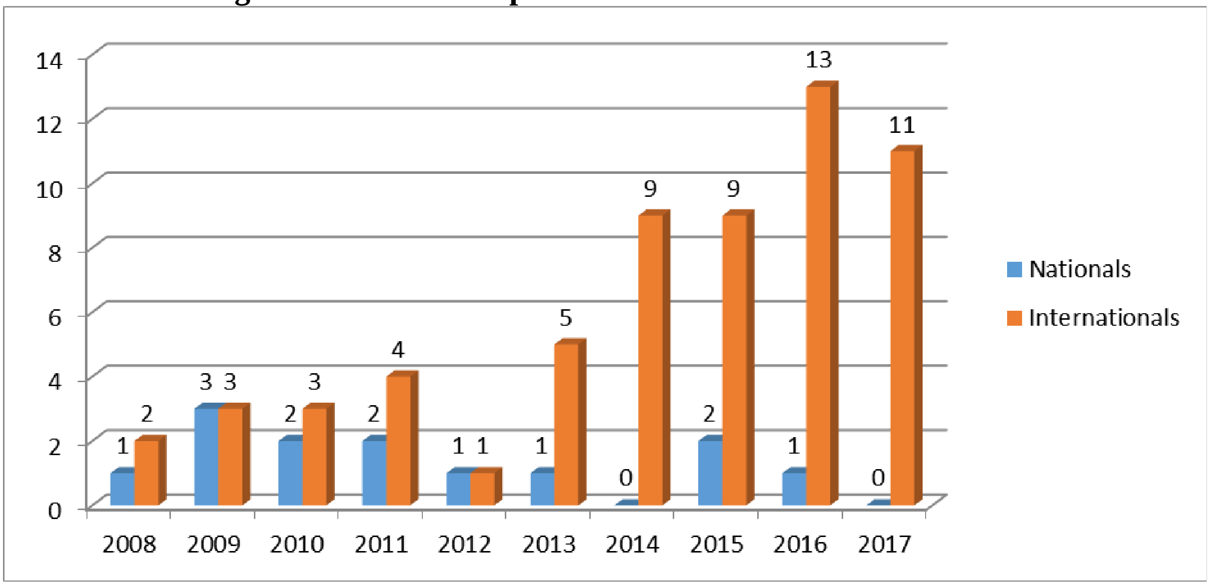
3 RESULTS

The novel dataset consisted of 60 articles sampled from non-Brazilian databases and 13 articles sampled from Brazilian databases. The sample of 60 peer-reviewed articles taken from the Scopus, Web of Science and Science Direct databases covered 31 countries, used to address all studies.

3.1 Bibliometric analysis of articles

About the distribution of searches carried out in national and international databases, 60 articles were published in international journals and 13 in national journals, in the period corresponding to 2008 to 2017. Figure 1 shows the evolution of these publications over the years.

Figure 1 – Number of publications between 2008 and 2017.

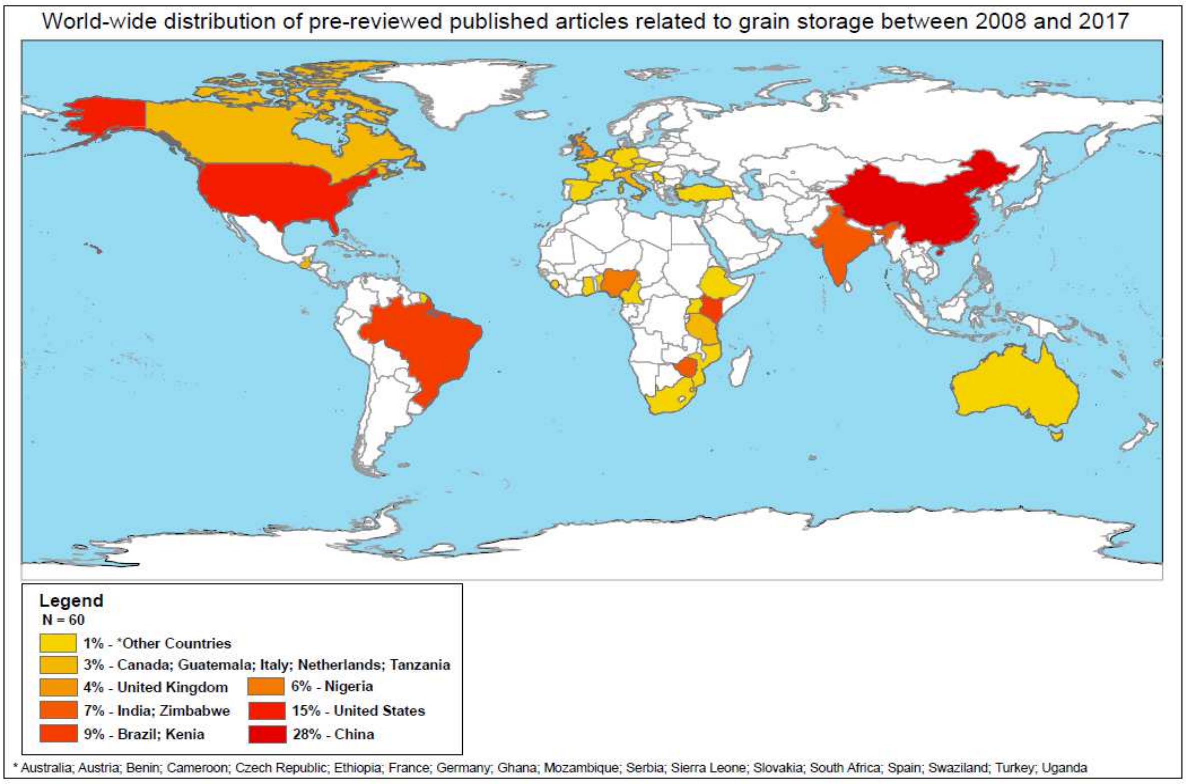


Source: Prepared by the authors. Nacionais = sampled from Brazilian databases (*Scielo* and *Spell)*; Internacionais = sampled from non-Brazilian databases (*Scopus, Web of Science e Science Direct)*; *searches related to the year 2017 ended during November.

Until 2012, articles from Brazilian and non-Brazilian databases showed similar numbers. From 2013, a boost was observed on publications related to the storage of maize and soya in non-Brazilian databases.

The geographical distribution and the number of the publications according to country is presented in Figure 3. China ranks first (28% of articles), followed by the United States (15% of articles), Brazil and Kenya (both with six articles).

Figure 2 – Geographical distribution and number of the sampled articles using non-Brazilian data sets.



Source: Prepared by the authors using the databases *Scopus, Web of Science and Science Direct* (2017).

Regarding the 60 articles sampled from non-Brazilian databases, 58 authors were identified (16 from China and 8 from the USA). In this same group of articles, 172 co-authors were identified, of which only 7.5% (12) were addressed to more than one article. In the group of 13 articles sampled from Brazilian databases, no repetition of authors was identified (authors were not identified in more than one article). These findings are probably due to the great variability of themes related to research on grain storage. Researchers presenting authorship in at least two articles are listed in Table 3.

Table 3 – Authors and co-authors with at least two authorships within the articles sampled with non-Brazilian databases.

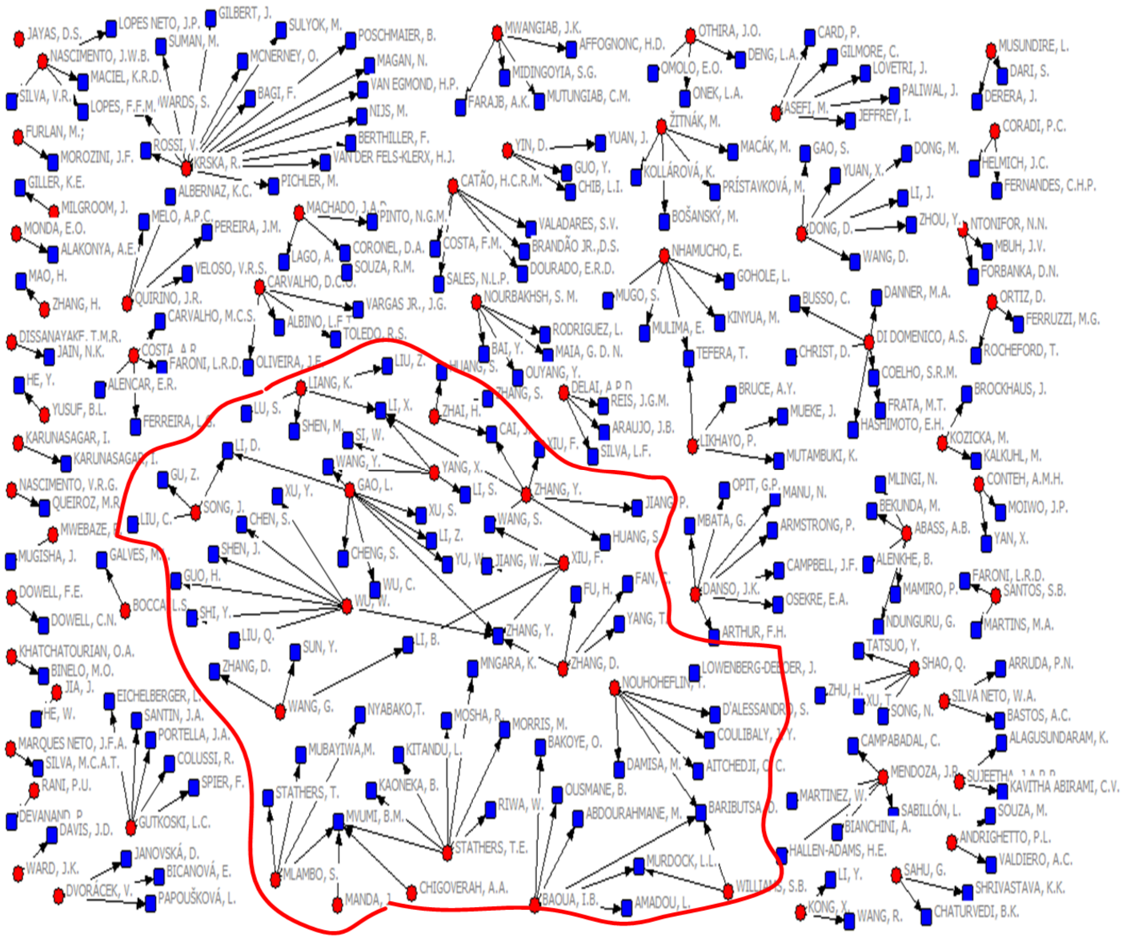
Author	Country	Scientific publications	Co-author	Country	Scientific publications
Baoua, I.B.	Nigeria	2	Baributsa, D.	United States	4
Zhang, Y.	China	2	Zhang, Y.	China	4
			Li, X.	China	3
			Murdock, L.L.	United States	3

Mvumi, B.M.	Zimbabwe	3
Amadou, L.	Nigeria	2
Tefera, T.	Kenya	2
Wang, S.	China	2
Wang, Y.	China	2
Cai, J.	China	2
Li, B.	China	2
Li, D.	China	2

Source: Prepared by the authors from the databases *Scopus*, *Web of Science and Science Direct* (2017). No researchers listed in the Brazilian databases presented two or more authorships.

The authors of China and Nigeria each have 2 articles published in the area. Zhang, Y., of China, also appears in 4 other manuscripts as co-author. Baributsa, D., from USA, is co-author of 4 other manuscripts.

Figure 3 - Network of authorships highlighting the co-authors linked to more than one article.



Legend: blue square=co-author; red dot=first author; article=a dot-square complex.

Among all countries, Brazil, China and USA were the countries with the highest numbers related to authorship (18, 17 and 7 respectively) and co-authorship (55 and 64 and 26, respectively).

In terms of number of collaboration in peer-reviewed manuscripts, some co-authors stood out. For example, LI, X. (from China) collaborated with three different articles (Liang, K (China), with Zhang (China) and Yang (China)). This shows collaboration between Chinese co-authors linked to different articles. In Brazil, there was no collaboration between Brazilian co-authors linked to different articles.

Other authors which stood out the most in the collaboration network was Zhang, Y.; Li, D.; Li, B.; Cai, J.; and also Baributsa, D. This last author (addressed to the USA) collaborated with Williams, S.B. (USA), with Baoua, I.B. (Nigeria) and Nouhoheflin, T. (USA) (Figure 4). Despite never being first authors, some researchers stood out in terms of bridging names from different articles in the network scheme. For example, this was the case of Mvumi, B.M. from Zimbabwe, showing collaboration in four different articles (Figure 4). The researchers that presented first authorship twice were Di Domenico, A.S.; Zhang, Y.; and Baoua, I.B. In these cases, all co-authors (blue squares in Figure 4) were linked to a unique article (red dot in Figure 4).

The articles with the highest number of citations are presented in Table 4. The ten most cited articles were all sampled from non-Brazilian databases. The percentages of citations regarding the articles sampled from non-Brazilian databases (60) were: 16% (10) with eight or more citations, 52% (31) between one and seven citations, and 32% (19) with no citation. The most cited article was "*Courting the rain: Rethinking seasonality and adaptation to recurrent drought in semi-arid southern Africa*" by *MILGROOM, J.* from the *Wageningen University (Netherlands),* with 29 citations. From the 10 top cited articles, the titles of four were specifically related to the African continent.

Table 4 – The most cited peer-reviewed articles in the dataset related to storage of maize and soya

Title	Citations
Courting the rain: Rethinking seasonality and adaptation to recurrent drought in semi-arid southern áfrica	29
Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania	24
PICS bags for post-harvest storage of maize grain in West Africa	23
Insecticidal potency of Hyptis spicigera preparations against Sitophilus zeamais (l.) and Tribolium castaneum (herbst) on stored maize grains	20

Do diatomaceous earths have potential as grain protectants for small-holder farmers in sub-Saharan Africa? The case of Tanzania	17
Simulation of three-dimensional airflow in grain storage bins	14
Efficiency of different plant foliar extracts on grain protection and seed germination in maize	14
Grain bin monitoring via electromagnetic imaging	9
Storing Grains for Food Security and Sustainability	8
Influence of Temperature and Humidity on the Stability of Carotenoids in Biofortified Maize (Zea mays L.) Genotypes during Controlled Postharvest Storage	8

Source: Prepared by the authors from the databases *Scopus, Web of Science and Science Direct* (2017).

Table 5 shows the five most cited articles sampled from Brazilian databases. In this case, Marques Neto, from University Unicamp (county of Campinas, São Paulo) wrote the article with the highest number of citations (6). Of the 13 articles, five were cited between two or six times, 2 were cited only once and the remaining six were not cited yet.

Table 5 – Most cited articles that were sampled with Brazilian databases.

Title	Citation
Applying structural masonry for granular material storage systems	6
Different aeration strategies for stored corn: temperature and moisture content	3
Quality of corn grain stored in silo bags	3
Physical, physiological and seed health qualities of maize landrace seeds produced on northern Minas Gerais, Brazil	2
Physical, physiological and seed health qualities of maize landrace seeds produced on northern Minas Gerais, Brazil	2

Source: Prepared by the authors from the databases *Scielo and Spell* (2017).

The number of articles published in each scientific journal, their relative frequency, country of origin, as well as the journal impact factor calculated according to the SJR (Scimago Journal Ranking - year 2016) is shown in Table 6. The articles found in non-Brazilian databases were published in 41 journals. The journals that published at least two articles within the sample accounted for 42% of the articles sampled from non-Brazilian databases (Table 6). Among the 60 articles found in non-Brazilian datasets, 25 are related to 6 journals, representing 42% of the sample (Table 6). Two journals (Journal of Stored Products Research; Crop Protection) are from the UK, representing 16% (10 articles from Journals assigned to the UK). The journals from non-Brazilian databases that were not listed in Table 6 appeared in one journal each (35 articles published in 35 different journals). This included journals from USA (7), Brazil (5), Holland (4), China (1), UK (1), India (1) and Nigeria (1), among others.

Table 6 – Journals from non-Brazilian databases with more than two publications in the theme and their impact factor[1] according to SJR classification

Journal	Number of articles	Relative frequency	Impact factor	Country of origin
Journal of Stored Products Research	8	13%	1,825	United Kingdon
Nongye Gongcheng Xuebao	7	12%	*	China
Journal of the Chinese C. and Oils Association	4	7%	*	China
Journal of Entomology	2	3%	*	Pakistan
Crop Protection	2	3%	1,920	United Kingdon
Biosystems Engineering	2	3%	2,132	United States
	25	42%		

Source: Prepared by the authors based on the databases *Scopus*, *Web of Science and Science Direct* (2018). [1]checked during April, 2019; *The Impact factor was not accounted for these journals.

Regarding the articles sampled from Brazilian databases, indexing of articles in a same journal was observed only in three situations: *Ciência Rural, Engenharia Agrícola* and *Revista Ciência Agronômica* (Table 7). The three journals are classified as B1 according to the Qualis CAPES criteria. This is a quality indicator based on a seven-level classification scale (A1, A2, B1, B2, B3, B4, C), adopted in all Brazilian post graduation programs.

Table 7 –Journals that published articles on grain storage of maize and soya, identified by systematic sampling in Brazilian databases

Journal	Number f articles	Relative frequency	Journal rank	ISSN
Ciência Rural	2	15%	B1	1678-4596
Engenharia Agrícola	2	15%	B1	0100-6916
Revista Ciência Agronômica	2	15%	B1	1806-6690
Bragantia	1	8%	B1	1678-4499
Food Science and Technology	1	8%	B1	0101-2061
Gestão & Regionalidade	1	8%	B2	2176-5308
Pesquisa Agropecuária Brasileira	1	8%	B1	1678-3921
Reuna	1	8%	B3	2179-8834
Revista Brasileira de Eng. Agrícola e Ambiental	1	8%	B1	1807-1929
Revista Brasileira de Zootecnia	1	8%	B1	1806-9290
	13	100%		

Source: Prepared by the authors based on the databases *Scielo* and *Spell* (2017). Qualis CAPES classification from the year 2016.

The 60 articles sampled using non-Brazilian databases were linked to a total of 96 universities and institutions. A total of 18 universities and research institutions were addressed to at least 2 articles each, representing 36% of the articles sampled with non-Brazilian databases.

The Purdue University stands out due to the development of Purdue Improved Crop Storage technology (PICS). This refers to a storage option with hermetic conditions so that small farmers may minimize losses caused by pests without the use of insecticides. Two co-authors listed in Table 3 (Baributsa, D. and Murdock, L.L.) presented collaboration in grain storage studies in Purdue University.

A summary of the most frequent key-words (a total of 30) identified in articles sampled from Brazilian and non-Brazilian datasets is shown in Figure 5.

Figure 5 – Word-cloud built with keywords used at least two times in 73 peer-reviewed articles related to the storage of maize and soya.

Source: Prepared by the authors using Tagul - Word Cloud Art (online software).

3.2 GROUPING ARTICLES IN CATEGORIES

Using content analysis, 73 articles were clustered into 18 categories. The name of each category is a rough summary of the content, presented in Frame 1.

Frame 1 Allocation of articles in categories (CTG) as a result of qualitative clustering based on the similarity of content.

	Category name	Authors	f

1	Innovation and Technology adoption	Mlambo *et al.*, 2017; Williams *et al.*, 2017; Krska *et al.*, 2016; Asefi *et al.*, 2015; Yusuf e He, 2011; Shao *et al.*, 2015; Jia e He, 2015; Zhang *et al.*, 2014; Liang *et al.*, 2013; Kong *et al.*, 2009; Khatchatourian e Binelo, 2008; Ward e Davis, 2013; Nascimento *et al.*, 2009; Andrighetto *et al.*, 2008; Marques Neto e Silva, 2011. Othira *et al.*, 2009; Stathers *et al.*, 2008; Wang *et al.*, 2014; Zhang *et al.*, 2014; Chigoverah e Brighton, 2016; Baoua *et al.*, 2014; Conteh *et al.*, 2015; Mwebaze e Mugisha, 2011; Dissanayake e Jain, 2010	24
2	Prevention against pests and insects	Dowell e Dowell, 2017; Nhamucho *et al.*,2017; Danso *et al.*, 2017; Baoua *et al.*, 2015; Musundire *et al.*, 2015; Quirino *et al.*, 2013; Ntonifor *et al.*, 2011; Rani e Devanand, 2011; Zhang e Mao, 2009	9
3	Control and management of grain quality	Coradi *et al.*, 2016; Zhang *et al.*, 2014; Furlan; Morozini, 2013; Santos *et al.*, 2012; Nascimento e Queiroz, 2011; Catão *et al.*, 2010; Costa *et al.*, 2010; Gutkoski *et al.*, 2009	8
4	Storage techniques	Mendoza *et al.*, 2017; Likhayo *et al.*, 2016; Yang *et al.*, 2016; Di Domenico *et al.*, 2016; Sahu *et al.*, 2015; Wu *et al.*, 2014	6
5	Control of losses	Mwangiab *et al.*, 2017; Gao *et al.*, 2016; Karunasagar e Karunasagar, 2016; Dong *et al.*, 2014;	4
6	Food Security	Monda e Alakonya, 2016; Zhai et al., 2015; Domenico *et al.*, 2015; Jayas, 2012	4
7	Implementation of storage facilities and investments	Bocca; Galves, 2016; Nourbakhsh *et al.*, 2016; Machado *et al.*, 2015	3
8	Quality of grain stored for feed	Dafei *et al.*, 2017; Carvalho *et al.*, 2009	2
9	Static capacity and logistics	Nouhoheflin *et al., 2017;* Silva Neto *et al.*, 2016	2
10	Gender issues	Manda; Mvumi, 2010	1
11	Management techniques	Abass *et al.*, 2014	1
12	Climate change	Milgroom; Giller, 2013	1
13	Characteristics of grain	Song *et al.*, 2016	1
14	Prevention and analysis of risks and accidents	Žitňák *et al.*, 2015	1
15	Influence on grain commercialization	Delai *et al.*,2017	1
16	Research on carotenoids	Ortiz *et al.*, 2016	1
17	Influence on storage conditions	Dvořáček *et al.*, 2010	1
18	Referring to "storage"	Kozicka *et al.*,2017; Xiu *et al.*, 2013; Sujeetha *et al.*, 2014.	3

f= frequency; **Source:** Prepared by the authors from the observation of *abstracts.*

The category that contained the highest number of articles (24) was Innovation and technology adoption, accounting for 32.8% of the articles. In second, the category Prevention against pests and insects (9), with 12.3%, followed by Control and management of grain quality (8) (10.9%) and Storage techniques (6), with 8.2% (Frame 1).

Four subcategories (SC) emerged from the major category Innovation and technology adoption (Frame 2). The subcategories were referred to (baptized) as (a) SC1: Technology and innovation related to food security (6), (b) SC2: Technology and innovation related to control and prevention against pests and insects (7), (c) SC3: Technology and innovation about loss and waste prevention (4), (d) SC4: Technology and innovation related to specific topics and case studies (6). In Frame 2, the title of every article allocated in the major category (Innovation and Technology adoption) is illustrated.

Frame 2 – Authors and title of articles that were sorted in subcategories after zooming-in the major category in the data set: Innovation and technology adoption

Authors	Title of the articles in each subcategory found in category Innovation and technology adoption	f
	Subcategory 1: Technology and innovation related to Food Security	
Zhang *et al.*,2014	An online detection model of granary storage quantity	6
Liang *et al.*, 2013	Real-time monitoring system for grain moisture content based on equilibrium moisture model	
Conteh *et al.*, 2015	The determinants of grain storage technology adoption in Sierra Leone	
Krska *et al.*, 2016	Safe food and feed through an integrated toolbox for mycotoxin management: The MyToolBox approach	
Asefi *et al.*, 2015	Grain bin monitoring via electromagnetic imaging	
Yusuf; He, 2011	Design, development and techniques for controlling grains post-harvest losses with metal silo for small and medium scale farmers	
Subcategory 2: Technology and innovation related to control and prevention against pests and insects		
Stathers *et al.*, 2008	Do diatomaceous earths have potential as grain protectants for small-holder farmers in sub-Saharan Africa? The case of Tanzania	8
Othira *et al.*, 2009	Insecticidal potency of Hyptis spicigera preparations against Sitophilus zeamais (l.) and Tribolium castaneum (herbst) on stored maize grains	
Mlambo *et al.*, 2017	Field efficacy of hermetic and other maize grain storage options under smallholder farmer management	
Williams *et al.*, 2017	Safe storage of maize in alternative hermetic containers	
Wang *et al.*, 2014	Present situation and prospects of storage pests based on vision inspection technology	
Zhang *et al.*, 2014	Research and application progress on monitoring stored grain security by gas analyzing	
Chigoverah; Brighton, 2016	Efficacy of metal silos and hermetic bags against stored-maize insect pests under simulated smallholder farmer conditions	
Baoua *et al.*, 2014	PICS bags for post-harvest storage of maize grain in West Africa	
Subcategory 3: Technology and innovation about loss and waste prevention		
Nascimento *et al.*, 2009	Concrete blocks for the modular construction of circular silos	4
Marques Neto; Silva, 2011	Applying structural masonry for granular material storage systems	
Mwebaze; Mugisha, 2011	Adoption, utilization and economic impacts of improved post-harvest technologies in maize production in Kapchorwa District, Uganda	
Dissanayake; Jain, 2010	Status of post-harvest technology of agricultural crops in Sri Lanka	
Subcategory 4: Technology and innovation related to specific topics and case studies		
Shao *et al.*, 2015	Design and experiment for grain storage monitoring system based on 3-D	6

	laser scanning technology	
Jia; He, 2015	Study on heat insulation performance of external wall of low temperature grain storage granary	
Kong *et al.*, 2009	Refrigeration performance of a silica GelWater adsorption chiller driven by variable heat source	
Khatchatourian; Binelo, 2008	Simulation of three-dimensional airflow in grain storage bins	
Ward; Davis, 2013	A system to assess grain bag storage internal environment	
Andrighetto *et al.*, 2008	Automatic control of slide gate valves with pneumatic drive in agricultural storage facilities	

f= frequency; **Source:** Prepared by the authors from the observation of *abstracts.*

Regarding research on topics related to technology and innovation, associated to infestation of pests and insects, some articles were focused on metal silos and hermetic bags (using natural (i.e., plant extracts), artificial or mixed pesticides). Some articles included control methods using real-time infestation levels. In Addition, the scope of Innovation and technology adoption, several articles referred to post-harvest losses, the reduction of food waste and food safety. Some articles referred to the usage of electromagnetic images to monitor stored grains and referenced upcoming (necessary) technology and projects related to small-scale metal silos.

In the category Innovation and technology adoption, the team grouped up the notes and listed the following items: options to store, hermetic alternatives, real-time monitoring (on-line), grain monitoring, natural insecticides, 3D Technology, thermal isolation, sensors and hermetic Bags (PICS). There was also emphasis on controlling the levels of oxygen and moisture, insect damage, rate of grain germination and size of the insect population. Different forms of temperature control and grain cooling are being evaluated such as airflow simulation that may optimize storage systems, 3-D monitoring of grains and the use of electromagnetic images that may avoid grain residues. Some technologies such as thermal insulation are being discussed in terms of energy saving alternatives. Comparisons about the the efficiency of the GrainPro Super Grain Bags (SGB) IVR and Purdue Improved Crop Storage (PICS) stood out. These were related to the control of pests and insects in different seasons and applications of organic or synthetic insecticides. Also, research on PICS sealing technology stood out, which is a storage system for small farmers (family farmers), besides topics on PET bottles.

Overall, the research team converged and agreed that issues related to grain losses could be summarized i.e. to some analysis of the storage conditions, monitoring of grains and the control of carbon dioxide. Similarly, food security could be summarized to storage methods, including hermetic alternatives, and also management systems that facilitate or support grain storage and grain quality.

4. FINAL CONSIDERATIONS

The methodology undertaken, combining bibliometrics, systematic review and content analysis generated a portfolio, looking at the statistics of available literature. This enabled insights on the scientific publications on grain storage, specifically soya and maize. The workflow developed allowed traceability of the adopted procedures. Scientific publications were sorted in categories and subcategories, baptized *a posteriori*, according to the similarity of content. Notably, the research team struggled to perform qualitative clustering and converge to an ideal grouping structure. The main reason for struggle was the similarity and interdependency of themes. Hence, the predominant focus of the articles was the criteria to perform sub grouping. This was tricky especially when disentangling notes related to food security, grain loss, and insect and pest control. These topics linked closely to each other.

The results from clustering clearly showed that technology is the emphasis given by authors in the scientific publications. This is sustained because majority (33%, *f*=24) of the articles were grouped in a category baptized *a posteriori* as Innovation and technology adoption (Frame 1). In Frame 2, one can observe that the spotlight on technology spans to four major subtopics. This is represented by four subcategories (Frame 2). The structure of sub categorization suggests that Innovation and technology adoption is frequently related to benefits on food safety and food security, reductions of losses through waste and contamination (Frame 2). Because maize and soya are commodities, the content is embedded in the scope of maintaining grain quality and the volume of production.

In addition, summarizing the scientific publications on grain storage revealed that technology encompassed not only issues related to infrastructure but several technical aspects that span grain production and storage. In fact, reading the name of subcategories and the titles of the articles (Frame 2), repeatedly, helped to verify the content linked to several risk factors that may lead to irreparable damage. These factors resemble guidelines and comprehensive goals, necessary to guarantee food supply for livestock and human population worldwide. The variability of themes (categories and subcategories) provided new insights and are, most probably, a consequence of choosing *a posteriori* criteria to sort out content and baptize clusters instead of fixing group names prior to analysis (FRANCO, 2007a; FRANCO 2007b).

Notably, technology adoption and grain storage have been discussed in behalf of small scale, family farmers with respect to alleviation of hunger and food security (i.e. Yusuf; He, 2011) (subcategory 1, Frame 2), technology to control pests and insects (i.e. Stathers *et al.*, 2008; Mlambo *et al.*, 2017; Williams *et al.*, 2017; Chigoverah; Brighton, 2016) (subcategory 2, Frame 2). Also, social (i.e. category 10 and 14, Frame 1) and environmental (i.e. category 12, Frame 1) concerns are stated in research related to grain storage. This means that even if there is a bias towards technology, grain storage is not decoupled from the topics that shape the goals for the third millennium (FAO, date). In fact, content analysis revealed that technology has enabled the reduction of indiscriminate use of pesticides in grain storage, minimizing environmental impacts and avoiding worker exposure to toxic products (i.e. Ntonifor *et al.*, 2011 (category 2, Frame 1); Othira *et al.*, 2009 (subcategory 2, Frame 2). In some cases, it was observed that the cost related to pest control has decreased and the quality of the storage grain has improved considerably (i.e. Othira *et al.*, 2009 (subcategory 2, Frame 2).

Regarding the author network (Figure 4), some effect is possibly driving distinct network configuration between China and Brazil. In which extent could the isolation among research teams hinder grain storage modernization? Does this encourage the discussion about scientific societies related to grain storage? These issues should be explored in subsequent research. No doubt, inter-team discussion and collaboration is strategic to generate innovation and impact on the technological, social, economic and environmental aspects of grain storage.

Some aspects were not followed by the set of key-words used to sample articles in the databases. Interestingly, articles pinpointing the cost-benefit of adopting technological alternatives (designed to improve grain storage), seemed very discrete (i.e. Mwebaze and Mugisha, 2011 (subcategory 3, Frame 2); Dissanayake and Jain, 2010 (subcategory 3, Frame 2,); Ntonifor *et al.*, 2011 (category 2, Frame 1)). This finding suggests a gap in terms of scientific publications. Little research on the economic and financial capacity of farmers to implement grain storage systems may possibly limit decision making. This includes decisions made by actors from several sectors from the supply chain. No doubt, the adoption of post harvest technologies is necessary to avoid production losses and to add value to stored grains (DISSANAYAKE and JAIN, 2010). However, the technological alternatives need to be linked to cost-benefit analyzes (MWEBAZE and MUGISHA, 2011). Surprisingly, this was not the case. For example, grain storage within the farm is believed to make traffic (i.e. tractors) less intense during harvesting seasons, minimizing infrastructure problems and better meeting the demands of the industry. Hence, characterization of the economic and financial capability of farmers to implement storage systems is relevant. Likewise, it would be suitable to forecast how improvements on grain storage logistics would affect the country's economy or farmers' profit. These issues are of great concern, and may potentially affect farmers´ intention to adopt or adapt any storage facility.

The limitation of data leads to uncertainties. For example, how do costs and earnings vary according to the geographic distance of grain producers and current storage facilities? How would improvements on logistics affect the economy of countries that export grain? There seems to be limited knowledge on how the static storage deficit affects the current supply chain and how it may limit profit and the empowerment of farmers. Governmental or private grain storage initiatives (defined as "*condominiums*" in some latin countries to refer to arrangements to store grains in a local cooperative fashion)) seem to be unexplored in studies focused on economic viability. If investment decisions rely on understanding uncertainties, it seems unlikely that farmers will invest time and money to install or adapt storage facilities, especially in the absence of guarantees and proper grain storage policies. Bridging these issues may be the key to generate innovative research on grain storage. It may open the door for new contributions on food control in the perspective of modern agribusiness and world economics.

A statistical overview of the available literature on grain storage topics seemed to be a good start for listing down topics and encouraging in-depth analysis. In terms of the method, some limitation were consequences of group decisions made prior to sampling the articles in literature. Neglecting literature present in book chapters may have limited the representability of the overview, failing to retrieve valuable research on the topic of interest. Also, focusing only on grain storage of maize and soya ended up concealing contributions on subjects such as integrated pest management (IPM). Recently, there is great emphasis on pest management programs in grain storage (KENKEL AND ADAM, 2018).

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REFERENCES

ABASS, A.B.; NDUNGURU, G.; MAMIRO, P.; ALENKHE, B.; MLINGI, N.; BEKUNDA, M. Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. **Journal of Stored Products Research**. V. 57, p. 49-57, 2014.

ADAM, B.D.; SIAPLAY, M.; FLINN, P.W.; BRORSEN, B.W.; PHILLIPS, T.W. Factores influencing economic profitability of sampling-based integrated pest management of wheat in country elevators. **Journal of Stored Products Research**. V. 46, p. 186-196, 2010.

ADEBO, G.M.; OLADELE, O.I. Awareness and use of non-chemical prevention and control of storage pests of grains: an internacional audience perpspective. **Mediterranean Journal of Social Sciences.** V. 5, n. 15, p. 150-155, 2014.

ANDRIGHETTO, P.L.; VALDIERO, A.C.; SOUZA, M. Controle automático de registros de descarga com acionamento pneumático em unidades de armazenagem agrícola. **Ciência Rural**. V. 38, n.9, p. 2626-2629, 2008.

ASEFI, M.; JEFFREY, I.; LOVETRI, J.; GILMORE, C.; CARD, P.; PALIWAL, J. Grain bin monitoring via electromagnetic imaging. **Computers and Electronics in Agriculture**. V. 119, n. 01, p. 133-141, 2015.

BAOUA, I.B.; AMADOU, L.; ABDOURAHMANE; M.; BAKOYE, O.; BARIBUTSA, D.; MURDOCK, L.L.Grain storage and insect pests of stored grain in rural Niger. **Journal of Stored Products Research**. V. 64, p. 8-12, 2015.

BAOUA, I.B.; AMADOU, L.; OUSMANE, B.; BARIBUTSA, D.; MURDOCK, L.L. PICS bags for post-harvest storage of maize grain in West Africa. **Journal of Stored Products Research**. V. 58, p. 20-28, 2014.

BARDIN, L. Análise de conteúdo. **Lisboa, Portugal**. 5ª Ed. 2010.

BOCCA, L.S.; GALVES, M.L. Technical paper multicriteria decision aid to implement an on-farm storage system for soybeans. **Engenharia Agricola**. V. 36, n. 6, p. 1250-1260, 2016.

BORGATTI, S.P., EVERETT, M.G. AND FREEMAN, L.C. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: **Analytic Technologies**, 2002.

CARVALHO, D.C.O.; ALBINO, L.F.T.; VARGAS JUNIOR, J.G.; TOLEDO, R.S.; OLIVEIRA, J.E.; SOUZA, R.M. Coeficiente de digestibilidade verdadeira dos aminoácidos e valores de aminoácidos digestíveis do milho submetido a diferentes temperaturas de secagem e períodos de armazenamento. **Revista Brasileira de Zootecnia**. V. 38, n.5, p. 850-856, 2009.

CATÃO, H.C.R.M.; VALADARES, S.V.; DOURADO, E.R.; BRANDÃO JUNIOR, D.S.; SALES, N.L.P.; COSTA, F.M. Qualidade física, fisiológica e sanitária de sementes de milho crioulo produzidas no norte de Minas Gerais. **Ciência Rural**. V. 40, n. 10, p. 2060-2066, 2010.

CHIGOVERAH, A.A.; MVUMI, B.M. Efficacy of metal silos and hermetic bags against stored-maize insect pests under simulated smallholder farmer conditions. **Journal of Stored Products Research.** V. 69, p. 179-189, 2016.

CONTEH, A.M.H.; YAN, X.; MOIWO, J.P. The determinants of grain storage technology adoption in Sierra Leone. **Cahiers Agricultures**. V. 24, n.1, p. 47-55, 2015.

CORADI, P.C.; FERNANDES, C.H.P.; HELMICH, J.C. Adjustment of mathematical models and quality of soybean grains in the drying with high temperatures. **Revista Brasileira de Engenharia Agrícola e Ambiental**. V. 20, n. 4, p. 385-392, 2016.

COSTA, A.R.; FERREIRA, L.G.; CARVALHO, M.C.S.; FARONI, L.R.D.; ALENCAR, E.R. Qualidade de grãos de milho armazenados em silos bolsa. **Revista Ciência Agronômica.** V. 41 n. 2, p. 200-207, 2010.

CRUVINEL, P.E.; KOENIGKAN, L.V.; PEREIRA, M.F.L. Visualizing thermal information and knowledge creation in graisn storage Bin based on three-dimensional (3D) interface model and computer graphic techniqyes. **International Conference on Semantic Computing**, 2016.

DAFEI, Y.; JIANMIN, Y.; YUMING, G.; LEE, I. C. Effect of storage time on the characteristics of maize and efficiency of its utilization in broiler chickens. **Animal Nutrition**. V. 3, n. 3, p. 252-257, 2017.

DANSO, J.K.; OSEKRE, E.A.; MANU, N.; OPIT, G.P.; ARMSTRONG, P.; ARTHUR, F.H.; CAMPBELL, J.F.; MBATA, G. Moisture content, insect pests and mycotoxin levels of maize at harvest and pos-harvest in the Middle Belt of Ghana. **Journal of Storage Products Research**. V. 74, p. 46-55, 2017.

DELAI, A.P.D.; ARAUJO, J.B.; REIS; J.G.M.; SILVA, L.F. Storage and logistic profits: A comparative analysis for soybean commercialization in the state of Mato Grosso do Sul. **Revista em Agronegócio e Meio Ambiente**. V. 10, n. 2, p. 395-414, 2017.

DI DOMENICO, A.S.; BUSSO, C.; HASHIMOTO, E.H.; FRATA, M.T.; CHRIST, D.; COELHO, S.R.M.; Occurrence of Aspergillus sp., Fusarium sp., and aflatoxins in corn hybrids with different systems of storage. **Acta Scientiarum – Agronomy.** V. 38, n. 1, p. 111-121, 2016.

DI DOMENICO, A.S.; BUSSO, C.; CHRIST, D.: COELHO, S.R.M.; DANNER, M.A. Análise de trilha da contaminação por aflatoxinas em grãos de milho armazenados. **Pesquisa Agropecuária Brasileira**. V. 50, n.6, p. 441-449, 2015.

DISSANAYAKE, T.M.R.; JAIN, N.K. Status of post harvest technology of agricultural crops in Sri Lanka. AMA, Agricultural Mechanization in Asia, **Africa and Latin America**. V. 41, n. 4, p. 16-23, 2010.

DONG, D.; DONG, M.; GAO, S.; WANG, D.; ZHOU, Y.; YUAN, X.; LI, J.; Farmers' maize ear storage characteristics and storage losses. **Journal of the Chinese Cereals and Oils Association**. V. 29, n. 3, p. 74-89, 2014.

DOWELL, F.E.; DOWELL, C.N.; Reducing grain storage losses in developing countries. **Quality Assurance and Safety of Crops & Foods.** V. 9, ed. 01, p. 93-100, 2017.

DUNKEL, F.V. The stored grain ecosystem: a global perspective. **Journal of Stored Products Research**. V. 28, n. 2, p. 73-87, 1992.

DVOŘÁČEK, V.; JANOVSKÁ, D.; PAPOUŠKOVÁ, L.; BICANOVÁ, E. Post-harvest content of free titratable acids in the grain of proso millet varieties (Panicum milliaceum L.), and changes during grain processing and storage. **Czech Journal of Genetics and Plant Breeding.** V. 46, p. S90-S95, 2010.

EMBRAPA – **EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA**. Disponível em: <http://www.embrapa.br>. Acesso em setembro de 2017.

FERENHOF, H.A.; FERNANDES, R.F. Desmistificando a revisão de literatura como base para redação científica: método SSF. **Revista ACB.** V. .21, n.3, p. 550-563, 2016.

FLINN, P.W.; HAGSTRUM, D.W.; REED, C.; PHILLIPS, T.W. United States Department of Agriculture-Agricultural Research Service sotored-grain areawide integrated pest management program. **Pest Management Science.** V. 59, n. 6, p. 614-618, 2003.

FURLAN, M.; MOROZINI, J.F. Implementation of ISO 22000 in a storage unit of a grain cooperative from the midwest region of Paraná. **Custos e Agronegócios**. V. 9, n. 4, p. 232-256, 2013.

FRANCO, M.L.P.B. Análise de conteúdo. Brasília: **Líber Livro Editora**. V.6, p. 69-78, 2007a.

FRANCO, M.L.P.B. As categorias de análise. In. Análise de conteúdo. Brasília: **Líber Livro Editora**. V. 6, p.59-68, 2007b.

GAO, L.; XU, S.; LI, Z.; CHENG, S.; YU, W.; ZHANG, Y.; Li, D.; WANG, Y.; WU, C. Main grain crop posharvest losses and its reducing potential in China. **Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering**. V. 32, n. 23, p. 1-11, 2016.

GUTKOSKI, L.C.; EICHELBERGER, L.; SANTIN, J.A.; PORTELLA, J.A.; SPIER, F.; COLUSSI, R. Avaliação da composição química de milho seco e armazenado em silo tipo alambrado com ar natural forçado. **Food Science and Technology**. V. 29, n.4, p. 879-885, 2009.

HARA, T. Brazil´s grain storage infrastructure current state and future needs. **Bulk solids Handling**. V. 29, n. 6, p. 344-345, 2009.

HOFFMANN, M. G.; FERNANDES, R. F.; FEUERSCHUTTE, S. G.; LEMOS, D. C. Fatores condicionantes à inovação: aproximação ao estado da arte por meio da bibliometria e da revisão sistemática. **Pretexto.** V.17, n.2, p. 11-27, 2015.

JAYAS, D.S. Storing grains for food security and sustainability. **Agricultural Research.** V. 1, n. 1, p. 21-24, 2012.

JIA, J.; HE, W. Study on heat insulation performance of external wall of low temperature grain storage granary. **Advance Journal of Food Science and Technology.** V. 8, n. 4, p. 306-311, 2015.

KALETA, A.; GÓRNICKI, K. Criteria of determination of safe grain storage time – a review. **Advances in Agrophysical research**, 2013.

KARUNASAGAR, I.; KARUNASAGAR, I. Challenges of Food Security – Need for Interdisciplinary Collaboration. **Procedia Food Science.** V. 6, p. 31-33, 2016.

KENKEL, P.; ADAM, B.D. Economic theory versus reality in stored grain IPM: Theory and practice in stored product management. **Recent Advances in Stored Product Protection.** V. 19, p. 261-273, 2018.

KHATCHATOURIAN, O.A.; BINELO, M.O.; Simulation of three-dimensional airflow in grain storage bins. **Biosystems Engineering**. V. 101, n. 2, p. 225-238, 2008.

KONG, X.; WANG, R.; LI, Y.; Refrigeration performance of a silica GelWater adsorption chiller driven by variable heat source. **Nongye Jixie Xuebao/Transactions of the Chinese Society of Agricultural Machinery**. V. 40, n. 9, p. 127-160, 2009.

KOZICKA, M.; KALKUHL, M.; BROCKHAUS, J. Food Grain Policies in India and their Implications for Stocks and Fiscal Costs: A Dynamic Partial Equilibrium Analysis. **Journal of Agricultural Economics**. V. 68, n. 1, p. 98-122, 2017.

KRSKA, R.; DE NIJS, M.; MCNERNEY, O.; PICHLER, M.; GILBERT, J.; EDWARDS, S.; SUMAN, M.; MAGAN, N.; ROSSI, V.; VAN DER FELS-KLERX, H.J.; BAGI, F.J, POSCHMAIER, B.; SULYOK, M.; BERTHILLER, F.; Van Egmond, H.P.; Safe food and feed through an integrated toolbox for mycotoxin management: The MyToolBox approach. **World Mycotoxin Journal.** V. 9, n. 4, p. 487-495, 2016.

LIANG, K.; SHEN, M.; LU, S.; LIU, Z.; LI, X. Real-time monitoring system for grain moisture content based on equilibrium moisture model. **Nongye Jixie Xuebao/Transactions of the Chinese Society for Agricultural Machinery.** V.44, n. 1, p. 125-130, 2013.

LIKHAYO, P.; BRUCE, A.Y.; MUTAMBUKI, K.; TEFERA, T.; MUEKE, J. On-Farm Evaluation of Hermetic Technology Against Maize Storage Pests in Kenya. **Journal of Economic Entomology.** V. 9, n.4, p. 1943-1950, 2016.

MACHADO, J.A.D.; CORONEL, D.A.; PINTO, N.G.M.; LAGO, A. O Processo Decisório na Implantação de Estrutura para Armazenagem de Soja ao nível de propriedade rural: o caso da microrregião de Santo Angelo – RS. **Reuna.**

MANDA, J.; MVUMI, B.M. Gender relations in household grain storage management and marketing: The case of Binga District, Zimbabwe. **Agriculture and Human Values**. V. 27, n.1, p. 85-103, 2010.

MARQUES NETO, J.F.A.; SILVA, M.C.A.T. Aplicação da alvenaria estrutural em sistemas de armazenamento de produtos agrícolas a granel. **Engenharia Agrícola**. V. 31, n. 1, p. 201-210, 2011.

MARTENS, M.L.; BRONES, F.; CARVALHO, M.M. Lacunas e tendências na literatura de sustentabilidade no gerenciamento de projetos: uma revisão sistemática mesclando bibliometria e análise de conteúdo. **Revista de Gestão e Projetos – GeP**. V.4, n.1, p. 165-195, 2013.

MENDOZA, J.R.; SABILLÓN, L.; MARTINEZ, W.; CAMPABADAL, C.; HALLEN-ADAMS, H.E.; BIANCHINI, A. Traditional maize post-harvest management practices amongst smallholder farmers in Guatemala. **Journal of Stored Products Research**. V. 71, p. 14-21, 2017.

MILGROOM, J.; GILLER, K.E. Courting the rain: Rethinking seasonality and adaptation to recurrent drought in semi-arid southern Africa. **Agricultural Systems.** V. 118, p. 91-104, 2013.

MLAMBO, S.; MVUMI, B. M.; STATHERS, T.; MUBAYIWA, M.; NYABAKO, T Field efficacy of hermetic and other maize grain storage options under smallholder farmer management. **Crop Protection.** V. 98, p. 198-210, 2017.

MONDA, E.O.; ALAKONYA, A.E. A review of agricultural aflatoxin management strategies and emerging innovations in sub-Saharan Africa. **African Journal of Food, Agriculture, Nutrition and Development.** V. 16, n. 3, p. 11126-11138, 2016.

MWANGIAB, J.K.; MUTUNGIAB, C.M.; MIDINGOYIA, S.G.; FARAJB, A.K.; AFFOGNONC, H.D. An assessment of the magnitudes and factors associated with postharvest losses in off-farm grain stores in Kenya. **Journal of Stored Products Research**. V. 73, p. 7-20, 2017.

MWEBAZE, P.; MUGISHA, J. Adoption, utilisation and economic impacts of improved post-harvest technologies in maize production in Kapchorwa District, Uganda. International **Journal of Postharvest Technology and Innovation**. V. 2, n. 3, p. 301-327, 2011.

NASCIMENTO, J.W.B.; LOPES NETO, J.P.; LOPES, F.F.M.; MACIEL, K.R.D.; SILVA, V.R. Blocos de concreto para construção modular de silos cilíndricos. **Revista Brasileira de Engenharia Agrícola e Ambiental.** V. 13, p. 991-998, 2009.

NASCIMENTO, V.R.G.; QUEIROZ, M.R. Estratégias de aeração de milho armazenado: temperatura e teor de água. **Engenharia Agrícola**. V. 31, n. 4, p. 745-759, 2011.

NHAMUCHO, E.; MUGO, S.; GOHOLE, L.; TEFERA, T.; KINYUA, M.; MULIMA, E. Control of the larger grain borer prostephanus truncatus (horn) (Coleoptera: Bostrichidae) in different maize seed and grain storage methods. **Journal of Entomology**. V. 14, n. 4, p. 136-147, 2017.

NOUHOHEFLIN, T.; COULIBALY, J.Y.; D'ALESSANDRO, S.; AITCHEDJI, C.C.; DAMISA, M.; BARIBUTSA, D.; LOWENBERG-DEBOER, J. Management lessons learned in supply chain development: the experience of PICS bags in West and Central Africa. **International Food and Agribusiness Management Review.** V. 20, n. 3, p. 427-438, 2017.

NOURBAKHSH, S.M.; BAI, Y.; MAIA, G.D.N.; OUYANG, Y.F.; RODRIGUEZ, L. Grain supply chain network design and logistics planning for reducing post-harvest loss. **Biosystems Engineering.** V. 151, p. 105-115, 2016.

NTONIFOR, N.N., FORBANKA, D.N., MBUH, J.V. Potency of Chenopodium ambrosioides powders and its combinations with wood ash on Sitophilus zeamais in stored maize. **Journal of Entomology**. V. 8, n. 4, p. 375-383, 2011.

ODUM, E. Ecology and our endangered life-support systems. **Sinauer Associates Inc. Mass**. ISBN 0-87893-635-1. P. 283, 1989.

ORTIZ, D.; ROCHEFORD, T.; FERRUZZI, M.G. Influence of Temperature and Humidity on the Stability of Carotenoids in Biofortified Maize (Zea mays L.) Genotypes during Controlled Postharvest Storage. **Journal of Agricultural and Food Chemistry**. V. 64, n.13, p. 2727-2736, 2016.

OTHIRA, J.O.; ONEK, L.A.; DENG, L.A.; OMOLO, E.O. Insecticidal potency of Hyptis spicigera preparations against Sitophilus zeamais (l.) and Tribolium castaneum (herbst) on stored maize grains. **African Journal of Agricultural Research**. V. 4, n. 3, p. 187-192, 2009.

PARMAR, M.J.; JAIN, B.K. Indigenous storage practices and related traditional knowledge – a case study from Gujarat (India). **International Journal of Pharma and Bio Sciences**. V. 7, n. 4, p. B485-B489, 2016.

QUIRINO, J.R.; MELO, A.P.C.; VELOSO, V.R.S.; ALBERNAZ, K.C.; PEREIRA, J.M. Resfriamento artificial na conservação da qualidade comercial de grãos de milho armazenados. **Bragantia.** V. 72, n.4, p. 378-386, 2013.

RANI, P.U., DEVANAND, P. Efficiency of different plant foliar extracts on grain protection and seed germination in maize. **Research Journal of Seed Science**. V. 4, n. 1, p. 1-14, 2011.

SAHU, G.; SHRIVASTAVA, K.K.; CHATURVEDI, B.K. Adoption of storage practices of food grains among the farmers of northern hills of Chhattisgarh, India. **Plant Archives**. V. 15, n. 2, p. 813-815, 2015.

SANTOS, S.B.; MARTINS, M.A.; FARONI, L.R.D.; BRITO JUNIOR, V.R. Perda de matéria seca em grãos de milho armazenados em bolsas herméticas. **Revista Ciência Agronômica.** V. 43, n.4, p. 674-682, 2012.

SHAO, Q.; XU, T.; TATSUO, Y.; SONG, N., ZHU, H. Design and experiment for grain storage monitoring system based on 3-D laser scanning technology. **Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering.** V. 31, n. 20, p. 262-267, 2015.

SILVA NETO, W.A.; ARRUDA, P.N.; BASTOS, A.C. O Déficit na Capacidade Estática de Armazenagem de Grãos no Estado de Goiás. **Gestão & Regionalidade.** V. 32, n. 96, p. 151-169, 2016.

SONG, J.; LIU, C.; LI, D.; GU, Z.; Postharvest changes in physicochemical characteristics and free amino acids content of immature vegetable soya bean (Glycine max L.) grains. **International Journal of Food Science and Technology**. V. 51, n. 2, p. 461-469, 2016.

STATHERS, T.E.; RIWA, W.; MVUMI, B.M.; MOSHA, R.; KITANDU, L.; MNGARA, K.; KAONEKA, B.; MORRIS, M.; Do diatomaceous earths have potential as grain protectants for small-holder farmers in sub-Saharan Africa? The case of Tanzania. **Crop Protection.** V. 27, n. 1, p. 44-70, 2008.

STRUECKER, D. R.; HOFFMANN, M. G. Participação social nos serviços públicos: caracterização do estado da arte por meio da bibliometria e da revisão sistemática. **REGE – Revista de Gestão**. V.24, p. 371-380, 2017.

SU, L.; ADAM, B.D.; LUSK, J.L.; ARTHUR, F. Anchoring, information, and fragility of choice experiments: Na application to consumer willingness to pay for rice with improved storage management. **Journal of Agricultural and Resource Economics**. V. 42, p. 255-274, 2017.

SUJEETHA, J.A.R.P.; KAVITHA ABIRAMI, C.V.; ALAGUSUNDARAM, K. Biointensive safe storage methods for pulses: Review. **Journal of Biopesticides**. V. 7, n. 1, p. 98-103, 2014.

TEZA, P.; MIGUEZ, V.B.; FERNANDES, R.F.; DANDOLINI, G.A.; SOUZA, J.A. Ideias para a inovação: um mapeamento sistemático da literatura. **Gestão e Produção**. V. 23, n.1, p. 60-83, 2016.

USDA – U.S. **DEPARTMENT OF AGRICULTURE**. Disponível em: https://www.usda.gov. Acesso em janeiro de 2019.

WANG, J.; LIU, Z.; YAN, C. Comparative analysis of economic efficiency of grain storage by solar absorption refrigeration. Advances in Information **Science and Service Sciences**. V. 4, n. 14, p. 342-348, 2012.

WANG, G., ZHANG, D., LI, B., SUN, Y. Present situation and prospects of storage pests based on vision inspection technology. **Journal of the Chinese Cereals and Oils Association.** V. 29, n. 4, p. 124-128, 2014.

WARD, J.K.; DAVIS, J.D. A system to assess grain bag storage internal environment. **Transactions of the ASABE.** V. 56, n. 4, p. 1503-1509, 2013.

WILLIAMS, S.B.; MURDOCK, L.L.; BARIBUTSA, D. Safe storage of maize in alternative hermetic containers. **Journal of Stored Products Research.** V. 71, p. 125-129, 2017.

WU, W.; GUO, H.; XU, Y.; ZHANG, Y.; CHEN, S.; SHEN, J.; LIU, Q.; SHI, Y.; Ecological regionalization of grain storage in Jilin based on water and heat balance model of grain. **Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering.** V. 30, n. 21, p. 286-292, 2014.

XIU, F.; ZHANG, Y.; WANG, S.; LI, B.; JIANG, W.; Temperature characteristic and inhibition effect on insect pest in grain storehouse based on heat pipe technology. **Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering**. V. 29, n. 14, p. 256-261, 2013.

YANG, X.; SI, W.; LI, X.; LI, S.; WANG, Y. Basic research status of food storage and preservation in China – based on the analysis of applied and approved NSFC – funded projects. **Journal of Chinese Institute of Food Science and Technology.** V. 16, n. 3, p. 1-12, 2016.

YUSUF, B.L.; HE, Y. Design, development and techniques for controlling grains post-harvest losses with metal silo for small and medium scale farmers African. **Journal of Biotechnology.** V. 10, n. 65, p. 14552-14561, 2011.

ZHAI, H.; ZHANG, S.; HUANG, S.; CAI, J. Prevention of toxigenic fungal growth in stored grains by carbon dioxide detection. Food Additives and Contaminants. **Part A Chemistry, Analysis, Control, Exposure and Risk Assessment.** V. 32, n. 4, p. 596-603, 2015.

ZHANG, H.; MAO, H. Comparison of four methods for deciding objective weights of features for classifying stored-grain insects based on extension theory. **Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering.** V. 25, n. 1, p. 132-136, 2009.

ZHANG, D.; YANG, T.; FU, H.; FAN, C. An online detection modelo of granary storage quantity. **Zidonghua Xuaeba/Acta Automatica Sinica**. V. 40, n. 10, p. 2213-2220, 2014.

ZHANG, Y.; CAI, J.; JIANG, P.; HUANG, S.; Research and application progress on monitoring stored grain security by gas analyzing. J**ournal of the Chinese Cereals and Oils Association**. V. 29, n. 10, p. 122-128, 2014a.

______; XIU, F.; LI, X.; WANG, S.; Research on cooling methods for heat pipe-based grain storehouse in Summer. **Journal of the Chinese Cereals and Oils Association**. V. 29, n. 5, p. 106-124, 2014b.

ŽITŇÁK, M.; KOLLÁROVÁ, K.; MACÁK, M.; PRÍSTAVKOVÁ, M.; BOŠANSKÝ, M. Assessment of risks in the field of safety, quality and environment in post-harvest line. **Research in Agricultural Engineering**. V. 61, p. S26-S36, 2015.

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1) concepção e planejamento.	X	X		
2) análise e interpretação dos dados.	X	X		
3) elaboração do rascunho ou na revisão crítica do conteúdo.	X	X	X	X
4) participação na aprovação da versão final do manuscrito.	X	X	X	X