Celal Bayar University Journal of Science

Evaluation of the Altmetric Attention Score of Recent Hazard Food-Marker: Advanced Glycation End Products

Büşra Yusufoğlu[1*]

[1*] Department of Chemistry, Science and Letter Faculty İstanbul Technical University Ayazağa, Sarıyer, 34467, İstanbul, Türkiye
*yusufoglu@itu.edu.tr
*Orcid No: 0000-0002-9158-9732

Received: 6 November 2024
Accepted: 10 January 2025
DOI: 10.18466/cbayarfbe.1580554

Abstract

Recent trends in dietary habits have led to increased oxidative stress, heightened inflammatory responses and an increased incidence of chronic disease. With the increasing consumption of processed foods, advanced glycation end products (AGEs) have gained attention as significant "hazard food markers" associated with diets high in sugar and fat. AGEs can originate internally in the body or externally from sources such as food and smoking. This study examines the Altmetric Attention Score (AAS) to assess the online visibility and impact of recent research on AGEs. By conducting systematic searches of scientific databases and analyzing data from the Altmetric platform, the study evaluates the AAS and related online engagement metrics. The results show that AGEs-related articles receive varying levels of online attention, with notable interactions on social media, news platforms and forums. Moreover, keyword co-occurrence analysis revealed three dominant thematic areas in AGEs-related research, including dietary sources, oxidative stress mechanisms, and food processing-induced formation. This research highlights how factors such as publication venue, article type and topic relevance influence AAS, highlighting its importance in understanding the digital impact of food safety research.

Keywords: Altmetric Attention Score, AGEs, Food Processing, Food Safety

1. Introduction

The concept of food safety refers to the process of preventing some chemically and physically hazardous substances from entering the food supply chain at any stage, starting with the production of food, and continuing until its storage and consumption [1]. Studies on food safety behaviors of socio-demographic factors and information sources investigate consumers' knowledge levels, attitudes towards food safety and actual practices. Study findings highlighted the need to inform policymakers about effective food safety information dissemination methods [2]. In these stages, processing of food is one of the most basic issues and it creates some health risks for public health by affecting the nutritional elements of the food and causing the formation of some chemical molecules [3].
Ultra-processed foods are found to be more energy-dense and contain higher amounts of sugar, fat, and sodium than less processed foods, and consuming these foods has been shown to have potential health effects [4].

Advanced glycation end products (AGEs), one of the non-enzymatic reactions that occur in foods, are formed as a result of food processing and are one of the most important food safety and public health problems [5, 6]. AGEs are formed endogenously during normal metabolism but can also be introduced exogenously through diet, particularly by consuming foods processed at high temperatures [6]. To shed on light details of AGEs, it should get to their different molecular types such as early, intermediate and advanced phases. All phases are responsible basic reactive AGEs formations including Nε-(carboxymethyl)lysine, Nε-(carboxyethyl) lysine (CEL), methylglyoxal (MGO), glyoxal (GO), pentosidine etc. [7]. These complex molecules formed through the non-enzymatic reaction of reducing sugars with proteins, lipids, or nucleic acids. They play a significant role in the aging process and the development of various diseases, including diabetes, cardiovascular diseases, and neurodegenerative diseases as hazards food markers [8]. AGEs content in food, highlighting the relationship between frying conditions, moisture content, oil absorption and AGEs formation [9]. Peng et al., 2023 have investigated the inhibitory effects of blueberry

anthocyanins extract (BAE) on the formation of AGEs and their consequent inflammation in cells. It demonstrates BAE's capability to attenuate AGEs formation and AGEs-induced inflammatory responses, showcasing its potential as a natural inhibitor for AGEs and chronic inflammation caused by AGEs [10]. Si et al., (2024) have presented a comprehensive analysis of the association between the consumption of AGEs from various food sources and the risks of for all-reasons, cardiovascular disease (CVD), and cancer mortality. Utilizing data from a large national cohort, the study assesses AGEs intake through dietary questionnaires and investigates its correlation with mortality risks. The findings highlight the significance of dietary AGEs consumption about CVD and cancer mortality, offering insight into the impact of diet on long-term health outcomes [11]. Sourris et al. (2024) have delved into the impact of glucagon-like peptide-1 receptor (GLP-1R) signaling on diabetic kidney disease, focusing on its role in mitigating receptor for advanced glycation end products (RAGE)-induced inflammation. It presents findings from studies on mice, revealing that GLP-1R signaling is crucial for kidney health, and its deficiency can lead to kidney damage, which is exacerbated by diabetes. The study also demonstrates the therapeutic potential of the GLP-1R agonist liraglutide in reducing kidney injury by modulating RAGE expression and promoting anti-inflammatory responses [12]. Takeuchi et al., (2024) have explored the connection between the habitual overconsumption of sugars and the onset of lifestyle-related diseases (LSRD), focusing on the role of toxic advanced glycation end-products (TAGE) derived from glyceraldehyde. It discusses the formation and characteristics of these AGEs, their potential cytotoxic effects, and the relevance of TAGE as biomarkers for early diagnosis and monitoring of LSRD. The study underscores the importance of understanding AGEs structures and their varying toxicity to address and mitigate the health risks associated with high sugar consumption and LSRD [13]. AGEs are responsible some disease categories such as metabolic disorders (obesity and insulin restistance etc.), cardiovascular diseases, renal diseases, neurological disorders (Alzheimer’s and Parkinson’s disease etc.), cancer (breast, colorectal, pancreatic etc.), skin disorders (aging and wrinkles) [14].

Altmetric attention scores (AAS) are updated in real-time, allowing researchers, publishers, and institutions to see the immediate impact of their work. On the other hand, altmetric has captured the diverse ways research impacts society by tracking mentions across different platforms, offering a more comprehensive view of an article's reach than citations alone. AAS reflects how research is discussed and disseminated among the public, not just within academic circles [15-16].

The Altmetric Attention Score is a quantitative measure of the attention that a scholarly article or academic research output receives. It aggregates data from various sources, including social media, news media, policy documents, blogs, and online reference managers, among others, to gauge the broader impact and dissemination of research beyond traditional citation metrics. Used alongside traditional citation metrics, Altmetric offers a more nuanced and complete picture of research impact, enriching the evaluation of academic outputs. Altmetric Attention Score provides a multi-dimensional view of the impact and dissemination of research, capturing the immediate and diverse ways in which scholarly work engages with the wider world [15-16].

Advantages of the AAS including various aspects are assessing the impact of scholarly work, great sources for researchers, librarians, and academics, public engagement, discuss the integration of altmetrics into academic evaluation processes, discuss the role of social media. This social media perspective has present new perspective for scientists how to promote their research for maximum impact on public. In this context, the study aims to raise public awareness and reveal the effects of scientific studies on social media.

2. Materials and Methods

A bibliometric analysis was conducted using Web of Science (WoS) platform (https://www.webofscience.com) through a topic-based search method related to advanced glycation end products (AGEs). The search was performed on June 17, 2024, using the query TS=("advanced glycation end products") AND TS=("food" OR "diet" OR “nutrition"). Then, publications were filtered to peer-reviewed articles, review articles, and proceedings papers published from 1992 to 2025. As a result, a total of 1766 publications were obtained for analysis. The data was extracted in plain text format with full records and cited references and analysed using VOSviewer software (v1.6.20). A keyword co-occurrence analysis was carried out through the full counting method, and 477 keywords were included in the map after use of minimum occurrence threshold on the data. Figure 1 shows a summary of the data collection.

Celal Bayar University Journal of Science
Volume 21, Issue 2, 2025, p 105-117
Doi: 10.18466/cbayarfbe.1580554

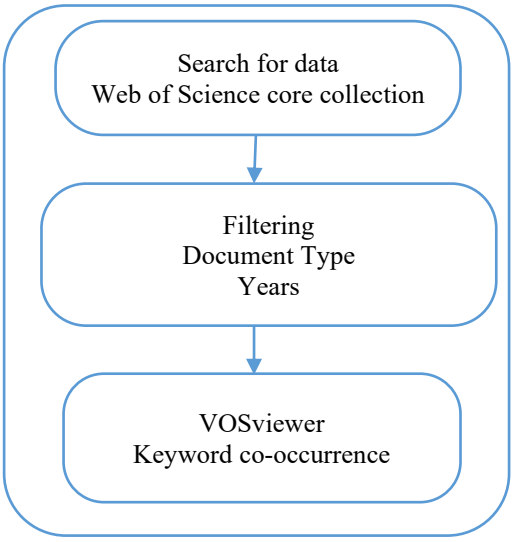

Figure 1. Overview of the bibliometric analysis process using VOSviewer

Moreover, the information for this bibliometric citation analysis was collected using the Web of Science (WoS) Core Collection database and PubMed. To find relevant articles in the WoS database, we have searched for the term "Advanced Glycation End Products." From a total of 17.630 articles, we have investigated the first 100 research, review and proceeding book studies (T100) that received the highest number of citations. For additional details on the study, we also consulted PubMed. To gather Altmetric attention scores (AASs), we downloaded the "Altmetric" tool from the Altmetric.com website. The AAS is determined by an algorithm that calculates a weighted total of all the attention a research piece gets. We explored the relationship between the total number of citations and Altmetric scores.

3. Results and Discussion

Based on the network visualisation created by VOSviewer, 477 keywords formed a clustered structure reflecting different but interconnected research areas. The map given in Figure 2 consists of three main thematic clusters. The green cluster in the center includes keywords such as Maillard reaction, protein glycation, dietary AGEs, diabetes, and hyperglycemia. In this cluster, dietary and physiological terms are prominent, and it is seen that the majority of the literature examines how AGEs are formed, absorbed, and metabolically processed.

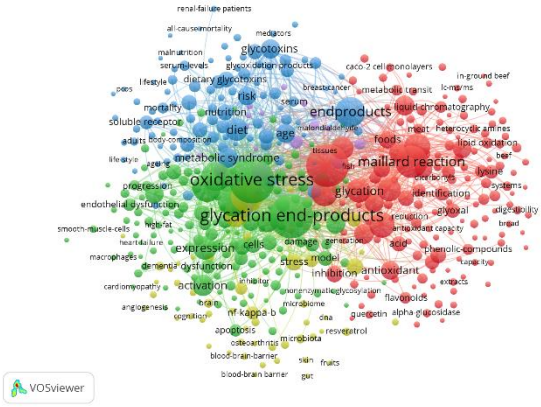

Figure 2. Keyword co-occurrence network map of AGEs-related publications in the field of food and nutrition (1992–2025).

Another cluster group, the blue cluster, is seen to include concepts such as inflammation, endothelial dysfunction, renal failure, and diabetes mellitus, as well as the concept of oxidative stress as the main character. This group emphasises the pathophysiological mechanisms linking AGEs to the development of chronic diseases. Due to the frequency of vascular and renal complication terms observed in clinical terms, it shows that the biomedical consequences of AGE accumulation are emphasised in studies.

Finally, the red cluster showed a focus on food processing topics, including keywords such as thermal processing, grilled meat, advanced food technologies, and analytical methods. This cluster indicated the technological dimension of AGEs research, which is related to the formation of harmful AGEs during food processing methods and the methods developed for their measurement and reduction.

The connections between these clusters emphasise the interdisciplinary nature of AGEs research, bridging food chemistry, nutritional sciences, and biomedical research. The distribution of keywords also reflects the increasing emphasis on areas such as studies on AGE-mediated cellular damage, dietary changes, and the effects of food processing

To investigate the novel aspects of the top 100 (T100) most cited scientific research papers in academia, 100 most discussed research papers were selected on social media platforms about AGEs from 1993 to 2014 and they were compared in terms of bibliometrics in web of science and in terms of social media impact in altmetric.com. All articles are published in English. We found the average citation of the top 100 articles to be 444.46±270 (242–1898). According to Table 1, the average altmetric value of T100 is 29.22±135 (0–1335). The list of 100 articles is ranked by the number of

citations. All articles were published in English. One of the scientific papers that received the most cited "Advanced glycation end-products: a review " scientific paper named was published by Rajesh Sing et al. 2001 and received 1.898 citations. AGEs studies carried out in the Australia and United States of America made up the first three publications with more than 3000 citations, as you can see in Table 1. The article with the highest Altmetric value is the 7th article with the highest citation value. When T100 articles are examined according to the distribution of research areas, “Advanced Glycation End Products” constitute the subject. When T100 articles are examined according to the distribution of document type, most articles were published as research articles and review articles (n:100).

As a result of social media platforms mentioned in various including Patents (980), facebook page (135), news outlets (140), blogs (33), Twitter (999), wikipedia pages (58), youtube creators (86), policy source (2), redittors (3), Research Highlight Platform (2), Mendeley (270) respectively.

Twitter geographical and demographic breakdown datas were collected from the profiles of Twitter users who shared these scientific papers and were categorized as the number of shares on Twitter. Our results demonstrate that the United States of America (USA) (61) is the country where most of the social media posts have been done in the world. USA is followed by the Japan (17) and Germany (15). In the top 45 journals that published T100 articles, one or more scientific publications were published.

Most articles published in Journal of Biological Chemistry, the number of articles published was 17. The majority of the articles were published in Journal of Biological Chemistry and Journal of Clinical Investigation, with 17 and 9 articles published, respectively. The average H-index of 45 journals with two or more AGEs publications are 265,59±168.13. When we compared our results in Table 2 in terms of quartile (Q) scores of the journals, 37 of them were in Q1, 4 of them were in Q2, 3 of them were in Q3, and 1 of them was in Q4. In the list of countries where T100 articles are published most, with USA (61) dominates in the first place, followed by Japan (17) and Germany (15) (Figure 2). Twenty-five universities with 3 or more publications were included in the list of universities with the highest number of T100 articles. The universities where the most articles were published were Columbia University (USA, 23), University of South Carolina Columbia (USA, 10), University of South Carolina System (USA, 10), and Baker Heart and Diabetes (USA,7) (Figure 3). We found that the most prominent authors in T100 articles were Shoichi Yamagishi with 3 publications, Josephine M. Forbes, Jaime Uribarri and Helen Vlassara with 2 publications.

A study has examined the ketogenic diet's impact and popularity, particularly focusing on altmetric analysis, which gauges the digital attention and engagement research receives on various platforms. The study contrasts the top 100 most-cited research papers with the top 100 most-discussed research papers on social media platforms, evaluating the correlation between traditional biblio-metric analyses and altmetric scores. The study underscores the importance of both bibliometric and altmetric assessments in comprehending the reach and impact of scientific research in the field of the ketogenic diet [16].

Table 1: Details of T100 scientific paper in terms of other metrics

Rank	Title	Year	First Author	TC	AC	AS
1	Advanced glycation end-products: a review	2001	Rajesh Sing	1,898	79.08	58
2	Advanced glycation end products: sparking the development of diabetic vascular injury	2006	Alison Goldin	1,635	86.05	79
3	Enhanced cellular oxidant stress by the interaction of advanced glycation end products with their receptors/binding proteins	1994	Shi Du Yan	1,084	34.97	11
4	Understanding RAGE, the receptor for advanced glycation end products	2005	Angelika Bierhaus	1,000	50	11
5	RAGE is a Cellular Binding Site for Amphoterin-Mediation of neurite outgrowth and co-expression of rage and amphoterin in the developing nervous system	1995	Osamu Hori	991	33.03	9
6	Advanced Glycation End Products and Diabetic Complications	2014	Varun P. Singh	879	79.91	67
7	Advanced Glycation End Products in Foods and a Practical Guide to Their Reduction in the Diet	2010	Jaime Uribarri	818	54.53	1335
8	Role of advanced glycation end products in cellular signaling	2014	Christiane Ott	764	69.45	13
9	CML Adducts of Proteins Are Ligands for Receptor for AGEs That Activate Cell Signaling Pathways and Modulate Gene Expression	1999	T. Kislinger	763	29.35	6
10	The role of advanced glycation end products in progression and complications of diabetes	2008	Su-Yen Goh	761	44.76	3
11	Advanced glycation end products contribute to amyloidosis in Alzheimer disease	1994	Michael P. Vitek	741	23.9	8
12	Advanced glycation end products and vascular inflammation: implications for accelerated atherosclerosis in diabetes	2004	Giuseppina Basta	728	34.67	51
13	The Advanced Glycation End Product, Ne -(Carboxymethyl)lysine, Is a Product of both Lipid Peroxidation and Glycoxidation Reactions	1996	Min-Xin Fu	701	24.17	40
14	Advanced Glycation End Products and Oxidative Stress in Type 2 Diabetes Mellitus	2015	Kerstin Nowotny	685	68.5	165

15	Survey of the Distribution of a Newly Characterized Receptor for Advanced Glycation End Products in Tissues	1993	Jerold Brett	682	21.31	4
16	Activation of the receptor for AGEs triggers a p21(ras)-dependent mitogen-activated protein kinase pathway regulated by oxidant stress	1997	Harry M. Lander	649	23.18	12
17	Activation of receptor for AGEs - A mechanism for chronic vascular dysfunction in diabetic vasculopathy and atherosclerosis	1999	Ann Marie Schmidt	643	24.73	10
18	Effect of collagen turnover on the accumulation of advanced glycation end products	2000	Nicole Verzijl	641	25.64	58
19	Advanced glycation end products and RAGE: a common thread in aging, diabetes, neurodegeneration, and inflammation	2005	Ravichandran R.	613	30.65	19
20	Novel splice variants of the receptor for AGEs expressed in human vascular endothelial cells and pericytes, and their putative roles in diabetes-induced vascular injury	2003	Hideto Yonekura	607	27.59	9
21	The biology of the receptor for advanced glycation end products and its ligands	2000	Ann Marie Schmidt	591	23.64	9
22	Improved arterial compliance by a novel advanced glycation end-product crosslink breaker	2001	David A. Kass	562	23.42	3
23	RAGE-mediated neurite outgrowth and activation of NF-kB require the cytoplasmic domain of the receptor but different downstream signaling pathways	1999	Henri J. Huttunen	548	21.08	6
24	Cellular receptors for AGEs. Implications for induction of oxidant stress and cellular dysfunction in the pathogenesis of vascular lesions	1994	Ann Marie Schmidt	541	17.45	51
25	Diastolic stiffness of the failing diabetic heart: importance of fibrosis, advanced glycation end products, and myocyte resting tension	2008	Loek van Heerebeek	539	31.71	4
26	Coregulation of Neurite Outgrowth and Cell Survival by Amphoterin and S100 Proteins through RAGE Activation	200	Henri J. Huttunen	502	20.08	6
27	Receptor-mediated endothelial cell dysfunction in diabetic vasculopathy-Soluble receptor for AGEs blocks hyperpermeability in diabetic rats	1996	Jean-luc Wautier	473	16.31	9
28	AGEs activate endothelium through signal-transduction receptor RAGE- A mechanism for amplification of inflammatory responses	2002	Giuseppina Basta	454	19.74	7
29	N.epsilon.-(Carboxymethyl)lysine Is a Dominant Advanced Glycation End Product (AGEs) Antigen in Tissue Proteins	1995	Sharanya Reddy	449	14.97	9
30	Convergence and amplification of TLR and receptor for RAGE signaling pathways via high mobility group B1 (HMGB1)	2008	Judy R. van Beijnum	436	25.65	4
31	Receptor for advanced glycation end products (RAGE) regulates sepsis but not the adaptive immune response	2004	Birgit Liliensiek	434	20.67	10
32	Characterization and functional analysis of the promoter of RAGE, the receptor for advanced glycation end products	1997	Jianfeng Li	431	15.39	7
33	Modification of low density lipoprotein by advanced glycation end products contributes to the dyslipidemia of diabetes and renal insufficiency.	1994	Rick Bucala	429	13.84	7
34	Release of high mobility group box 1 by dendritic cells controls T cell activation via the receptor for advanced glycation end products	2005	Ingrid E. Dumitriu	428	21.4	10
35	Advanced glycation end products induce glomerular sclerosis and albuminuria in normal rats.	1994	Helen Vlassara	407	13.19	6
36	Advanced Glycation End Products (AGE) and Diabetes: Cause, Effect, or Both?	2014	Helen Vlassara	395	35.91	25
37	rboxymethyl)lysine Protein Adduct Is a Major Immunological Epitope in Proteins Modified with AGEs of the Maillard Reaction	1996	Kazuyoshi Ikeda	394	13.59	12
38	Beta 2-Microglobulin modified with advanced glycation end products is a major component of hemodialysis-associated amyloidosis.	1993	Toshio Miyata	394	12.31	6
39	Expression of advanced glycation end products and their cellular receptor RAGE in diabetic nephropathy and nondiabetic renal disease	2000	Nozomu Tanji	389	15.56	6
40	Hyperglycemia-Induced Reactive Oxygen Species Increase Expression of the Receptor for Advanced Glycation End Products (RAGE) and RAGE Ligands	2010	Dachun Yao	383	25.53	3
41	RAGE is induced by the glycation products themselves and TNF-a through nuclear Factor-KB, and by 17ß-estradiol through Sp-1 in human vascular endothelial cells	2000	Nobushige Tanaka	376	15.04	7
42	Cellular signalling of the receptor for advanced glycation end products (RAGE)	2013	Jianling Xie	371	30.92	3
43	Advanced glycation end products cause epithelial-myofibroblast transdifferentiation via the RAGE	2001	Matthew D. Oldfield	368	15.33	6
44	Advanced glycation end-products and advanced oxidation protein products in patients with diabetes mellitus	2002	Marta Kalousova	358	15.57	0
45	Receptor for advanced glycation end-products is a marker of type I cell injury in acute lung injury	2006	Tokujiro Uchida	357	18.79	6
46	Advanced glycation end products Key players in skin aging?	2012	Paraskevi Gkogkolou	354	27.23	165
47	Randomized trial of an inhibitor of formation of advanced glycation end products in diabetic nephropathy	2004	W. Kline Bolton	353	16.81	3
48	A breaker of advanced glycation end products attenuates diabetes-induced myocardial structural changes	2003	Riccardo Candido	352	16	3

49	Crosslinking by AGEs increases the stiffness of the collagen network in human articular cartilage - A possible mechanism through which age is a risk factor for osteoarthritis	2002	Nicole Verzijl	346	15.04	8
50	Advanced glycation end products increase retinal vascular endothelial growth factor expression	1998	Ming Lu	343	12.7	6
51	Mechanisms of disease: advanced glycation end-products and their receptor in inflammation and diabetes complications	2008	Shi Fang Yan	342	20.12	0
52	Breakers of advanced glycation end products restore large artery properties in experimental diabetes	1998	Bruce H. R.	341	12.63	10
53	Receptor for advanced glycation end products (RAGE) deficiency attenuates the development of atherosclerosis in diabetes	2008	Aino Soro-Paavonen	340	20	0
54	Involvement of beta 2-microglobulin modified with advanced glycation end products in the pathogenesis of hemodialysis-associated amyloidosis. Induction of human monocyte chemotaxis and macrophage secretion of tumor necrosis factor-alpha and interleukin-1	1994	Toshio Miyata	339	10.94	3
55	Blockade of receptor for advanced glycation end-products restores effective wound healing in diabetic mice	2001	Mouza T. Goova	338	14.08	3
56	Does Accumulation of Advanced Glycation End Products Contribute to the Aging Phenotype?	2010	Richard D. Semba	336	22.4	46
57	Advanced Glycation End Products in Alzheimer's Disease and Other Neurodegenerative Diseases	1998	Noboyuki Sasaki	331	12.26	30
58	Identification of Galectin-3 As High-Affinity Binding Protein for AGEs: A New Member of the AGE-Receptor Complex	1995	Helen Vlassara	331	11.03	7
59	Advanced Glycation End Product-Induced Activation of NF-κB is Suppressed by α-Lipoic Acid in Cultured Endothelial Cells	1997	Angelika Bierhaus	330	11.79	4
60	Implication of an increased oxidative stress in the formation of advanced glycation end products in patients with end-stage renal failure	1997	Toshio Miyata	330	11.79	3
61	Plasma Levels of Soluble Receptor for Advanced Glycation End Products and Coronary Artery Disease in Nondiabetic Men	2005	Colomba Falcone	328	16.4	9
62	Diet-derived advanced glycation end products are major contributors to the body's AGE pool and induce inflammation in healthy subjects	2005	Jaime Uribarri	327	16.35	26
63	AGEs on the surface of diabetic erythrocytes bind to the vessel wall via a specific receptor inducing oxidant stress in the vasculature: a link between surface-associated AGEs and diabetic complications.	1994	Jean-luc Wautier	324	10.45	16
64	The Role of Advanced Glycation End Products in Aging and Metabolic Diseases: Bridging Association and Causality	2018	Jyotiska Chaudhuri	315	45	101
65	The myeloperoxidase system of human phagocytes generates *CML* on proteins: a mechanism for producing AGEs at sites of inflammation	1999	Melissa Anderson	314	12.08	9
66	Prevention of Diabetic Vascular Dysfunction by Guanidines: Inhibition of Nitric Oxide Synthase Versus AGEs-Formation	1993	Ronald G. Tilton	308	9.63	0
67	Skin Autofluorescence, a Measure of Cumulative Metabolic Stress and AGEs, Predicts Mortality in Hemodialysis Patients	2005	Robbert Meerwaldt	301	15.05	11
68	Advanced glycation end products and the kidney	2005	Jürgen Bohlender	297	14.85	1
69	AGEs-induced Apoptosis and Overexpression of VEGF and Monocyte Chemoattractant Protein-1 in Human-cultured Mesangial Cells	2002	Sho-ichi Yamagishi	295	12.83	0
70	Immunochemical approach to characterize AGEs of the Maillard reaction: Evidence for the presence of a common structure	1991	Seikoh Horiuchi	287	8.44	6
71	Advanced Glycation end Products, Oxidative Stress and Diabetic Nephropathy	2010	Sho-ichi Yamagishi	286	19.07	0
72	Determination of Advanced Glycation End Products in Serum by Fluorescence Spectroscopy and Competitive ELISA	1997	Gerald Münch	286	10.21	0
73	Advanced glycation end products-driven angiogenesis *in vitro*	1997	Sho-ichi Yamagishi	286	10.21	3
74	Advanced glycation end products up-regulate gene expression found in diabetic glomerular-disease	1994	Chih-Wei Yang	281	9.06	6
75	Inhibition of NADPH Oxidase Prevents AGEs–Mediated Damage in Diabetic Nephropathy Through a PKC-α–Dependent Pathway	2008	Vicki Thallas-Bonke	278	16.35	0
76	Role of the Maillard reaction in aging of tissue proteins- AGEs-dependent increase in imidazolium cross-links in human lens proteins	1998	Elisabeth B. Frye	278	10.3	4
77	Collagen, cross-linking, and advanced glycation end products in aging human skeletal muscle	2007	Jacob M. Haus	276	15.33	8
78	rAGEs has a central role in vessel wall interactions and gene activation in response to circulating AGE proteins	1994	Ann Marie Schmidt	276	8.9	9
79	Immunohistochemical and ultrastructural detection of AGEs in atherosclerotic lesions of human aorta with a novel specific monoclonal antibody	1995	Shuichi Kume	275	9.17	0
80	Expression of receptors for RAGE is closely associated with the invasive and metastatic activity of gastric cancer	2002	Hiroki Kuniyasu	273	11.87	1
81	Advanced glycation end products (AGEs) co-localize with AGE receptors in the retinal vasculature of diabetic and of AGE-infused rats	1997	Alan Stitt	272	9.71	0
82	Chelating activity of advanced glycation end-product inhibitors	2001	David L. Price	271	11.29	4
83	RAGE is a central mediator of the interaction of AGE-beta2microglobulin with human mononuclear phagocytes via an oxidant-sensitive pathway. Implications for the pathogenesis of dialysis-related amyloidosis.	1996	Toshio Miyata	271	9.34	9

84	Oxidative stress and advanced lipoxidation and glycation end products (ALEs and AGEs) in aging and age-related diseases	2019	N.Moldogazie	266	44.33	17
85	Advanced glycation end product interventions reduce diabetes-accelerated atherosclerosis	2004	Josephine M. Forbes	266	12.67	1
86	Restriction of dietary glycotoxins reduces excessive advanced glycation end products in renal failure patients	2003	Jaime Uribarri	263	11.95	12
87	Dietary advanced glycation end products and aging	2010	C.L. Contreras	261	17.4	101
88	Role of advanced glycation end products in diabetic nephropathy	2003	Josephine M. Forbes	259	11.77	0
89	Advanced glycation end-products and the progress of diabetic vascular complications	2004	Vladimir Jakuš	258	12.29	3
90	Advanced glycation end products stimulate osteoblast apoptosis via the MAP kinase and cytosolic apoptotic pathways	2007	Mani Alikhani	255	14.17	0
91	RAGE sustains autophagy and limits apoptosis, promoting pancreatic tumor cell survival	2010	Rui Kang	252	16.8	4
92	Angiotensin II Receptor Antagonists and Angiotensin-Converting Enzyme Inhibitors Lower *in vitro* the Formation of AGEs Biochemical Mechanisms	2002	Toshio Miyata	251	10.91	9
93	Advanced glycation end products: A nephrologist's perspective	2000	Dominic Raj	251	10.04	3
94	In Vitro Kinetic Studies of Formation of Antigenic Advanced Glycation End Products (AGEs)	1997	A. Ashley Booth	249	8.89	9
95	Immunochemical evidence for the presence of advanced glycation end products in human lens proteins and its positive correlation with aging	1992	Noire Araki	249	7.55	0
96	Restriction of advanced glycation end products improves insulin resistance in human type 2 diabetes: potential role of AGER1 and SIRT1	2011	Jaime Uribarri	248	17.71	21
97	RAGE-binding COOH-terminal motif of amphoterin inhibits invasive migration and metastasis	2002	Henri J. Huttunen	248	10.78	0
98	Regulation of human mononuclear phagocyte migration by cell surface-binding proteins for advanced glycation end products.	1993	Ann Marie Schmidt	246	7.69	8
99	Role of advanced glycation end products in cardiovascular disease	2012	Zeinab Hegab	242	18.62	24
100	Reduction of the accumulation of advanced glycation end products by ACE inhibition in experimental diabetic nephropathy	2002	Josephine M. Forbes	242	10.52	6
TC:Total Citation, ***AC:***Avarage Citation, ***AS:***Altmetric Score						

A study has focused on social attention of the relationship between oxidative stress and cancer in terms of AAS. They have used altmetric scores to gauge the impact of these articles on social media and other digital platforms. The study is pioneering in evaluating how cancer and oxidative stress research resonates in the digital space, emphasizing the increasing importance of online social media in academic and public domains (15). Araujo and his colleagues have shown that a systematic review analyzing how different variables of published articles and journals relate to altmetric scores, which reflect the online media attention garnered by scientific articles. The study identifies key factors like citation counts, journal impact factor, and open access status as influential for altmetric scores, providing insights into the dynamics between scholarly impact and social media presence [17]. Baspakova et al. (2024) have carried out a comprehensive bibliometric analysis, exploring the intricate relationship between ultra-processed foods and gut microbiota. It identifies key research articles, analyzes publication and citation trends, and assesses the global research. The study underscores the escalating concern regarding ultra-processed foods and their potential adverse effects on human health, particularly on the gut microbiota [18]. Alkan et al. (2023) have investigated the relationship between dietary and serum AGEs and serum inflammatory and oxidative stress biomarkers in breast cancer patients. The study assesses the correlation of dietary carboxymethyl lysine (dCML) intake and serum levels of CML with inflammation and oxidative stress markers, considering the treatment phase and human epidermal growth factor receptor-2 (HER2) status [19]. Yu et al. (2021) have discussed a comprehensive analysis of AGEs in peanuts during the roasting process. It emphasizes the relationship between roasting conditions (temperature and time) and the formation of harmful compounds like AGEs. The study provides a detailed correlation analysis among these compounds, revealing a significant increase in AGEs with the roasting temperature and duration. This research highlights the importance of monitoring and controlling the levels of AGEs in thermally processed foods to ensure food safety [20]. CML, a biomarker of AGEs, is a focal point in food safety due to its potential health implications. Golchinfar et al. have provided a comprehensive overview of the formation, perception, and biological consequences of CML in food and the human body, highlighting the significance of chemical analysis in understanding and mitigating the risks associated with dietary AGEs [21]. Brzezowska et al., 2023 have presented a comparative study on the antioxidant, antiglycation, and chemoprotective potential of beetroot juice powder formulations with functional carriers. It explores the effect of fermentation and carrier type on the quality of freze and spray-dried powders derived from beetroot juice, assessing their physicochemical, biological properties, and implications for health. The research highlights the relevance of processing methods and the choice of carriers in enhancing the functional properties of beetroot juice powders [22]. Gutierrez Mariscal et al. (2024) have studied the effects of dietary intervention on kidney function in patients with type 2 diabetes and coronary heart disease, focusing on the reduction of circulating methylglyoxal levels and the modulation of AGEs metabolism. It compares the impact of a Mediterranean

diet to a low-fat diet over a five-year period, observing that the Mediterranean diet is linked to a preservation of kidney function, especially in patients with mildly decreased estimated glomerular filtration rate. The study emphasizes the potential benefits of dietary modification in managing AGE-related health issues [23]. Henney et al., (2024) have conducted a systematic review and meta-analysis to explore the association between ultra-processed food intake and dementia risk. It highlights a statistically significant association between high intake of ultra-processed foods and increased dementia risk, underlining the importance of dietary quality in cognitive health and dementia prevention [24]. Huang et al. (2022) have evaluated the formation of AGEs, specifically N-carboxymethyl-lysine (CML), in broiler muscle during postmortem aging and storage. It compares the CML content in white and yellow feather broilers, examining the impact of storage and aging on CML formation. The study also assesses the effect of boiling on CML levels, providing insights into how different types of broiler meat and processing methods influence AGEs formation [25]. Liu et al. (2024) have carried out the role of the Maillard reaction and lipid oxidation in forming AGEs in batter-coated meat products during frying. The study assesses the impact of frying temperature and time on AGE formation, revealing that higher temperatures and longer durations increase AGE levels. It emphasizes the importance of controlling frying conditions to manage a cohort study explores the dietary patterns during pregnancy, particularly focusing on the increased intake of ultra-processed foods (UPF). It examines the association between this dietary shift and various factors like age, education, and lifestyle behaviors. The study provides insights into how these changes impact maternal and fetal health and highlights the need for targeted public health policies to promote healthier eating habits during pregnancy [26]. A comparison study is related to evaluation of the effect of phenylpropanoids on the binding of heparin to human serum albumin and glycosylated human serum albumin concerning anticoagulant activity. They examine the interaction between phenylpropanoids (caffeic acid, cinnamic acid and p-coumaric acid) and human serum albumin (HSA)/glycosylated human serum albumin (gHSA). It focuses on the implications for anticoagulant activity, particularly in the context of diabetes-related complications. The study utilizes spectroscopic techniques and molecular docking to understand the binding interactions, aiming to contribute to the development of more effective molecules for treating protein conformational diseases [27].

The study utilizes spectroscopic techniques and molecular docking to understand the binding interactions, aiming to contribute to the development of more effective molecules for treating protein conformational diseases [27]. One of the recent investigates the impact of plant extracts on reducing the formation of harmful AGEs in meatballs during cooking. It particularly focuses on the CML levels and explores the phytochemical and bioactivity properties of the extracts. The study provided detailed methodologies on the preparation of meatball samples, cooking, and analysis, aiming to contribute to healthier food processing practices [28].

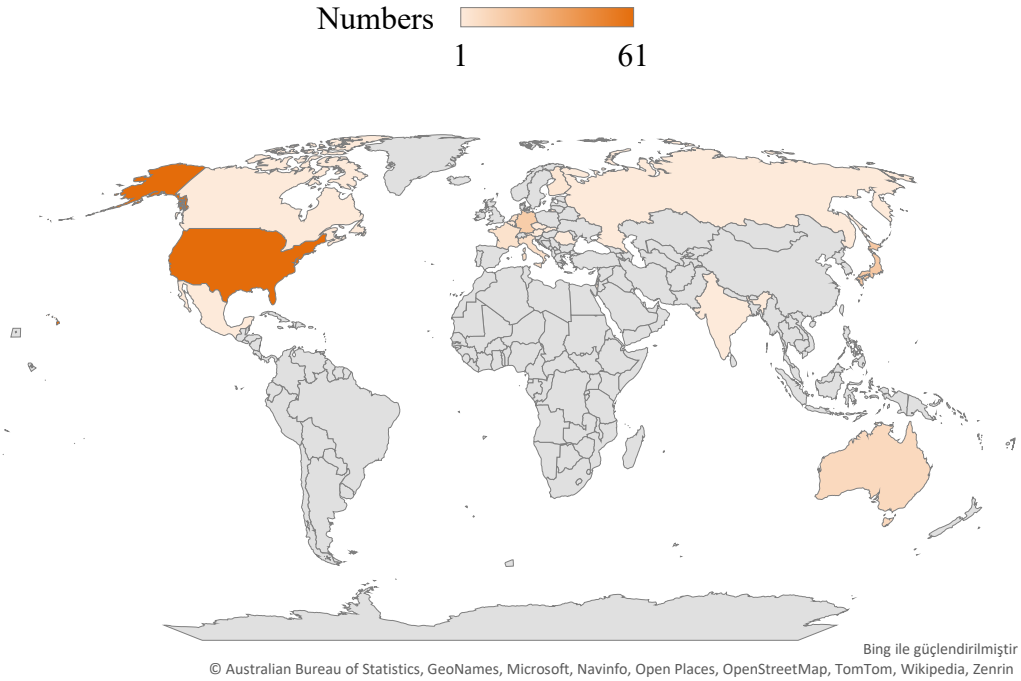

Figure 2. Sources of scientific papers from different various countries (T100, WOS).

Table 2. Journals with top-100 articles, ranked according to the citations

Journal name	Number of articles	IF*	Q category**	H index**
Journal of Biological Chemistry	17	***	Q1	544
Journal of Clinical Investigation	9	15.9	Q1	527
Diabetes	7	7.7	Q1	359
Proceedings of The National Academy of Sciences of The United States of America	7	11.1	Q1	838
American Journal of Pathology	5	6	Q1	297
Journal of The American Society of Nephrology	5	13.6	Q1	306
Circulation	4	37.8	Q1	654
Biochemistry	2	2.9	Q1	269
Circulation Research	2	20.1	Q1	369
Oxidative Medicine and Cellular Longevity	2	7.310	Q1	134
Physiological Research	2	2.103	Q3	77
Arteriosclerosis, Thrombosis, and Vascular Biology	2	8.7	Q1	287
American Journal of Kidney Diseases	1	13.2	Q1	231
American Journal of Nephrology	1	13.6	Q1	306
American Journal of Physiology Renal Physiology	1	4.2	Q1	184
American Journal of Respiratory and Critical Care Medicine	1	24.7	Q1	404
Angiogenesis	1	9.8	Q1	98
Annals of The New York Academy of Sciences	1	5.2	Q1	274
Journal of Molecular Medicine- JMM	1	4.7	Q1	152
Korean Journal of Physiology& Pharmacology	1	2.0	Q4	37
Redox Biology	1	11.4	Q1	120
Journal of Clinical Endocrinology & Metabolism	1	5.8	Q1	378
Biomolecules	1	5.5	Q2	89
Biochemical Journal	1	4.1	Q2	282
Journal of Immunology	1	5.426	Q1	401
Molecular Medicine	1	5.7	Q1	128
Kidney International	1	19.6	Q1	304
Cell Metabolism	1	29	Q1	318
Arthritis and Rheumatism	1	13	Q1	353
European Journal of Clinical Chemistry and Clinical Biochemistry	1	6.8	Q1	115
Journal of Applied Physiology	1	3.3	Q2	251
The Journal of Pathology: a Journal of the Pathological Society of Great Britain and Ireland	1	2.43	Q1	210
Nutrients	1	5.9	Q1	178
Bone	1	4.1	Q1	217
Cell Death and Differentiation	1	12.4	Q1	243
Diabetes Care	1	16.2	Q1	399
Cancer Research	1	11.2	Q1	483
World Journal of Cardiology	1	1.9	Q3	9
Current Diabetes Reports	1	4.2	Q1	94
Cellular Signalling	1	4.8	Q2	163
Dermato- Endocrinology	1	0.043	Q3	45
Nature Clinical Practice Endocrinology& Metabolism	1	40.5	Q1	187
Journal of Gerontology Series A Biology Sciences and Medical Sciences	1	5.1	Q1	210
Cardiovascular research	1	10.9	Q1	234
Redox Biology	1	11.4	Q1	120
Journal of Clinical Endocrinology & Metabolism	1	5.8	Q1	378
Biomolecules	1	5.5	Q2	89
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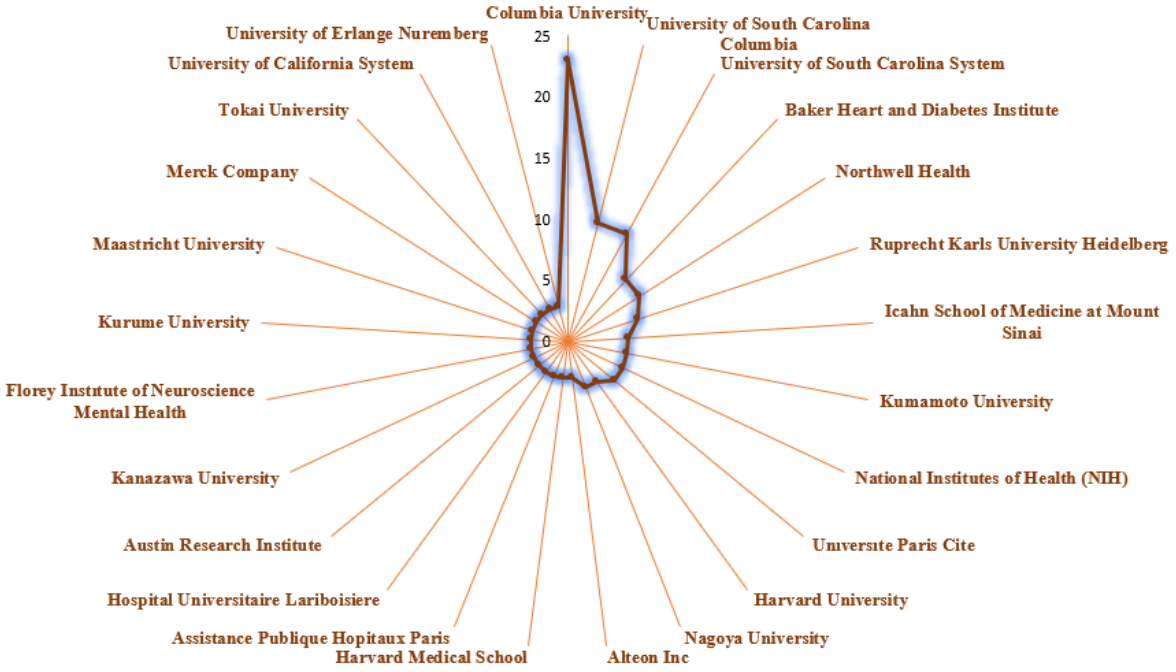

Figure 3. Some familiar institutions/universities of T100 most cited pape

As Figure 4 has demonstrated, there is no correlation between altmetric scores and the number of citations. This may be because not all AGEs articles are shared on social media because they don't get enough attention from scientists and other researchers. In light of this, it would be preferable for any academic research on public health to be posted on social media platforms so that everyone is able to read it in order to enhance their knowledge and behaviors.

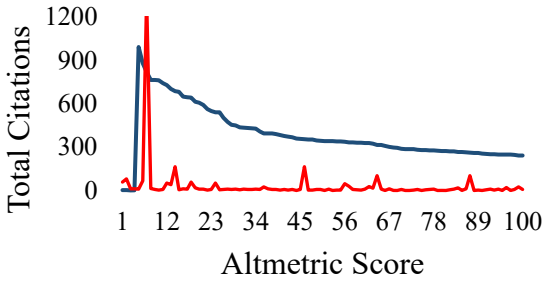

Figure 4: Graph of correlations TC-AS numbers

In recent years, the intersection of analytical and organic chemistry has emerged as a pivotal force in enhancing food preservation and safety. The focus has been on leveraging these scientific disciplines to innovate in areas such as advanced food packaging, precise detection methods for harmful substances, and the creation of ingredients that promote health. This multidisciplinary approach is not only addressing current industry challenges but is also setting a new standard for ensuring the safety and quality of food products. With the backing of impactful research and a commitment to excellence, the field continues to evolve, offering promising solutions to some of the most pressing issues faced by the food industry today. Considering the significant impact of dietary habits on AGEs accumulation, the most fundamental intervention to limit AGEs intake would be to reduce endogenous AGEs formation. Another strategy is to adopt a diet rich in raw fruits and vegetables, reduce processed food intake, and use cooking methods that minimize the formation of AGEs. In addition, lifestyle changes such as physical activities and quitting smoking also play an important role in reducing AGEs accumulation. On the other hand, the formation and accumulation of AGEs play a critical role in aging and the pathogenesis of various chronic diseases. Although endogenous formation of AGEs is a natural part of metabolism, lifestyle and dietary choices significantly affect their levels in the body. Adopting a diet low in AGEs and making conscious lifestyle choices can potentially reduce the risk or slow the progression of diseases associated with AGEs. Further research to fully understand the complex mechanisms of the formation of AGEs and their precise role in disease pathology is important and offers a promising avenue for the development of targeted interventions. Recently, studies have emphasized the latest innovations in food packaging and safety, as well as the use of analytical methods during the detection of toxic molecules and to ensure food quality. In this context, emerging research topics such as the use of bioinformatics, biosensors and computational

chemistry in food science are also areas that need to be focused on.

The relationship between the AAS and research on AGEs involve how the scientific community and the public engage with and value this research. The AAS provides a quantitative measure of the attention a research article receives across various platforms, including social media, news outlets, blogs, and academic citations. AAS could show some crucial four points to scholar/researchers such as public engagement, research impact, academic interest, feedback loop. Research on AGEs that garners high Altmetric scores likely resonates with or is deemed relevant by a broader audience. This can include patients, healthcare providers, or individuals interested in aging, diabetes, and related health issues. High scores indicate that the research has been widely shared, discussed, or mentioned across various media. A high Altmetric score suggests that the research on AGEs has a significant impact on its field or on public awareness. This could influence funding decisions, policy-making, or further studies in the area of glycation and its implications for health and disease. Beyond public engagement, high scores can also reflect academic interest, indicating that the research is being cited in other scholarly works, discussed in academic circles, or presented at conferences. This level of interest can contribute to the development of new hypotheses, research projects, and collaborations. The attention measured by Altmetric can create a feedback loop, where increased visibility leads to more research, funding, and further public and academic interest in AGEs. This can accelerate advancements in understanding and potentially addressing the health impacts associated with AGEs. In summary, the relationship between the AASs and research on AGEs underscores the importance of disseminating scientific findings and engaging a wide audience. It highlights the relevance of research on AGEs to various stakeholders, from scientists to the general public, and its potential impact on health and disease understanding and management.

This study provides a comprehensive analysis of the social interactions surrounding a critical public health issue. The analysis of these interactions, using tools such as AAS, provides valuable insights into how academic research transcends traditional boundaries and impacts various professional, social and interdisciplinary contexts. The study highlights the potential of research to contribute to public discourse and its application in broader societal conversations, thus emphasizing the extended impact of academic knowledge. In addition, a high AAS can increase the visibility of research, potentially leading to more collaborations, funding opportunities and citations. This helps researchers understand and demonstrate the wider impact of their work. Such studies are a guide to the assessment of the social relevance and impact of research, and a basis for the design of future projects to better meet public needs and expectations. Such studies provide a guide to assessing the level of social relevance and impact of the research. It also has the potential to become a research basis for the design of future projects to better meet public needs and expectations. In addition, these findings can inform strategies for more effective dissemination of research results to a broader public. In this context, the present study provides a detailed analysis of the biochemical pathways leading to the formation of AGEs, a topic of significant public health relevance. It also examines the major dietary sources of AGEs and the role of food processing in their accumulation. The study aims to highlight the importance of AGEs accumulation for both individual and societal health and to provide a basis for future research and public health interventions.

The article also examined bibliometric and altmetric analysis of research topics such as AGEs and the link between chemistry, biochemistry, food chemistry, clinical studies, and natural compounds. It also highlighted the importance of both traditional citation metrics and modern digital engagement metrics in understanding the reach and impact of scientific research in terms of the impact of ultra-processed foods.

4. Conclusion

Food preservation and safety are paramount for public health. Recent strides in analytical and biochemistry studies have significantly bolstered our ability to maintain food quality and safety. This article synthesizes findings from four pivotal studies, highlighting the interplay between chemical analysis, food vendor practices, and the biological implications of foodborne compounds like AGEs. Exploration of the most-cited and most-discussed research articles in fields like the AGEs, highlighting the correlation between traditional bibliometric analyses and altmetric scores. The significance of social media and digital platforms in disseminating and discussing glycation and clinical research findings. This study provides a comprehensive overview of AGEs from previous to today, beginning of their formation, health implications, and possible interventions. Once the content of the provided documents is accessible, more specific details and citations can be incorporated to enrich the article with recent research findings and data. This encompasses a range of activities including proper agricultural practices, hygienic food processing, thorough testing for contaminants, and educating consumers about safe food handling. In the contemporary landscape of food science, the intersection of nutritional quality, food safety, and the impact of food processing techniques remains a critical area of research. The global dependency on processed foods, underscored by the burgeoning consumption of pre-packaged and thermally processed items, necessitates a profound understanding of their nutritional profiles and potential health implications. Moreover, the articles extend beyond the laboratory to encompass the realm of digital engagement and societal discourse, exploring the impact of scientific research in the digital age through bibliometric and altmetric analyses.

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