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# Mapping of Tapioca (Sago) Research in India: A Scientometric Analysis

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## Introduction

Sago research is analyzed and compared with number of document, journals, and international collaboration from 1973 to 2010. Using HistCite, the visualization technique developed by Garfield and colleagues, the historiographs for India based on both local citation scores (LCS) and global citation scores have been constructed, and the key papers have been identified.

Scientometry is the study of the evolution of science through some quantitative measures of scientific information such as the number of scientific articles published in a given period of time and their citation impact.

Scientometric research publications are a quantitative measure for the basic research activity in a country. Many scientometric studies have appeared in the literature focusing on the performance of science in the field of Sago.

## Objective

The main objective of this study is to analyze the research performance of India in Tapioca in the national and global context, as reflected in the publications's output during 1997-2010. In particular, the study focused on:

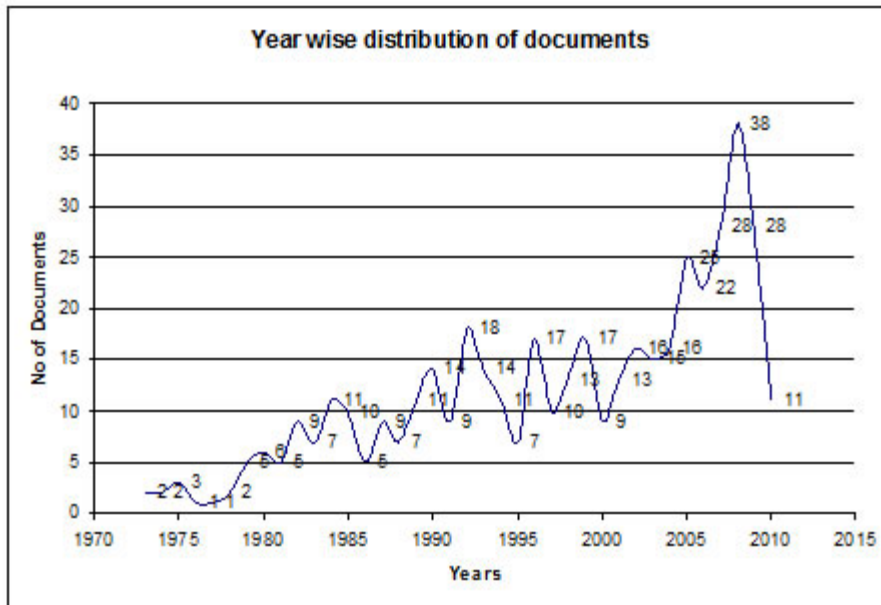
1. Indian research out, its growth, and global publications' share and impact.
2. The Patterns of International and major collaborative partners.
3. The Publications' productivity and impact of leading institutions of India.
4. The characteristics of the most prolific authors and high-cited papers and
5. The patterns of research communication in the most productivity journals.

## Methodology

Data was collected from the Science Citation Index (SCI) which is available via the Web of Science (WoS). The WoS is a search platform provided by Thomson Reuters (the former Thomson Scientific emerged from the Institute for Scientific Information (ISI) in Philadelphia). SCI database is one of the very comprehensive databases covering all aspects of science. The study period (1973-May2010) selected as the database is available in machine from 1973. The search string "Sago" in the "Basic search" field of SCI was used during 1973-2010 to download the records on the subjects of Sago. A total of 447 records were downloaded and analyzed by using the Histcite software application as per the objectives of the study.

## Results and Discussion

Chart 1 - Year wise distribution of documents



During 1973 – 2010, a total of 447 papers were published on sago by India. The average number of publications produced per year was 11.76%. The highest number of publications produced was 38 in 2008. Chart 1 gives the year wise growth and collaboration rate in Sago. It can be clearly visualized from the Chart 1 that growth of the literature was very low during 1975 - 1976 and it peaked in 2007, 2008 and 2009. It indicates that research in sago received a major impetus during this period

Table 1: Top 20 most productive Journals with respect to the number of articles dealing with Sago, Source: SCI (WoS)

S. No	Journal	Recs	TLCS	TGCS
1	Starch-Starke	40	43	293
2	Current Science	20	8	52
3	Journal of food science and technology-mysore	18	11	20
4	Indian journal of agricultural sciences	13	2	24
5	Journal of the science of food and agriculture	13	34	99

6	Applied biochemistry and biotechnology	9	10	42
7	Process biochemistry	9	37	450
8	World journal of microbiology & biotechnology	9	6	54
9	Annals of applied biology	8	18	209
10	Bio resource technology	6	15	88
11	Journal of environmental biology	6	4	12
12	Journal of scientific & industrial research	6	7	12
13	Starke	6	17	53
14	Archives of virology	5	9	40
15	Biotechnology letters	5	17	58
16	Indian journal of virology	5	0	0
17	Journal of agricultural and food chemistry	5	11	50
18	Journal of applied polymer science	5	3	37
19	Tropical agriculture	5	0	7
20	Virology	5	15	183

The most productive Journal is starch-starke with 40 papers dealing with Sago and 8.94% of all papers were published in this Sago research field. The journal of the seminal publication on Sago given in table 1 is about current science and it is a Journal of food science and technology. Both the journals hold rank 2 (20 publication 4.47%) and 3 (18 Publication 4.02%), respectively.

Table 2 – Collaboration publication output (Top 25)

S. No	Country	Recs	TLCS	TGCS
1	India	437	375	2650
2	UK	23	49	450
3	Brazil	11	35	379
4	Germany	7	8	148
5	France	5	1	95

6	Nigeria	5	2	48
7	USA	5	4	117
8	Egypt	4	6	120
9	South Korea	4	0	8
10	Netherlands	3	1	41
11	Sweden	3	5	16
12	Australia	2	1	10
13	Pakistan	2	6	110
14	Switzerland	2	1	78
15	Canada	1	0	1
16	Cote Ivoire	1	0	9
17	Czech Republic	1	0	6
18	Japan	1	1	9
19	Malagasy Republ	1	0	8
20	Malawi	1	1	14
21	Mexico	1	0	70
22	Slovenia	1	0	3
23	Sri Lanka	1	8	63
24	Thailand	1	0	0
25	Uganda	1	0	6

The Extent of International collaboration as seen from co-authored is presented in Table 2. India has collaborated often with UK and Brazil with 23 and 11 papers. Other countries less than 10 research papers collaborated with India.

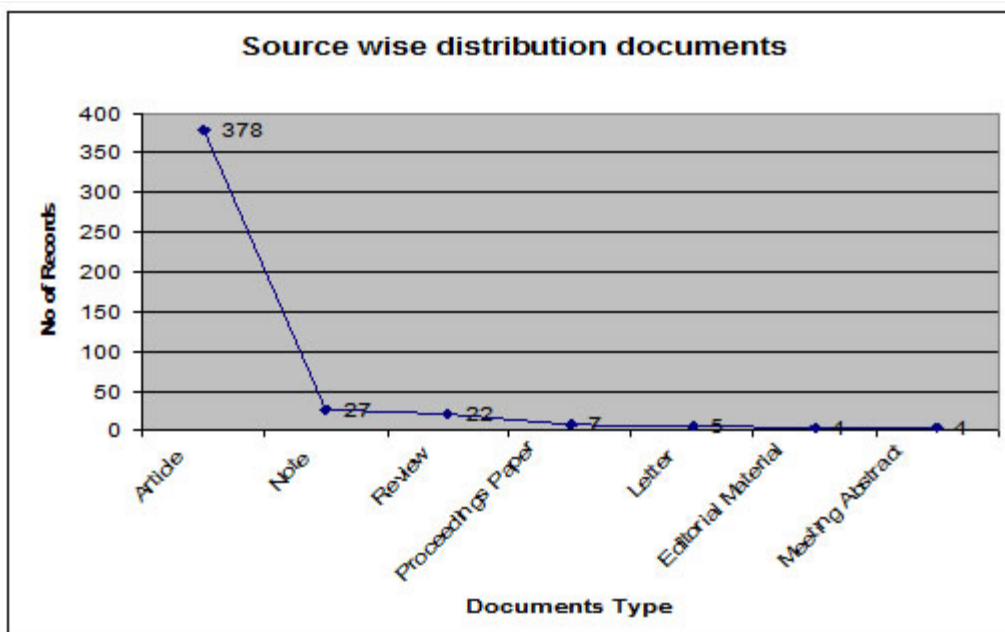
Table 3: Top 20 most productive authors with respect to the number of article dealing with Sago: SCI (WoS)

S.No	Author	Reccs	TLCS	TGCS

1	Moorthy SN	38	52	275
2	Pandey A	22	66	533
3	Ray RC	20	26	51
4	Raja KCM	18	25	59
5	Lonsane BK	15	36	149
6	Jyothi AN	13	12	63
7	Nambisan B	13	31	127
8	Padmaja G	12	35	99
9	Ramnujam T	12	8	52
10	Ghildyal NP	11	26	124
11	Nampoothiri KM	11	31	84
12	Soccol CR	11	35	379
13	Abraham TE	10	9	65
14	Balagopalan C	10	10	45
15	Kar S	10	17	37
16	Muniyappa V	9	15	136
17	Ramakrishna SV	9	13	40
18	John RP	8	25	69
19	Jos JS	8	5	19
20	Sajeev MS	8	5	18

The most productive author is Moorthy SN with 38 papers dealing with Sago and 8.50% of all papers was published in this research field. Among the authors of the seminal publication on Sago given in Table 3, Pandey A and Ray RC appear on rank 2 (22 papers) and 3 (20 papers), respectively.

Chart 2 - Source wise distribution documents



Sago Scientists communicated their research results through a variety of communication channels. Chart-2 provides the distribution of publications in various channels of communication. It was observed that (378) 84.56 percent of the article was published in Article followed by (27)16.04 percent in Note, (22) 4.92 percent in Review, (7) 1.56 Percent in Proceeding paper, (5)1.11 percent in Letter, (4) 0.89 percent in Editorial Material and (4) 0.89 percent in Meeting abstract.

Table 4 - Institution wise documents distribution (First - 18 Documents)

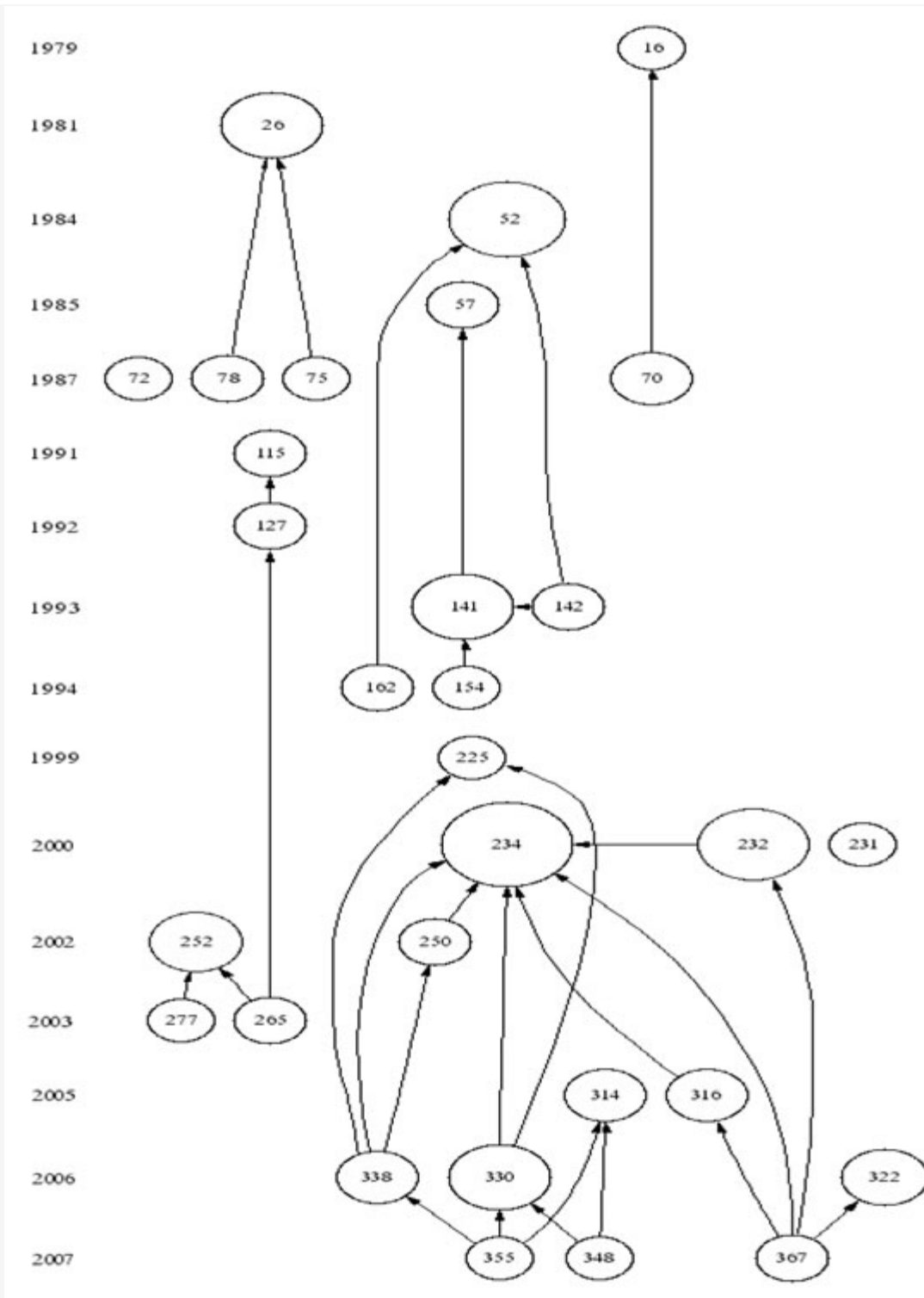
S. No	Institution	Recs	TLCS	TGCS
1	Central Tuber Crops Research Institute	74	99	487
2	CSIR	28	54	248
3	Central Food Technology Research Institute	22	44	158
4	University of Kerala	18	9	83
5	REG Research Laboratory	17	21	101
6	Indian Institute of Science	10	12	70
7	Indian Agriculture Research Institute	9	22	207
8	University Fed Parana	9	30	368
9	Tamil Nadu Agricultural University	8	3	22
10	University of Agriculture Science, Bangalore	7	13	110
11	Indian Institute of Technology	6	4	57

12	Madurai Kamaraj University	6	5	120
13	Indian Council of Agricultural Research	5	5	25
14	Institute Crops Research Inst Semi Arid Trop	5	2	52
15	MAHYCO Research Foundation	5	2	48
16	University Delhi	5	6	35
17	University Ibadan	5	2	48
18	University Madras	5	5	17

There were 295 institutions involved in research activity in the field of Sago. Table-4 provides publication productivity of top 18 institutions. Central Tuber Crops Research Institute topped the list with 74 publications followed by CSIR with 28 publications, Central Food Technology Research Institute with 22 publications, University of Kerala with 18 publications, REG Research Laboratory with 17 publications, Indian Institute of Science with 10 publications.

Figure 1 Historiograph of Cassava research in India based on local citation scores





1.	16	ABRAHAM TE, 1979, J FOOD SCI TECHNOL-MYSORE, V16, P237	4	6
2.	26	KUNHI AAM, 1981, STARKE, V33, P275	9	12
3.	52	NAMBISAN B, 1984, J ASSN OFFIC ANAL CHEM, V67, P641	12	24
4.	57	MOORTHY SN, 1985, J AGR FOOD CHEM, V33, P1227	5	20
5.	70	RAJA KCM, 1987, J SCI FOOD AGR, V39, P59	6	9

6.	72	SRIKANTA S, 1987, STARCH, V39, P132	4	12
7.	75	SRIKANTA S, 1987, STARCH, V39, P234	4	7
8.	78	BUDIATMAN S, 1987, BIOTECHNOL LETT, V9, P597	5	13
9.	115	HARRISON BD, 1991, ANN APPL BIOL, V118, P299	5	37
10.	127	SWANSON MM, 1992, ANN APPL BIOL, V120, P425	5	25
11.	141	MOORTHY SN, 1993, J SCI FOOD AGR, V61, P443	9	14
12.	142	PADMAJA G, 1993, J SCI FOOD AGR, V63, P473	5	12
13.	154	PADMAJA G, 1994, J AGR FOOD CHEM, V42, P766	4	7
14.	162	NAMBISAN B, 1994, J SCI FOOD AGR, V66, P503	5	12
15.	225	Anuradha R, 1999, PROCESS BIOCHEM, V35, P367	4	39
16.	231	Sailaja RRN, 2000, J POLYMER MATERIALS, V17, P165	4	10
17.	232	Pandey A, 2000, PROCESS BIOCHEM, V35, P1153	11	247
18.	234	Pandey A, 2000, BIORESOURCE TECHNOL, V74, P81	15	78
19.	250	Woiciechowski AL, 2002, BRAZ ARCH BIOL TECHNOL, V45, P393	5	10
20.	252	Saunders K, 2002, VIROLOGY, V293, P63	8	63
21.	265	Varma A, 2003, ANN APPL BIOL, V142, P145	5	90
22.	277	Briddon RW, 2003, VIROLOGY, V312, P106	4	87
23.	314	Rojan PJ, 2005, BIOTECHNOL LETT, V27, P1685	6	15
24.	316	Jyothi AN, 2005, PROCESS BIOCHEM, V40, P3576	6	8
25.	322	Swain MR, 2006, POL J MICROBIOL, V55, P289	7	11
26.	330	John RP, 2006, PROCESS BIOCHEM, V41, P759	9	26
27.	338	John RP, 2006, APPL BIOCHEM BIOTECH, V134, P263	6	10
28.	348	John RP, 2007, J BASIC MICROB, V47, P25	4	9

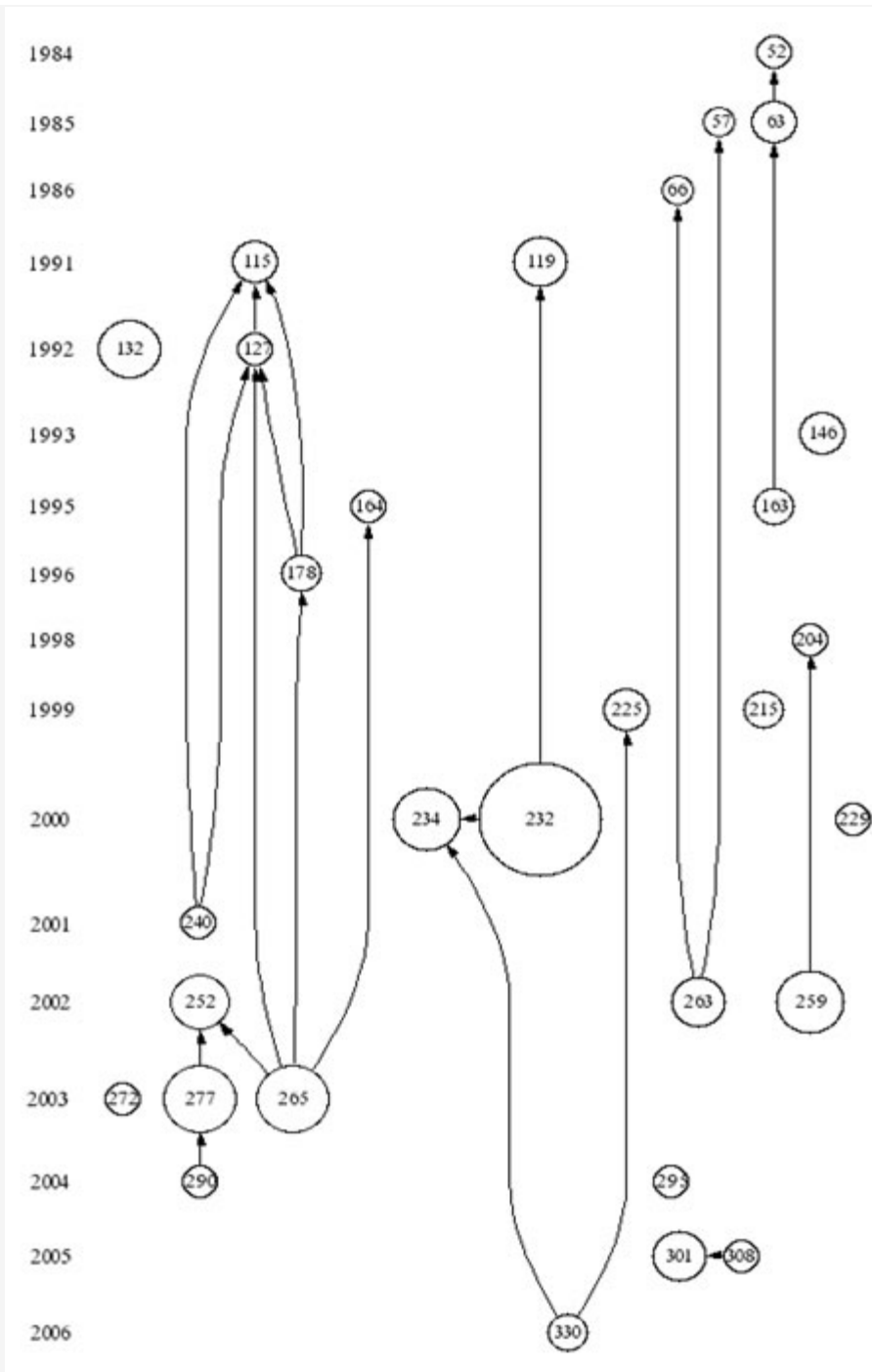
29.	355	John RP, 2007, LETT APPL MICROBIOL, V44, P582	4	9
30.	367	Swain MR, 2007, J BASIC MICROB, V47, P417	5	6

An attempt have been made to trace the evolution of cassava research in India by constructing historiographs using HistCite software (developed by Garfield and colleagues) in conjunction with *Web of Science*. All of India's 447cassavapapers have been considered. All the references quoted in these 447 papers have been included. All the papers that have cited these 447 papers as well as all the references quoted in those citing papers have been added. The resulting aggregate is called the Cassava India collection. The collection is exported to HistCite to obtain a large list of 9157 cited references along with their local and global citation scores (LCS and GCS).

The LCS for a paper denotes the number of times the paper is cited within the Cassava India collection, and the GCS denotes all citations to the paper (found in *Web of Science*). Thus, LCS will always be a subset of GCS. HistCite enables one to draw a citation network among highly cited papers from which one gets a feel for the evolution of the subject (or research front) over the years. What HistCite does is to reduce the clutter. In the huge population of papers and citations that constitute the Cassava India collection, one will not get anywhere if one tries to view all the citation links. By clever use of algorithms and networking tools, HistCite prunes many of the not so important links and leaves one with a manageable and compact scientograph.

Figure 1 is the historiograph of Cassava research in India based on the 30 most highly cited papers in the cassava India collection based on their LCS. It covers the period from 1970 to 2010. In this historiographs, the story begins with a paper by Abraham T E in Journl of food science technology published in 1979. In this paper no.16 (1979), ABRAHAM T E from Regional *Research Laboratory (CSIR)* in *Trivandrum* has studied the quality aspects of a few varieties of cassava. This paper has received 10 citations so far.

Figure: 2 Historiograph of Cassava research in India based on global citation scores



1.	52	NAMBISAN B, 1984, J ASSN OFFIC ANAL CHEM, V67, P641	12	24
2.	57	MOORTHY SN, 1985, J AGR FOOD CHEM, V33, P1227	5	20
3.	63	NAMBISAN B, 1985, J SCI FOOD AGR, V36, P1197	3	34
4.	66	MOORTHY SN, 1986, STARCH, V38, P58	3	19
5.	115	HARRISON BD, 1991, ANN APPL BIOL, V118, P299	5	37
6.	119	PANDEY A, 1991, PROCESS BIOCHEM, V26, P355	2	47

7.	127	SWANSON MM, 1992, ANN APPL BIOL, V120, P425	5	25
8.	132	LONSANE BK, 1992, PROCESS BIOCHEM, V27, P259	0	70
9.	146	ABRAHAM TE, 1993, STARCH, V45, P131	1	38
10.	163	PADMAJA G, 1995, CRIT REV FOOD SCI NUTR, V35, P299	2	26
11.	164	SRIVASTAVA KM, 1995, J VIROL METH, V51, P297	2	25
12.	178	Nateshan HM, 1996, ANN APPL BIOL, V128, P233	2	28
13.	204	Mohan V, 1998, DIABETES METAB REV, V14, P153	1	23
14.	215	Gawande BN, 1999, APPL MICROBIOL BIOTECHNOL, V51, P504	1	30
15.	225	Anuradha R, 1999, PROCESS BIOCHEM, V35, P367	4	39
16.	229	Singh V, 2000, CARBOHYD POLYM, V41, P191	3	24
17.	232	Pandey A, 2000, PROCESS BIOCHEM, V35, P1153	11	247
18.	234	Pandey A, 2000, BIORESOURCE TECHNOL, V74, P81	15	78
19.	240	Pant V, 2001, J GEN VIROL, V82, P2559	1	22
20.	252	Saunders K, 2002, VIROLOGY, V293, P63	8	63
21.	259	Bhatia E, 2002, GASTROENTEROLOGY, V123, P1020	2	78
22.	263	Moorthy SN, 2002, STARCH, V54, P559	2	54
23.	265	Varma A, 2003, ANN APPL BIOL, V142, P145	5	90
24.	272	Abdullahi I, 2003, BULL ENTOMOL RES, V93, P97	2	23
25.	277	Briddon RW, 2003, VIROLOGY, V312, P106	4	87
26.	<a href="#">290</a>	Briddon RW, 2004, VIROLOGY, V324, P462	2	23
27.	295	Hari B, 2004, AQUACULTURE, V241, P179	1	21
28.	301	Trinks D, 2005, J VIROL, V79, P2517	1	54
29.	308	Shivaprasad PV, 2005, J VIROL, V79, P8149	0	24

Figure 2 is a similar historiograph but based on the GCS. It includes period from 1970 to 2010. In this historiographs, the story begins with a paper by Nambisan B, J. Assoc. Off. Anal. Chem. published in 1984. In this paper no.52 (1984), ABRAHAM T E from Central Tuber Crops Research Institute (CTCRI) has studied spectro photometric determination of cyanoglucosides in cassava. This paper has received 36 citations so far.

## Conclusion

In this study, the literature on Sago, a promising new material, has been analyzed by scientometric methods. The time evolution of the overall number of citations reveals that the impact increase of the Sago papers is possibly going to outrun the impact increase of the related research fields on Sago.

The average number of publications produced per year was 11.76%. The highest number of publications produced in 2008 was 38. It can be clearly visualized from Table 1 that the growth of the literature was very low during 1975 and 1976 and it peaked during 2007, 2008 and 2009

The most productive author is Moorthy SN with 38 papers dealing with Sago and 8.50% of all the papers was published in this research field. In the top 20 most productive country wise research, India is the top producing country with 437 publications (97.76%), UK with 23 publications (5.14%), Brazil with 11 publications (2.46%), and Germany with 7 Publications (1.56%).

A research landscape has been established illustrating the major research clusters with regard to the clustering concept. The most productive Journal is starch-starke with 40 papers dealing with Sago and 8.94% of all the papers has been published in this Sago research field.

It has been observed that (378) 84.56 percent of the article has been published in Article followed by (27)16.04 percent in Note, (22) 4.92 percent in Review, (7) 1.56 Percent in Proceeding paper, (5)1.11 percent in Letter, (4) 0.89 percent in Editorial Material and (4) 0.89 percent in Meeting abstract.

Finally, the sago has contributed to English language with 447 (100%) publications. Among the top 18 most productive research Institutions, there are Central Tuber Crops Research Institute which has topped the list with 74 publications followed by CSIR with 28 publications and Central Food Technology Research Institute with 22 publications.

For India we have also identified the key researchers and institutions Using HistCite, the visualization technique developed by Garfield and colleagues, we have constructed the historiographs for India based on both local citation scores (LCS) and global citation scores, and identified key papers. We find that the sago research knowledge flow among different Institutions in India

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