Research Trends on Food Preservation: A Scientometric Analysis

Ganesh Surwase, Lalit Mohan, B.S. Kademani and K. Bhanumurthy

Scientific Information Resource Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400 085
E-mail: surwaseg@barc.gov.in, lalitm@barc.gov.in, bsk@barc.gov.in, aditya@barc.gov.in

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 variety 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.

Vijay1 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. Poornima2, 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 Kumar3, 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. Salisbury4, 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 & Calvino5 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 various fields6,7.

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
(iii) Preservation by food types
(iv) Highly productive countries
(v) International collaboration
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.

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.
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 collaborating publications among them.

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>135</td>
<td>130</td>
<td>170</td>
<td>188</td>
<td>209</td>
<td>250</td>
<td>299</td>
<td>285</td>
<td>267</td>
<td>369</td>
<td>577</td>
<td>309</td>
<td>320</td>
<td>297</td>
<td>305</td>
<td>4110 (23.4 %)</td>
</tr>
<tr>
<td>Spain</td>
<td>35</td>
<td>44</td>
<td>51</td>
<td>46</td>
<td>59</td>
<td>79</td>
<td>71</td>
<td>88</td>
<td>85</td>
<td>145</td>
<td>179</td>
<td>122</td>
<td>132</td>
<td>130</td>
<td>170</td>
<td>1436 (8.2 %)</td>
</tr>
<tr>
<td>China</td>
<td>14</td>
<td>24</td>
<td>21</td>
<td>17</td>
<td>12</td>
<td>35</td>
<td>50</td>
<td>39</td>
<td>63</td>
<td>101</td>
<td>212</td>
<td>92</td>
<td>136</td>
<td>155</td>
<td>160</td>
<td>1131 (6.46 %)</td>
</tr>
<tr>
<td>Italy</td>
<td>17</td>
<td>28</td>
<td>24</td>
<td>27</td>
<td>56</td>
<td>53</td>
<td>58</td>
<td>59</td>
<td>68</td>
<td>86</td>
<td>138</td>
<td>97</td>
<td>111</td>
<td>89</td>
<td>92</td>
<td>1003 (5.73 %)</td>
</tr>
<tr>
<td>England</td>
<td>38</td>
<td>43</td>
<td>52</td>
<td>35</td>
<td>79</td>
<td>56</td>
<td>64</td>
<td>58</td>
<td>65</td>
<td>89</td>
<td>121</td>
<td>56</td>
<td>54</td>
<td>60</td>
<td>63</td>
<td>933 (5.33 %)</td>
</tr>
<tr>
<td>France</td>
<td>28</td>
<td>33</td>
<td>45</td>
<td>40</td>
<td>42</td>
<td>36</td>
<td>51</td>
<td>59</td>
<td>64</td>
<td>72</td>
<td>117</td>
<td>63</td>
<td>64</td>
<td>65</td>
<td>71</td>
<td>850 (4.85 %)</td>
</tr>
<tr>
<td>Japan</td>
<td>26</td>
<td>22</td>
<td>38</td>
<td>36</td>
<td>43</td>
<td>39</td>
<td>56</td>
<td>42</td>
<td>57</td>
<td>75</td>
<td>113</td>
<td>60</td>
<td>61</td>
<td>63</td>
<td>49</td>
<td>780 (4.45 %)</td>
</tr>
<tr>
<td>India</td>
<td>14</td>
<td>14</td>
<td>20</td>
<td>24</td>
<td>29</td>
<td>36</td>
<td>56</td>
<td>36</td>
<td>52</td>
<td>62</td>
<td>113</td>
<td>40</td>
<td>68</td>
<td>102</td>
<td>92</td>
<td>758 (4.33 %)</td>
</tr>
<tr>
<td>Canada</td>
<td>14</td>
<td>22</td>
<td>37</td>
<td>29</td>
<td>37</td>
<td>33</td>
<td>41</td>
<td>38</td>
<td>56</td>
<td>66</td>
<td>112</td>
<td>67</td>
<td>41</td>
<td>65</td>
<td>69</td>
<td>727 (4.15 %)</td>
</tr>
<tr>
<td>Germany</td>
<td>29</td>
<td>31</td>
<td>20</td>
<td>38</td>
<td>36</td>
<td>37</td>
<td>49</td>
<td>38</td>
<td>55</td>
<td>55</td>
<td>112</td>
<td>53</td>
<td>63</td>
<td>54</td>
<td>54</td>
<td>724 (4.13 %)</td>
</tr>
<tr>
<td>Brazil</td>
<td>7</td>
<td>6</td>
<td>11</td>
<td>8</td>
<td>22</td>
<td>18</td>
<td>17</td>
<td>28</td>
<td>37</td>
<td>50</td>
<td>60</td>
<td>62</td>
<td>47</td>
<td>79</td>
<td>80</td>
<td>532 (3.04 %)</td>
</tr>
<tr>
<td>South Korea</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>18</td>
<td>18</td>
<td>15</td>
<td>15</td>
<td>19</td>
<td>39</td>
<td>88</td>
<td>48</td>
<td>50</td>
<td>49</td>
<td>46</td>
<td>430 (2.46 %)</td>
</tr>
<tr>
<td>Turkey</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>19</td>
<td>15</td>
<td>30</td>
<td>25</td>
<td>23</td>
<td>32</td>
<td>51</td>
<td>35</td>
<td>54</td>
<td>41</td>
<td>34</td>
<td>381 (2.18 %)</td>
</tr>
<tr>
<td>Belgium</td>
<td>7</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>8</td>
<td>23</td>
<td>22</td>
<td>29</td>
<td>29</td>
<td>40</td>
<td>48</td>
<td>39</td>
<td>31</td>
<td>29</td>
<td>27</td>
<td>365 (2.08 %)</td>
</tr>
<tr>
<td>Australia</td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>11</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>25</td>
<td>38</td>
<td>52</td>
<td>37</td>
<td>42</td>
<td>35</td>
<td>29</td>
<td>361 (2.06 %)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>7</td>
<td>27</td>
<td>15</td>
<td>16</td>
<td>32</td>
<td>14</td>
<td>29</td>
<td>19</td>
<td>20</td>
<td>27</td>
<td>52</td>
<td>21</td>
<td>21</td>
<td>34</td>
<td>26</td>
<td>360 (2.06 %)</td>
</tr>
<tr>
<td>Denmark</td>
<td>11</td>
<td>17</td>
<td>19</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>26</td>
<td>16</td>
<td>20</td>
<td>17</td>
<td>34</td>
<td>18</td>
<td>19</td>
<td>18</td>
<td>19</td>
<td>273 (1.56 %)</td>
</tr>
<tr>
<td>Ireland</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>12</td>
<td>18</td>
<td>12</td>
<td>15</td>
<td>20</td>
<td>16</td>
<td>38</td>
<td>26</td>
<td>31</td>
<td>29</td>
<td>27</td>
<td>267 (1.50 %)</td>
</tr>
<tr>
<td>Greece</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>11</td>
<td>15</td>
<td>18</td>
<td>21</td>
<td>22</td>
<td>32</td>
<td>31</td>
<td>24</td>
<td>28</td>
<td>18</td>
<td>263 (23.4 %)</td>
</tr>
<tr>
<td>Argentina</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>11</td>
<td>17</td>
<td>12</td>
<td>14</td>
<td>18</td>
<td>10</td>
<td>25</td>
<td>26</td>
<td>25</td>
<td>29</td>
<td>25</td>
<td>32</td>
<td>261 (1.49 %)</td>
</tr>
<tr>
<td>Mexico</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>22</td>
<td>10</td>
<td>29</td>
<td>30</td>
<td>19</td>
<td>23</td>
<td>31</td>
<td>29</td>
<td>253 (1.44 %)</td>
</tr>
<tr>
<td>Poland</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>14</td>
<td>15</td>
<td>19</td>
<td>12</td>
<td>23</td>
<td>20</td>
<td>20</td>
<td>21</td>
<td>25</td>
<td>27</td>
<td>231 (1.32 %)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>13</td>
<td>10</td>
<td>16</td>
<td>16</td>
<td>32</td>
<td>22</td>
<td>17</td>
<td>18</td>
<td>31</td>
<td>225 (1.28 %)</td>
</tr>
<tr>
<td>Iran</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>21</td>
<td>24</td>
<td>25</td>
<td>36</td>
<td>38</td>
<td>58</td>
<td>222 (1.27 %)</td>
</tr>
<tr>
<td>Portugal</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>13</td>
<td>9</td>
<td>13</td>
<td>27</td>
<td>23</td>
<td>28</td>
<td>26</td>
<td>25</td>
<td>209 (1.19 %)</td>
<td></td>
</tr>
<tr>
<td>World</td>
<td>459</td>
<td>544</td>
<td>693</td>
<td>673</td>
<td>842</td>
<td>899</td>
<td>1083</td>
<td>1042</td>
<td>1166</td>
<td>1520</td>
<td>2407</td>
<td>1406</td>
<td>1554</td>
<td>1638</td>
<td>1585</td>
<td>17511 (100%)</td>
</tr>
</tbody>
</table>
had the highest activity index 1.76 in 2002 and $\geq 500$ publications each is given in Table 3. England (Spain) topped the list with 294 publications followed by Brazil with 1.66 in 2012 and 1.59 in 2011.

### Table 3. Activity index for top 11 countries

<table>
<thead>
<tr>
<th>Year</th>
<th>Brazil</th>
<th>Canada</th>
<th>China</th>
<th>England</th>
<th>France</th>
<th>Germany</th>
<th>India</th>
<th>Japan</th>
<th>Mexico</th>
<th>Netherlands</th>
<th>South Korea</th>
<th>Spain</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>USA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>0.50</td>
<td>0.73</td>
<td>0.47</td>
<td>1.55</td>
<td>1.26</td>
<td>1.53</td>
<td>0.70</td>
<td>1.27</td>
<td>0.93</td>
<td>1.25</td>
<td>1.17</td>
<td>1.25</td>
<td>1.02</td>
<td>1.05</td>
<td>1.25</td>
<td>1029</td>
</tr>
<tr>
<td>1999</td>
<td>0.36</td>
<td>0.97</td>
<td>0.68</td>
<td>1.48</td>
<td>1.25</td>
<td>1.38</td>
<td>0.90</td>
<td>0.91</td>
<td>0.99</td>
<td>1.02</td>
<td>0.97</td>
<td>1.34</td>
<td>0.70</td>
<td>0.82</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.52</td>
<td>1.29</td>
<td>0.47</td>
<td>1.41</td>
<td>1.34</td>
<td>0.70</td>
<td>0.82</td>
<td>1.23</td>
<td>0.90</td>
<td>1.01</td>
<td>1.19</td>
<td>1.37</td>
<td>0.82</td>
<td>0.82</td>
<td>1.12</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>0.52</td>
<td>1.04</td>
<td>0.39</td>
<td>1.76</td>
<td>1.22</td>
<td>1.37</td>
<td>0.80</td>
<td>1.15</td>
<td>0.97</td>
<td>1.03</td>
<td>1.11</td>
<td>1.03</td>
<td>0.82</td>
<td>0.82</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>0.86</td>
<td>1.06</td>
<td>0.22</td>
<td>1.17</td>
<td>1.03</td>
<td>1.03</td>
<td>0.93</td>
<td>1.16</td>
<td>0.90</td>
<td>1.09</td>
<td>1.00</td>
<td>1.06</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>0.66</td>
<td>0.88</td>
<td>0.22</td>
<td>1.11</td>
<td>0.82</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.97</td>
<td>1.08</td>
<td>1.06</td>
<td>1.05</td>
<td>0.82</td>
<td>0.82</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>0.52</td>
<td>0.88</td>
<td>0.22</td>
<td>1.04</td>
<td>0.82</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>1.04</td>
<td>1.16</td>
<td>0.22</td>
<td>1.04</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1.08</td>
<td>1.03</td>
<td>0.39</td>
<td>1.17</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>0.82</td>
<td>1.09</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>1.45</td>
<td>0.90</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1.00</td>
<td>0.90</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>1.59</td>
<td>0.90</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>1.66</td>
<td>0.90</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1.66</td>
<td>0.90</td>
<td>0.22</td>
<td>1.11</td>
<td>1.03</td>
<td>1.00</td>
<td>0.90</td>
<td>1.10</td>
<td>0.90</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>0.82</td>
<td>0.82</td>
<td>1.44</td>
<td></td>
</tr>
</tbody>
</table>

### 4.6 Activity Index

Activity index of top 11 countries which have $\geq 500$ 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

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Institute</th>
<th>Country</th>
<th>Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spanish National Research Council (CSIC)</td>
<td>Spain</td>
<td>294</td>
</tr>
<tr>
<td>2.</td>
<td>University of California</td>
<td>USA</td>
<td>217</td>
</tr>
<tr>
<td>3.</td>
<td>USDA Agricultural Research Service</td>
<td>USA</td>
<td>216</td>
</tr>
<tr>
<td>4.</td>
<td>French National Institute for Agricultural Research (INRA)</td>
<td>France</td>
<td>198</td>
</tr>
<tr>
<td>5.</td>
<td>USDA Eastern Regional Research Centre</td>
<td>USA</td>
<td>131</td>
</tr>
<tr>
<td>6.</td>
<td>University of Georgia</td>
<td>USA</td>
<td>129</td>
</tr>
<tr>
<td>7.</td>
<td>Washington State University</td>
<td>USA</td>
<td>125</td>
</tr>
<tr>
<td>8.</td>
<td>Ghent University</td>
<td>Belgium</td>
<td>108</td>
</tr>
<tr>
<td>9.</td>
<td>Cornell University</td>
<td>USA</td>
<td>108</td>
</tr>
<tr>
<td>10.</td>
<td>University of Sao Paulo</td>
<td>Brazil</td>
<td>103</td>
</tr>
<tr>
<td>11.</td>
<td>Ohio State University</td>
<td>USA</td>
<td>102</td>
</tr>
<tr>
<td>12.</td>
<td>Catholic University of Leuven (KU Leuven)</td>
<td>Belgium</td>
<td>95</td>
</tr>
<tr>
<td>13.</td>
<td>University of Campinas</td>
<td>Brazil</td>
<td>95</td>
</tr>
<tr>
<td>14.</td>
<td>National Scientific and Technical Research Council (CONICET)</td>
<td>Argentina</td>
<td>93</td>
</tr>
<tr>
<td>15.</td>
<td>University of Lleida</td>
<td>Spain</td>
<td>92</td>
</tr>
<tr>
<td>16.</td>
<td>University of Wisconsin</td>
<td>USA</td>
<td>90</td>
</tr>
<tr>
<td>17.</td>
<td>University of Florida</td>
<td>USA</td>
<td>87</td>
</tr>
<tr>
<td>18.</td>
<td>Technical University of Denmark</td>
<td>Denmark</td>
<td>86</td>
</tr>
<tr>
<td>19.</td>
<td>University of Zaragoza</td>
<td>Spain</td>
<td>84</td>
</tr>
<tr>
<td>20.</td>
<td>University College Cork</td>
<td>Ireland</td>
<td>83</td>
</tr>
<tr>
<td>21.</td>
<td>Texas A and M University</td>
<td>USA</td>
<td>82</td>
</tr>
<tr>
<td>22.</td>
<td>Central Food Technological Research Institute, Mysore</td>
<td>India</td>
<td>79</td>
</tr>
<tr>
<td>23.</td>
<td>National Research Council (CNR)</td>
<td>Italy</td>
<td>79</td>
</tr>
<tr>
<td>24.</td>
<td>University of Illinois</td>
<td>USA</td>
<td>76</td>
</tr>
<tr>
<td>25.</td>
<td>University of Helsinki</td>
<td>Finland</td>
<td>75</td>
</tr>
<tr>
<td>26.</td>
<td>Agricultural University of Athens</td>
<td>Greece</td>
<td>75</td>
</tr>
<tr>
<td>27.</td>
<td>North Carolina State University</td>
<td>USA</td>
<td>75</td>
</tr>
<tr>
<td>28.</td>
<td>Institute for Food Research and Technology (IRTA)</td>
<td>Spain</td>
<td>74</td>
</tr>
<tr>
<td>29.</td>
<td>Wageningen University</td>
<td>Netherlands</td>
<td>73</td>
</tr>
<tr>
<td>30.</td>
<td>Iowa State University</td>
<td>USA</td>
<td>73</td>
</tr>
<tr>
<td>31.</td>
<td>University of Bologna</td>
<td>Italy</td>
<td>69</td>
</tr>
<tr>
<td>32.</td>
<td>University of Foggia</td>
<td>Italy</td>
<td>69</td>
</tr>
<tr>
<td>33.</td>
<td>Polytechnic University of Valencia</td>
<td>Spain</td>
<td>68</td>
</tr>
<tr>
<td>34.</td>
<td>University of Massachusetts</td>
<td>USA</td>
<td>68</td>
</tr>
<tr>
<td>35.</td>
<td>University of Copenhagen</td>
<td>Denmark</td>
<td>65</td>
</tr>
<tr>
<td>36.</td>
<td>University of Guelph</td>
<td>Canada</td>
<td>63</td>
</tr>
<tr>
<td>37.</td>
<td>National Centre for Scientific Research (CNRS)</td>
<td>France</td>
<td>60</td>
</tr>
<tr>
<td>38.</td>
<td>University of Minnesota</td>
<td>USA</td>
<td>60</td>
</tr>
<tr>
<td>39.</td>
<td>University of Alberta</td>
<td>Canada</td>
<td>59</td>
</tr>
<tr>
<td>40.</td>
<td>University College Dublin</td>
<td>Ireland</td>
<td>59</td>
</tr>
<tr>
<td>41.</td>
<td>National Food Research Institute</td>
<td>Japan</td>
<td>58</td>
</tr>
<tr>
<td>42.</td>
<td>Nanjing Agricultural University</td>
<td>China</td>
<td>57</td>
</tr>
<tr>
<td>43.</td>
<td>Zhejiang University</td>
<td>China</td>
<td>57</td>
</tr>
<tr>
<td>44.</td>
<td>Technical University Munich</td>
<td>Germany</td>
<td>57</td>
</tr>
<tr>
<td>45.</td>
<td>Pennsylvania State University</td>
<td>USA</td>
<td>57</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>S. No.</th>
<th>Journals</th>
<th>Publications</th>
<th>IF 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Journal of Food Protection</em></td>
<td>902</td>
<td>1.832</td>
</tr>
<tr>
<td>2.</td>
<td><em>Journal of Agricultural and Food Chemistry</em></td>
<td>813</td>
<td>2.906</td>
</tr>
<tr>
<td>3.</td>
<td><em>International Journal of Food Microbiology</em></td>
<td>771</td>
<td>3.425</td>
</tr>
<tr>
<td>4.</td>
<td><em>Journal of Food Science</em></td>
<td>636</td>
<td>1.775</td>
</tr>
<tr>
<td>5.</td>
<td><em>Food Microbiology</em></td>
<td>283</td>
<td>3.407</td>
</tr>
<tr>
<td>6.</td>
<td><em>Journal of Food Engineering</em></td>
<td>276</td>
<td>2.276</td>
</tr>
<tr>
<td>7.</td>
<td><em>Food Chemistry</em></td>
<td>264</td>
<td>3.334</td>
</tr>
<tr>
<td>8.</td>
<td><em>Journal of Applied Microbiology</em></td>
<td>255</td>
<td>2.196</td>
</tr>
<tr>
<td>10.</td>
<td><em>Journal of the Science of Food and Agriculture</em></td>
<td>182</td>
<td>-</td>
</tr>
<tr>
<td>11.</td>
<td><em>Journal of Dairy Science</em></td>
<td>174</td>
<td>2.566</td>
</tr>
<tr>
<td>12.</td>
<td><em>Food Science and Technology</em></td>
<td>159</td>
<td>-</td>
</tr>
<tr>
<td>13.</td>
<td><em>Journal of Food Science and Technology</em></td>
<td>156</td>
<td>-</td>
</tr>
<tr>
<td>14.</td>
<td><em>Applied and Environmental Microbiology</em></td>
<td>154</td>
<td>3.678</td>
</tr>
<tr>
<td>15.</td>
<td><em>International Journal of Food Science and Technology</em></td>
<td>144</td>
<td>1.240</td>
</tr>
<tr>
<td>16.</td>
<td><em>Innovative Food Science and Emerging Technologies</em></td>
<td>141</td>
<td>2.528</td>
</tr>
<tr>
<td>17.</td>
<td><em>Letters in Applied Microbiology</em></td>
<td>99</td>
<td>1.629</td>
</tr>
</tbody>
</table>

Table 5. Journals with number of publications on food preservation
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.

United States had highest number (4110) of publications followed by Spain 1436, China 1131, and Italy 1003. There were 130 countries involved in international collaboration and produced 2784 (16.56 %) internationally collaborated papers. Spanish National Research Council (CSIC), Spain topped the list with 294 publications followed by Univ California, USA with 217 publications and USDA Agricultural Reseracher Service, USA with 216 publications.

The most preferred journals for publications were 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.

REFERENCES


**About the Authors**

**Mr Ganesh Surwase** is working at the Scientific Information Resource Division, Bhabha Atomic Research Centre (BARC), Mumbai. He has published more than 40 papers in various national and international journals and conferences. His areas of interest include: Scientometrics and information and communication technology.

**Mr Lalit Mohan** is working as Technical Officer ‘C’ at the Scientific Information Resource Division, BARC, Mumbai. He has published more than 30 papers in national and international journals. His areas of interest include: Scientometrics and bibliometrics.

**Dr B.S. Kademani** is working as Scientific Officer ‘G’ at the Scientific Information Resource Division, BARC, Mumbai, since 1988. He has published more than 115 papers in national and international journals. His areas of interest include: Scientometrics, library management and knowledge management.

**Dr K. Bhanumurthy** is Head, Scientific Information Resource Division, BARC, Mumbai. He has more than 130 research publications to his credit. His areas of interest include: Materials joining, nuclear materials, materials characterisation, reactor design and analysis, metallic fuels, scientometrics, digital resources and knowledge management.