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Research Trends on Food Preservation: A Scientometric Analysis

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ABSTRACT

The present study is aimed at analysing the global publication trends on food preservation using Scopus database for the period 1998-2012. The database contained 17511 publications on food preservation. The study analysed the broad features of literature on food preservation focusing on year-wise distribution of publications, highly productive countries, international collaboration, activity index, highly productive institutes, methods of food preservation, preservation by food types, and channels of communication.

Keywords: Food preservation, scientometric analysis, institutional productivity

1. INTRODUCTION

To ensure food and nutrition security of more than nine billion people is a daunting task for the entire world. To feed humanity, it requires increased production of grains, pulses, oilseeds, vegetables, fruits, milk, poultry, fish, meat, etc. Preservation of food is equally important to deal with the increased production as both animal and plant products are exposed to decomposition through biochemical changes, decay, fermentation by microorganisms, and destruction by pests. It is believed that insects and pests destroy more grain in storage than is distributed. This calls for better storage and preservation facilities.

Food preservation is the process of treating and handling food to stop or slow down spoilage (loss of quality, edibility or nutritional value). Preservation usually involves preventing the growth of bacteria, yeast, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. Food preservation helps in: increasing the self-life of perishable foods; making the seasonal food available throughout the year; adding variety to the diet; saving time by reducing preparation time and energy, as the food has already been partially processed; stabilising prices of food, as there is less scope of shortage of supply to demand; decreasing wastage of food by preventing decay or spoilage of food; and improving the nutrition of the population. Preserved foods help people to bring avariety in the diet, thereby decreasing nutritional inadequacies. With the advent of research, many methods of food preservation such as physical, chemical, microbial, radiation, refrigeration, etc., have been developed. A lot of research is being carried out all over the world in this area.

Vijay[1] analysed the research publications of Indian food scientists and technologists and found that the degree of collaboration among food scientists and technologists was 0.91. Poornima[2], *et al.* analysed 1060 publications by Indian scientists published during 1998 to 2010 on food science and technology and studied relative growth rate, documents type, collaboration pattern, prolific authors, institutes, journals, and citations scores in the field. A study by Hemantha Kumar[3], *et al.* evaluated the initiatives taken by India in the field of agriculture and food sciences to make the intellectual output accessible for all by publishing them in open access journals and repositories. Salisbury[4], *et al.* analysed the publication and citation patterns of food science faculty at the University of Arkansas for a fourteen-year period (1990-2003). Alfaraz & Calvino[5] have analysed of the scientific production in the food science and technology field for the period 1991-2000 in Iberian-America (IA). Many such studies have been carried out in variuos fields[6,7].

2. OBJECTIVES

The main objective of the study is to update the information available on food preservation and present the growth of literature and make the quantitative assessment of food preservation research by way of analysing the following aspects of research output:

(i) Year-wise growth

(ii) Methods of food preservation

(ii) Preservation by food types

(iv) Highly productive countries

(v) International collaboration

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(vi) Activity index

(vii) Highly productive institutes

(viii) Channels of communication.

3. MATERIALS AND METHODS

Data was collected from the Scopus database (1998-2012). *SCOPUS* database is one of the very comprehensive bibliographic databases covering all aspects of science & technology. The search string 'FOOD PRESERV*' was given in the 'article title, abstract and keyword' field of the Scopus database to retrieve the data. A total of 17511 records were downloaded and analysed by using the spreadsheet application as per the objectives of the study.

4. RESULTS AND DISCUSSIONS

4.1 Year-wise Distribution of Publications and Citations

A total of 17511 publications were published during 1998-2012. The average number of publications per year was 1167.4. Figure 1 gives the year-wise growth of publications. There were only 459 publications in 1998 and a continuous growth of publications was observed during 1998-2012. The highest publications (2407) were in 2008. It was observed that there was a steady growth of publications during 1998-2012.

These publications have received 235166 citations during 1998-2012. The highest number of citations (25863) were in 2008. The average citations per year was 15678. The average citations per publication was 13.43. There is a declining trend of citations in food preservation research in the world during 2009-2012. It is well known that the older publications tend to receive more citations than recent publications as the publications require more time to be noticed by the researchers and to find the context to cite them.

4.2 Methods of Food Preservation

Figure 2 gives the distribution of publications according to methods of food preservation. The publications on food preservation were classified into seven broad categories available in the literature. Out of the total publications, 'microbial' method of food preservation accounted for the highest percentage (30 %) of publications, followed by 'chemical' with 27 % of publications.

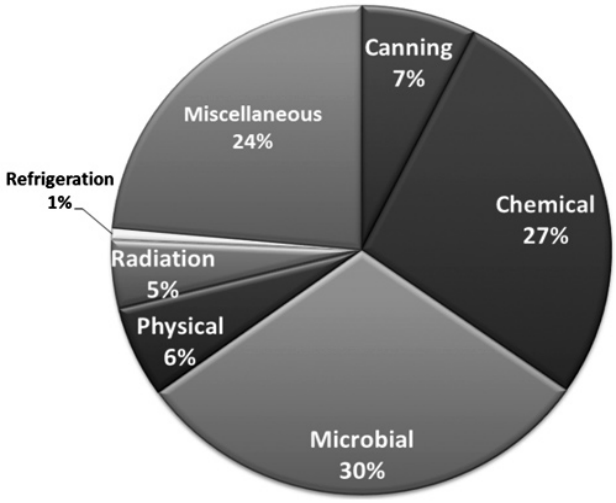

Figure 2. Distribution of publications according to methods of food preservation.

4.3 Preservation by Food Types

Figure 3 gives the distribution of publications on preservation of food by food types. The publications on preservation by food types were classified into eight broad categories available in the literature. Out of the total publications, 'meat' accounted for the highest percentage (20 %) of publications, followed by fruits' and 'oil seeds' with 18 % of publications each, 'dairy products' with 16 % of publications and 'sea food' and 'vegetables' each with 10 % of publications.

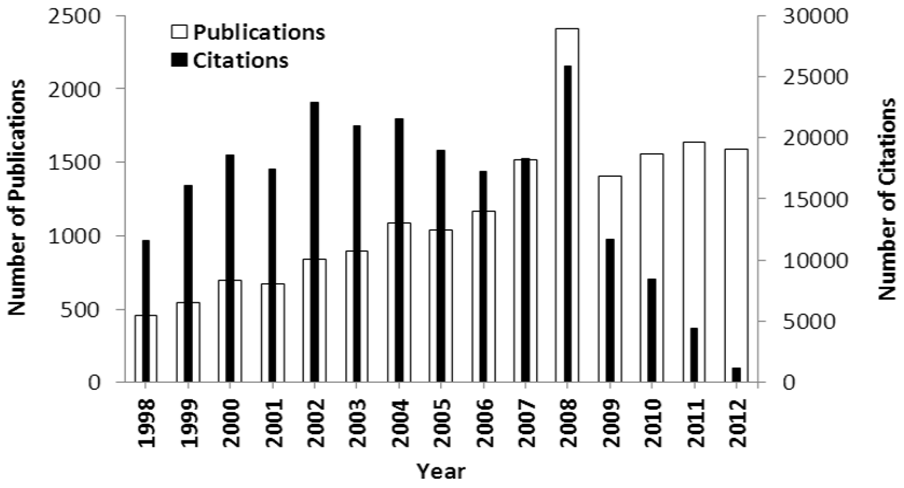

Figure 1. Year-wise growth of publications and citations on food preservation.

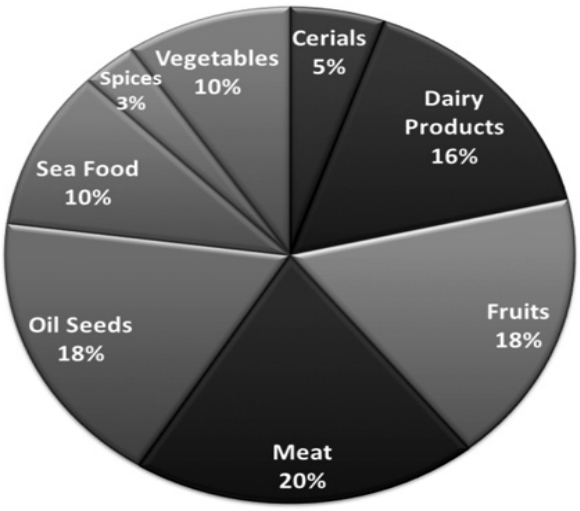

Figure 3. Distribution of publications according to type.

4.4 Highly Productive Countries

In all, there were 143 countries, who have publications in the field of food preservation. United States is the top producing country with 4110 publications followed by Spain with 1436 publications, China with 1131 publications and Italy with 1003 publications. Table 1 lists top countries (≥200 publications) actively pursuing research on food preservation.

4.5 International Collaboration

In all, there were 130 countries involved in international collaboration and produced 2784 (16.56 %) internationally collaborated papers. There were 13.4 % publications bilaterally collaborated. Table 2 gives international collaboration of top 20 countries with the number of collaborated publications among them.

Table 1. Country-wise distribution of publications on food preservation

Country	Publications															
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total (%)**
USA	135	130	170	188	209	250	299	285	267	369	577	309	320	297	305	**4110 (23.4 %)**
Spain	35	44	51	46	59	79	71	88	85	145	179	122	132	130	170	**1436 (8.2 %)**
China	14	24	21	17	12	35	50	39	63	101	212	92	136	155	160	**1131 (6.46 %)**
Italy	17	28	24	27	56	53	58	59	68	86	138	97	111	89	92	**1003 (5.73 %)**
England	38	43	52	35	79	56	64	58	65	89	121	56	54	60	63	**933 (5.33 %)**
France	28	33	45	40	42	36	51	59	64	72	117	63	64	65	71	**850 (4.85 %)**
Japan	26	22	38	36	43	39	56	42	57	75	113	60	61	63	49	**780 (4.45 %)**
India	14	14	20	24	29	36	56	36	52	62	113	40	68	102	92	**758 (4.33 %)**
Canada	14	22	37	29	37	33	41	38	56	66	112	67	41	65	69	**727 (4.15 %)**
Germany	29	31	20	38	36	37	49	38	55	55	112	53	63	54	54	**724 (4.13 %)**
Brazil	7	6	11	8	22	18	17	28	37	50	60	62	47	79	80	**532 (3.04 %)**
South Korea	4	6	5	10	18	18	15	15	19	39	88	48	50	49	46	**430 (2.46 %)**
Turkey	4	2	6	10	19	15	30	25	23	32	51	35	54	41	34	**381 (2.18 %)**
Belgium	7	12	12	9	8	23	22	29	29	40	48	39	31	29	27	**365 (2.08 %)**
Australia	12	6	9	11	16	16	16	17	25	38	52	37	42	35	29	**361 (2.06 %)**
Nether-lands	7	27	15	16	32	14	29	19	20	27	52	21	21	34	26	**360 (2.06 %)**
Denmark	11	17	19	11	13	15	26	16	20	17	34	18	19	18	19	**273 (1.56 %)**
Ireland	6	8	10	9	12	8	12	15	20	16	38	26	31	29	27	**267 (1.50 %)**
Greece	3	6	11	11	12	11	15	18	21	22	32	31	24	28	18	**263 (23.4 %)**
Argen-tina	5	5	7	11	17	12	14	18	10	25	26	25	29	25	32	**261 (1.49 %)**
Mexico	5	8	9	7	11	11	9	22	10	29	30	19	23	31	29	**253 (1.44 %)**
Poland	4	7	9	6	9	14	15	19	12	23	20	20	21	25	27	**231 (1.32 %)**
Switzer-land	4	6	10	11	9	10	13	10	16	16	32	22	17	18	31	**225 (1.28 %)**
Iran	2	0	0	0	0	1	7	5	5	21	24	25	36	38	58	**222 (1.27 %)**
Portugal	2	4	12	3	6	9	13	9	9	13	27	23	28	26	25	**209 (1.19 %)**
World	**459**	**544**	**693**	**673**	**842**	**899**	**1083**	**1042**	**1166**	**1520**	**2407**	**1406**	**1554**	**1638**	**1585**	**17511 (100%)**

Table 2. International collaboration of top 20 countries

Collaborating Country	Australia	Belgium	Brazil	Canada	China	Denmark	England	France	Germany	India	Ireland	Italy	Japan	Mexico	Netherlands	South Korea	Spain	Sweden	Switzerland	USA	Total
Australia	156	4	6	14	21	8	24	12	13	7	7	9	10	2	6	3	9	1	14	42	156
Belgium		142	0	7	2	9	15	11	19	1	4	11	2	1	26	0	16	2	11	14	142
Brazil			120	3	2	3	7	20	12	1	0	6	2	4	2	0	10	2	1	42	120
Canada				272	16	7	44	20	27	7	6	11	12	2	12	11	11	10	9	102	272
China					245	1	14	7	12	5	4	4	24	1	6	8	5	7	3	129	245
Denmark						102	25	10	18	1	4	13	4	1	16	2	9	13	10	17	102
England							410	33	49	5	36	33	11	10	41	2	40	14	22	92	410
France								307	23	5	6	32	9	4	25	3	33	7	17	56	307
Germany									290	10	11	23	7	3	24	4	23	16	34	64	290
India										85	0	7	11	2	3	6	3	1	3	24	85
Ireland											97	6	5	1	5	0	11	1	5	22	97
Italy												229	9	2	13	3	39	7	18	51	229
Japan													162	1	3	19	6	2	5	57	162
Mexico														110	0	2	24	0	1	45	110
Netherlands															160	1	14	6	9	31	160
South Korea																149	1	0	2	89	149
Spain																	357	8	6	73	357
Sweden																		97	11	19	97
Switzerland																			117	21	117
USA																				1029	1029

Table 3. Activity index for top 11 countries

Year	Activity index														
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Brazil	0.50	0.36	0.52	0.39	0.86	0.66	0.52	0.88	1.04	1.08	0.82	1.45	1.00	1.59	1.66
Canada	0.73	0.97	1.29	1.04	1.06	0.88	0.91	0.88	1.16	1.05	1.12	1.15	0.64	0.96	1.05
China	0.47	0.68	0.47	0.39	0.22	0.60	0.71	0.58	0.84	1.03	1.36	1.01	1.35	1.47	1.56
England	1.55	1.48	1.41	0.98	1.76	1.17	1.11	1.04	1.05	1.10	0.94	0.75	0.65	0.69	0.75
France	1.26	1.25	1.34	1.22	1.03	0.82	0.97	1.17	1.13	0.98	1.00	0.92	0.85	0.82	0.92
Germany	1.53	1.38	0.70	1.37	1.03	1.00	1.09	0.88	1.14	0.88	1.13	0.91	0.98	0.80	0.82
India	0.70	0.59	0.67	0.82	0.80	0.93	1.19	0.80	1.03	0.94	1.08	0.66	1.01	1.44	1.34
Italy	0.65	0.90	0.60	0.70	1.16	1.03	0.93	0.99	1.02	0.99	1.00	1.20	1.25	0.95	1.01
Japan	1.27	0.91	1.23	1.20	1.15	0.97	1.16	0.90	1.10	1.11	1.05	0.96	0.88	0.86	0.69
Spain	0.93	0.99	0.90	0.83	0.85	1.07	0.80	1.03	0.89	1.16	0.91	1.06	1.04	0.97	1.31
USA	1.25	1.02	1.05	1.19	1.06	1.18	1.18	1.17	0.98	1.03	1.02	0.94	0.88	0.77	0.82

4.6 Activity Index

Activity index[8] of top 11 countries which have ≥500 publications each is given in Table 3. England had the highest activity index 1.76 in 2002 and 1.55 in 1998 followed by Brazil with 1.66 in 2012 and 1.59 in 2011.

4.7 Highly Productive Institutes

Table 4 shows the institutes that have contributed 50 or more publications on food preservation during 1998-2012. Spanish National Research Council (CSIC) (Spain) topped the list with 294 publications followed by University of California (USA) with 217 publications

Table 4. Highly productive institutes with publications on food preservation

S. No.	Institute	Country	Publications
1.	Spanish National Research Council (CSIC)	Spain	294
2.	University of California	USA	217
3.	USDA Agricultural Research Service	USA	216
4.	French National Institute for Agricultural Research (INRA)	France	198
5.	USDA Eastern Regional Research Centre	USA	131
6.	University of Georgia	USA	129
7.	Washington State University	USA	125
8.	Ghent University	Belgium	108
9.	Cornell University	USA	108
10.	University of Sao Paulo	Brazil	103
11.	Ohio State University	USA	102
12.	Catholic University of Leuven (KU Leuven)	Belgium	95
13.	University of Campinas	Brazil	95
14.	National Scientific and Technical Research Council (CONICET)	Argentina	93
15.	University of Lleida	Spain	92
16.	University of Wisconsin	USA	90
17.	University of Florida	USA	87
18.	Technical University of Denmark	Denmark	86
19.	University of Zaragoza	Spain	84
20.	University College Cork	Ireland	83
21.	Texas A and M University	USA	82
22.	Central Food Technological Research Institute, Mysore	India	79
23.	National Research Council (CNR)	Italy	79
24.	University of Illinois	USA	76
25.	University of Helsinki	Finland	75
26.	Agricultural University of Athens	Greece	75
27.	North Carolina State University	USA	75
28.	Institute for Food Research and Technology (IRTA)	Spain	74
29.	Wageningen University	Netherlands	73
30.	Iowa State University	USA	73
31.	University of Bologna	Italy	69
32.	University of Foggia	Italy	69
33.	Polytechnic University of Valencia	Spain	68
34.	University of Massachusetts	USA	68
35.	University of Copenhagen	Denmark	65
36.	University of Guelph	Canada	63
37.	National Centre for Scientific Research (CNRS)	France	60
38.	University of Minnesota	USA	60
39.	University of Alberta	Canada	59
40.	University College Dublin	Ireland	59
41.	National Food Research Institute	Japan	58
42.	Nanjing Agricultural University	China	57
43.	Zhejiang University	China	57
44.	Technical University Munich	Germany	57
45.	Pennsylvania State University	USA	57

Cont..

46.	Royal Veterinary and Agricultural University	USA	57
47.	Colorado State University	Denmark	56
48.	Oregon State University	USA	56
49.	University of Nebraska	USA	56
50.	China Agricultural University	USA	56
51.	Technical University of Berlin	China	54
52.	Institute of Food Research	Germany	54
53.	University of Maryland	UK	54
54.	Islamic Azad University	USA	54
55.	Purdue University	Iran	53
56.	University of Tennessee	USA	53
57.	University of Granada	USA	53
58.	Louisiana State University	Spain	52
59.	Michigan State University	USA	51
60.	University of Buenos Aires	USA	51
61.	University of Manitoba	Argentina	50
62.	University of Manitoba	Canada	50

and USDA Agricultural Research Service (USA) with 216 publications.

4.8 Channels of Communication

The journal articles (79 %) were the most preferred channels for scholarly communication, followed by review articles (10 %), conference papers (8 %), and miscellaneous publications (3 %).

The publications on food preservation were spread over 3704 journals. The leading journals preferred by the scientists are: *Journal of Food Protection* with 902 publications followed by *Journal of Agricultural and Food Chemistry* with 813 publications, *International Journal of Food Microbiology* with 771 publications, and *Journal of Food Science* with 636 publications. Table 5 gives the list of journals with more than 40 publications.

5. CONCLUSIONS

The present study attempted to highlight the growth and development of research publication on food preservation. A total of 17511 publications were

Table 5. Journals with number of publications on food preservation

S. No.	Journals	Publications	IF 2012
1.	*Journal of Food Protection*	902	1.832
2.	*Journal of Agricultural and Food Chemistry*	813	2.906
3.	*International Journal of Food Microbiology*	771	3.425
4.	*Journal of Food Science*	636	1.775
5.	*Food Microbiology*	283	3.407
6.	*Journal of Food Engineering*	276	2.276
7.	*Food Chemistry*	264	3.334
8.	*Journal of Applied Microbiology*	255	2.196
9.	*Meat Science*	209	2.754
10.	*Journal of the Science of Food and Agriculture*	182	-
11.	*Journal of Dairy Science*	174	2.566
12.	*Food Science and Technology*	159	-
13.	*Journal of Food Science and Technology*	156	-
14.	*Applied and Environmental Microbiology*	154	3.678
15.	*International Journal of Food Science and Technology*	144	1.240
16.	*Innovative Food Science and Emerging Technologies*	141	2.528
17.	*Letters in Applied Microbiology*	99	1.629

Cont...

18.	*Food Additives and Contaminants*	93	-
19.	*European Food Research and Technology*	91	1.436
20.	*Food and Chemical Toxicology*	91	3.010
21.	*Radiation Physics and Chemistry*	86	1.375
22.	*Trends in Food Science and Technology*	82	4.135
23.	*Food Control*	79	2.738
24.	*Food Research International*	77	3.005
25.	*Food Science and Technology International*	76	0.907
26.	*Poultry Science*	76	1.516
27.	*Critical Reviews in Food Science and Nutrition*	75	-
28.	*Food Technology*	73	-
29.	*International Journal of Food Sciences and Nutrition*	72	1.257
30.	*Proceedings of SPIE - The International Society for Optical Engineering*	71	-
31.	*ActaHorticulturae*	65	-
32.	*Journal of Food Processing and Preservation*	64	0.450
33.	*African Journal of Biotechnology*	63	-
34.	*Journal of Chromatography - A*	59	4.612
35.	*Communications in Agricultural and Applied Biological Sciences*	53	-
36.	*Journal of AOAC International*	53	1.233
37.	*IndustrieAlimentari*	52	-
38.	*Lecture Notes in Computer Science*	51	-
39.	*ArchivosLatinoamericanos de Nutricion*	50	0.241
40.	*Packaging Technology and Science*	50	0.737
41.	*Pakistan Journal of Nutrition*	49	-
42.	*Drying Technology*	48	1.814
43.	*Food Additives and Contaminants - A*	47	2.220
44.	*Foodborne Pathogens and Disease*	47	-
45.	*Die Nahrung*	44	-
46.	*Journal of Archaeological Science*	44	1.889
47.	*Applied Microbiology and Biotechnology*	40	3.689
48.	*PLoS ONE*	40	3.730

published during 1998-2012. The average number of publications per year was 1167.4. There was a steady growth of publications during 1998-2012.

Out of the total publications, 'microbial' method of food preservation accounted for the highest percentage (30 %) of publications, followed by 'chemical' with 27 % of publications. Out of the total publications, 'meat' food type accounted for the highest percentage (20 %) of publications, followed by fruits' and 'oil seeds' with 18 % of publications each.

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