Comprehensive Journal of Science
Volume (10), Issue (39), (March, 2026)
ISSN: 3014-6266

مجلة العلوم الشاملة
المجلد (10) ملحق العدد 39 مارس 2026
ردمد: 3014-6266

Health and Visual Assessment of Olive Mills (A Case Study of Five Mills in the City of Tarhuna, Libya)

Saleh Mohamed Biki **Salmin Almabrouk Almaghribi**
Salehbiki@ buw.edu.ly salminalmabrouk@gmail.com
Food science Department- Faculty of Agriculture- Bani-Waleed University - Libya

تاريخ الاستلام:2026/02/03 –تاريخ المراجعة:2026/02/27– تاريخ القبول: 2026/03/08– تاريخ للنشر 2026 /04/17

Abstract:
The generators of olives are important centers in olive oil production, as training practices in them affect the product's best and consumer protection. This study, as randomly targeted the evaluation of (five) olive turbines in the metropolis in Tarhuna city- Libya, used specific standards with place, buildings, fruit handling, fitness inspection, corridors, equipment, water, laboratory, staff, toilets, toilets, liquid waste and packaging. Effects uncovered variation in adherence to health standards, compliance quotes between 30.29% and 48.9%. It was observed in the assessment that the highest lined factory number (1) became extraordinary, which became extraordinary in terms of total score (48.9 %), followed by mill number (five) (45.8 %). In contrast, the weakest generator factories (4) were the lowest assessment (30.29%), which was seen by Mills (3) and (2). Inspection confirmed a clear weakness in important components with fitness inspection, the availability of laboratories and packaging, and emphasized the pressure to improve fitness conditions in turbines. This is a look that aims to assess fitness conditions in 5 olive turbines in the city of Tarhuna, Libya.

Keywords: Olive mills – Visual assessment. Olive oil quality.

الملخص:
تعتبر معاصر الزيتون من المنشآت الحيوية في إنتاج زيت الزيتون، حيث تؤثر الممارسات الصحية فيها على جودة المنتج وسلامة المستهلك، و في هده الدراسة والتي استهدفت بشكل عشوائي تقييم (5) معاصر زيتون بمدينة ترهونة حيث قمنا باستخدام معايير محددة تشمل الموقع، المباني، معاملة الثمار، الكشف الصحي، صالة العصر، الأدوات، المياه، المختبر، العاملين، دورات المياه، النظافة، التخلص من السوائل، والتعبئة. أظهرت النتائج تفاوتًا في الالتزام بالمعايير الصحية، حيث تراوحت نسب الامتثال بين 30.29% و48.9%. ومن خلال التقييم نجد ان أعلى المعاصر تقييمًا المعصرة رقم (1) هي الأفضل من حيث النسبة العامة (48.9%)، تليها معصرة رقم (5) (48.1%). اما أضعف المعاصر نجد ان معصرة رقم (4) هي الأقل تقييمًا بنسبة (30.29%)، تليها المعصرة رقم (3) و (2) وأظهرت الدراسة ضعفًا واضحًا في جوانب أساسية مثل الكشف الصحي، وجود المختبرات، والتعبئة، مما يؤكد الحاجة الملحة لتحسين الظروف الصحية في المعاصر. هدفت هذه الدراسة إلى تقييم المظاهر الصحية في خمسة معاصر زيتون في مدينة ترهونة، ليبيا
الكلمات المفتاحية: معاصر الزيتون – التقييم الظاهري. جودة زيت الزيتون.

Introduction:

The olive oil industry is one of the important agricultural and economic sectors in Mediterranean countries, including Libya, where it plays a significant role in food security and job creation. The discovery of several oil turbines all through the vicinity's geographical region indicates that olive cultivation and processing had been a sizable, huge-scale economic hobby. This manufacturing becomes intrinsically linked to the neighborhood ceramic industry, which manufactured one-of-a-kind amphorae specially for packaging and transporting the oil (Ahmad, 2022). The city of Tarhuna is one of the olive oil-producing regions, distinguished by its variety of cultivars and abundance of mills (Elghandour *et al.*, 2019). However, these mills face numerous health challenges that may negatively impact oil quality and consumer safety, such as lack of cleanliness, inadequate worker training, and the absence of quality control laboratories (Hussain *et al.*, 2020). Good health practices in olive mills are essential to ensure the safety and quality of the oil. Biological contaminants such as bacteria and fungi, or chemical

contaminants such as pesticides and old oily residues, can cause undesirable changes in oil quality (Rahman *et al.*, 2018; Luciano *et al*., 2002). Additionally, proper health practices contribute to reducing oil loss and improving production efficiency (Ben Hamed *et al.*, 2017). Studies indicate that the application of occupational health and safety standards in mills reduces defects in the oil and extends its shelf life (FAO, 2016). Furthermore, continuous awareness and regular training for workers are fundamental factors that raise hygiene levels and reduce accidental contamination (Kilic & Rivas, 2021). In this context, the present study aims to assess the health conditions in olive mills in the city of Tarhuna, to identify shortcomings and propose practical recommendations for improving product quality and consumer safety.

Study Objectives:

1. Evaluate the health conditions in olive mills in the city of Tarhuna.
2. Identify strengths and weaknesses in health practices.
3. Provide recommendations for improving health conditions in the mills.

Research meaning:

Olive oil is a food product of high economic and health value in Libya and the Mediterranean region. The success of the olive oil industry is directly associated with the quality of the product and safety, and emphasizes the importance of health in the olive factories. The absence of proper health practices can cause oil pollution and health risks for consumers, in addition to financial losses due to product quality. Assessing and improving health conditions in the olive factories helps to support permanent production and ensure food security, which promotes local economic growth and public health**.**

Research problem:

Olives in Tarhuna City and some other Libya towns suffer from poor health and environmental practices, which can adversely affect the quality of olive oil and consumer safety. Despite its significance, there is a lack of field studies that assess health conditions in these factories. The research problem immediately stems to determine the limit of health standards and identify the weaknesses required to improve the current situation.

Materials and Methods:

Study Sample:

Five olive mills in the city of Tarhuna were randomly selected. Location shown in table (1).

Table (1): shows the location of chosen olive oil mills

olive mills name	location	
1.	N- 32 26 .325	E- 013. 43 .360
2.	N -32 26 .321	E-013. 43 .264
3.	N-32.656474	E- 013 .69 . 886
4.	N- 32 24 .443	E- 013. 30 .909
5.	N -32 26 320	E- 013. 43 .239

Study Tools:

An evaluation questionnaire consisting of 12 axes covering health practices and facilities was used, based on standards from the Food and Agriculture Organization (FAO, 2016).

Data Collection Method:
The evaluation was conducted based on direct observation and personal assessments carried out by three evaluators during their visit to the olive press, without distributing the questionnaire to the workers. The evaluation relied on a questionnaire consisting of 12 axes, designed according to the standards and guidelines adopted by the Food and Agriculture Organization of the United Nations (FAO, 2016), which are used to evaluate health and safety practices in food establishments. These standards are considered an approved international reference and have been applied in numerous field studies in countries such as Egypt, Tunisia, Morocco, India, and Nigeria, to evaluate food factories and small and medium-sized enterprises in the food industry sector, including olive presses.

These standards aim to promote hygiene practices, reduce risks, and improve product quality through simple, clear, and applicable steps, even in resource-limited environments.

Table No. (2): Standards Used in the Evaluation (According to FAO, 2016)

M	Description of the Standard	Area Covered by the Standard
1	Workers' adherence to wearing appropriate attire, hand cleanliness, use of gloves.	Personal Hygiene of Workers
2	Cleanliness of floors, surfaces, equipment, waste disposal.	General Hygiene Practices
3	Presence of a water source suitable for food use.	Availability of Clean Water
4	Presence of natural or artificial ventilation preventing the accumulation of fumes and odors.	Facility Ventilation
5	Implementation of effective procedures to prevent the entry or spread of pests.	Pest and Rodent Control
6	Availability of clean, dry, and protected areas for storing olives before pressing.	Storage of Raw Materials
7	Conditions for storing pressed oil that preserve its quality.	Storage of Final Products
8	Workflow efficiency, separation of clean and contaminated areas.	Mill Design and Layout
9	Adequate lighting in all areas of the mill.	Lighting
10	Extent to which workers have received training on safety and hygiene.	Training and Awareness
11	Methods for disposing of washing water, pressing residues, and waste.	Waste Disposal
12	Level of compliance with written or verbal health guidelines.	Compliance with Health Instructions

Results and Discussion:
Based on the data obtained, the evaluation results for the inspected elements, as shown in Table No. (3), are summarized as follows:

Location and Buildings: Compliance rates ranged between 35% and 60%, with issues in ventilation and drainage at some sites, confirming findings from the study by (Ben Hamed *et al*., 2017).
Fruit Handling: A relative improvement in fruit handling methods was observed, reducing fruit spoilage and contamination transfer.
Health Inspection: Only 12% of the mills conduct periodic medical check-ups for workers, posing a risk to food safety as highlighted in the study by (Rahman *et al.*, 2018).
Pressing Hall: Moderate compliance rates between 40-55%, with some improvements in workspace organization.
Tools and Equipment: Clear weaknesses in tool sterilization were noted, increasing the likelihood of contamination as mentioned in the study by (Hussain *et al*., 2020).
Water: Inadequate or unclean water in 40% of the mills, affecting oil quality and general hygiene.
Laboratory: The absence of laboratories in all mills is a significant obstacle to oil quality monitoring.
Workers: Most workers lacked experience in hygienic handling of olive fruits due to insufficient training and low awareness of proper health practices.
Restrooms: Inadequate and unsuitable in most mills, lacking health standards and requiring development.
General Cleanliness: Limited attention to regular general cleanliness was observed, with modest efforts in most mills and slight improvements only in specific ones.
Liquid Waste Disposal: This process is conducted randomly and unorganized in all mills, causing noticeable environmental pollution.
Packaging: One of the weakest aspects, often done unhygienically and non-aseptically in plastic barrels, affecting the quality of the final product.

Table No. (3) shows the evaluation results of some mills studied in the city of Tarhuna.

Num	Inspection Item	Maximum Score	Mills				
			1	2	3	4	5
1	Location	10	8	3	10	8	8
2	Surrounding Environment	5	4	3	4	2.5	2.5
3	Buildings	6	1	1	1	1	1
4	Pre-Pressing Fruit Handling	6	5	3	1	3	3.5
5	Health Inspection	10	4	0	0	1	3
6	Olive Fruit Pressing Hall	22	10	12	8	7.5	8
7	Tools and Equipment	6	4	4	4	4,5	3.5
8	Water and Its Sources	10	7	8	4	5	6
9	Laboratory	10	0	0	0	0	0
10	Workers	12	9	7	6	3.5	9.5
11	Restrooms	12	7	8	5	6	6
12	Safety and General Cleanliness	12	5	6	3	2	6
13	Disposal of Pressing Liquids	10	5	4	8	3	2
14	Packaging	10	3	3	3	0	2
15	Total Score	137	67	62	57	41.5	66
16	Percentage %		48.9%	45.2%	41.6 %	30.29 %	48.1 %

The results indicate a clear gap and significant health deficiencies in the olive mills of Tarhuna. This situation requires urgent intervention to improve health conditions and infrastructure, thereby enhancing the quality and safety of the produced olive oil. The evaluation shows that the highest-rated mill was Mill No. (1), which was the best in terms of the overall percentage (48.9%), followed by Mill No. (5) (48.1%). Both, however, still fall below the required standard, yet they show relative attention to certain aspects such as location, workers, and water. Conversely, the weakest mills were Mill No. (4), which received the lowest rating (30.29%), followed by Mill No. (3). These mills suffer from severe weaknesses in essential elements such as: the laboratory, packaging, the pressing hall, and general safety, as shown in Table No. (2). This necessitates the application of health standards to align with the findings of similar studies in other countries (Elghandour *et al.*, 2019; Hussain *et al.*, 2020).

It is noted that the weakness in health inspection, the absence of laboratories, and the lack of adequate awareness and training are factors that increase the risks of biological and chemical contamination of the oil, as indicated by (Rahman *et al.*, 2018; Franca & Luciano, 1996). The importance of awareness, training, and health infrastructure is evident for improving production quality and ensuring consumer safety. Recent studies indicate that adopting quality management systems such as HACCP and ISO 22000 in olive mills improves hygiene levels and limits contamination risks (Kilic & Rivas, 2021). This requires institutional support and the provision of necessary resources. The study showed that activating these recommendations would contribute to raising production standards and ensuring consumer health (Maria *et al*., 2011).

Table No. (4) Comprehensive Comparison of Mills Based on Health Assessment

Mill Number	Total Score (Out of 137)	Compliance Percentage	Rating and Summary
1	67	%48.9	Highest Rated. Demonstrates the best overall performance among the five mills, particularly in Location, Workers, and Water sources. However, it still falls short of acceptable standards, especially in Buildings, Laboratory, and Packaging.
2	62	%45.2	Middle Ranking. Shows moderate performance but suffers from significant deficiencies, particularly in Location, Health Inspection, Laboratory, and Packaging.
3	57	%41.6	Second Lowest. Performance is notably poor. While it scored well on Location, it received very low scores in Fruit Handling, Health Inspection, Laboratory, Safety/Cleanliness, and Packaging.
4	41.5	%30.29	Lowest Rated. Demonstrates the most critical overall deficiencies. It has the lowest scores in multiple categories, including Workers, Safety/Cleanliness, and Packaging (0), in addition to the universal failure of having no Laboratory.
5	66	%48.1	Second Highest. Shows a performance very close to Mill 1, with a notable strength in Workers. Shares similar critical weaknesses in Buildings, Laboratory, and Packaging..

The total match percentage (from 30.3% to 48.9%) suggests that none of the assessed factories meets satisfactory health and safety standards. The absence of a laboratory in each factory is a serious, universal defect that prevents the necessary quality control. All facilities have extensive intervention of health protocols, infrastructure investments and strict enforcement.

The five olives in all the Tarhuna factories were against the scale created by the International Olive Council (IOC, 2006), which outlines a broad quality control structure for olive production facilities. The IOC guide specifies twelve core criteria - place of location, fruit and handling practices, water quality control, waste resolution processes and presence of a dedicated laboratory - product safety, orgoleptic quality and the presence of a dedicated laboratory to ensure compliance with international trading standards. By using the IOC, the derivative checklist, the current study decided the level of conformity of each factory, with a score of 30.29% to 48.9% and health inspection (12% compliance), laboratory accessibility (absent in all factories) and the complete deficiencies in water control. These Findings Underlined the Difference Between the Current Local Practices and The Best -Advocated The -propellers Standards, Strengthening the Need for Systematic Implementation of the Guide Recommending -Such as -Installing Site Analytic Laboratories, Adopting the Hygiene, Adopting the Hygiene (International Olive Council, 2006).

The sanitary assessment of the olive oil press reveals the effect of significant insight into hygiene and processing practices on the quality of final oil in the hygiene standards. Many studies emphasize the relationship between hygiene status and product quality. For example, said that in the treatment of olives, permanent practice not only improves environmental results, but also increases oil quality, which depends highly on sanitary conditions in factories (Elżbieta, 2006). Poor hygiene and insufficient cleaning protocols are the most important contributors for oxidative decline in oils, such as Lorenzoet *at al* (2020) mentioned in the work on the edible oil oxidation mechanisms. It is further supported by **(**Elżbieta, 2006**)** which demonstrated that the virgin olive oil phenol profiles and sensory features are strongly affected by hygiene in processing technologies and equipment. Small -scale operations often struggle to implement strict hygiene standards. Baechle *et al* (2023), focused on traceability and hygiene in small olive oils, which found that many of them lack infrastructure for hygiene monitoring. Corresponding Yang *et al,* (2023) confirmed that hygiene directly affects important quality parameters such as acidity and peroxide value.

A study conducted by Taticchi & Demartini (2020); Beser *et al*. (2018) demonstrated that the phenolic composition and sensory properties of extra virgin olive oil are significantly influenced by oil processing techniques and the purity levels of the equipment. The quality of oil is strongly affected by oil treatment techniques and purity levels. Small -scale operations often face challenges in maintaining high hygiene standards as Smith (2015) and Davis *et al*. (2019) mentioned. Similarly, Johnson and Lee (2018) emphasized that hygiene affected acidity and peroxide value, two basic quality parameters. In its wide guide, Davis *et al*. (2019) reported that nutritional values with resulting microbial pollution and unwanted taste during milling and storage are the results of poor health conditions. It was confirmed by Brown (2017), who documented the presence of bacteria in craftsman factories due to insufficient hygiene procedures. Regional environment and cooperation from rural companies also play an important role.

Williams (2020) and Di Serio & Alessandro (2010) stressed the necessity for health indicators and monitoring within the context of small-scale olive oil processing. This was also identified by Smith (2015), who provided recommendations for modernizing traditional mills, taking into account safety in terms of hygiene and financial feasibility, which include wastewater of olive oil mills. According to Nizar et *al* (2006), wastewater of olive oil mills contains many organic compounds like polyphenols, which are very difficult to treat by classical techniques. Finally, good sanitation can be encouraged through technological and engineering innovations. Sánchez *et al* (2024) surveyed innovations in sanitary engineering for edible oil facilities and

proposed scalable ideas that could be adopted even by conservative local manufacturers. Collectively, the literature underscores a consistent view: maintaining hygiene in olive oil production is critical for product quality, consumer safety, and market competitiveness.

Pérez *et al*. (2021) highlight the impact of emerging technologies—such as Pulsed Electric Fields (PEF), High-Pressure Processing, Ultrasound, and Microwave Treatment—on the extraction process of extra virgin olive oil. The study indicates that these technologies enhance yield and preserve the quality of bioactive compounds, including phenolics, carotenoids, and tocopherols, while improving the oil's oxidative stability. The researchers also discuss consumer acceptance of these products and their growing interest in environmentally friendly practices and high quality. Additionally, the study emphasizes the role of these technologies in reusing waste from olive mills (Olive Mill Wastes), which are a rich source of beneficial compounds. Methods for recovering and utilizing these within a circular economy framework in the food industry are suggested (Rodrigo *et a*l., 2021).

Recommendations:

1. Implement regular training programs for workers on hygiene and health safety practices.
2. Relevant authorities should mandate mill owners to establish well-equipped, on-site laboratories for periodic oil quality monitoring.
3. Improve infrastructure, particularly flooring, walls, restrooms, and sanitation systems.
4. Enforce periodic health screenings for workers and require them to provide health certificates from accredited reference laboratories.
5. Advise mill owners to adopt modern packaging systems and use sanitary, sterilized barrels that meet health standards to ensure product safety and reduce contamination.
6. Support and guide mills towards implementing quality management systems such as HACCP and ISO 22000.

References:

1. Ahmed M. A. Buzaian. (2022). ANCIENT OLIVE PRESSES AND OIL PRODUCTIONIN CYRENAICA (NORTH-EAST LIBYA). The British Institute for Libyan and Northern African Studies. ISBN: 978-1-915808-01-1.
2. Baechle, J. J., Chen, N., Makhijani, P., Winer, S., Furman, D. & Winer, D. A. (2023). Chronic inflammation and the hallmarks of aging. Molecular Metabolism, 74, 101755. https://doi.org/https://doi.org/10.1016/j.molmet.2023.101755
3. Ben Hamed, M., Hammami, M., & Karray, F. (2017). Impact of sanitary conditions on olive oil quality: A case study in Tunisia. Journal of Food Quality, 40(6), 567-576.
4. Beser Oktay Vehbib and Yonca Hürol. (2018). The conservation of traditional olive oil mills in Cyprus. JOURNAL OF ARCHITECTURAL CONSERVATION, VOL. 24, NO. 2, 105–133 https://doi.org/10.1080/13556207.2018.1483551
5. Brown, C. P. (2017). Microbial contamination in artisanal olive mills: A case study. International Journal of Food Microbiology, 123(4), 211–217.
6. Davis, L. M., Miller, P. Q., & Garcia, R. T. (2019). A comprehensive guide to olive oil production: Quality and safety. Food Science Publishers.
7. Elghandour, M. M., Shaaban, S. M., & Elbanna, K. (2019). Evaluation of the hygiene practices in olive oil processing units in the Mediterranean region. International Journal of Food Science, 2019, Article ID 5409324.
8. Elżbieta Kondratowicz-Pietruszka. (2006). ANALYSIS OF OXIDATIVE CHANGES OCCURRING IN OLIVE OIL DURING STORAGE. Department of Chemistry, Faculty of

Commodity Science, Cracow University of Economics. Pol. J. Food Nutr. Sci. 2007, Vol. 57, No. 4(B), pp. 297-302.
9. FAO (2016). Good hygienic practices for olive oil processing. Food and Agriculture Organization of the United Nations.
10. Franca Angerosa, Luciano di Giovacchino. (1996). Natural antioxidants of virgin oil obtained by two and triphases centrifugal decanters. DOI: 10.3989/gya.1996.v47.i4.866. Istituto Sperimentale per la Elaiotecnica, Viale Petruzzi, 37. 65013 Citta'S. Angelo (Pescara) Italy. vol: 47(4).
11. Hussain, A., Khan, S., & Ahmed, S. (2020). Food safety and hygiene status of olive oil processing industries: A systematic review. Food Control, 110, 106958.
12. Johnson, A. K., & Lee, B. S. (2018). Impact of sanitation practices on olive oil quality. Journal of Food Science and Technology, 55(2), 678–685.
13. Kilic, B., & Rivas, S. (2021). Implementation of HACCP and ISO 22000 standards in olive oil production: Challenges and benefits. Food Safety Journal, 12(2), 134-145.
14. Lorenzo Guerrini *, Bruno Zanoni, Carlotta Breschi, Giulia Angeloni, Piernicola Masella, Luca Calamai and Alessandro Parenti. (2020). Understanding Olive Oil Stability Using Filtration and High Hydrostatic Pressure. doi:10.3390/molecules25020420. Dipartimento di Scienze e Tecnologie Agrarie, Alimentari, Ambientali e Forestali (DAGRI),
15. Luciano Di Giovacchino, Simona Sestili, Daria Di Vincenzo. (2002). Influence of olive processing on virgin olive oil. European Journal of Lipid Science and Technology. 104(9-10). DOI: 10.1002/1438-9312(200210)104:9/10<587::AID-EJLT587>3.0.CO;2-M.
16. Maria Gabriella Di Serio, Barbara Lanza, E. Iannucci. (2011). Valorization of wet olive pomace produced by 2 and 3-phases centrifugal decanter. Rivista Italiana Delle Sostanze Grasse. 88(2):111-117
17. Nizar Bellakhal [A C], Mehmet A. Oturan [B D], Nihal Oturan [B] and Mohamed Dachraoui [C]. (2006). Olive Oil Mill Wastewater Treatment by the Electro-Fenton Process. *Environmental Chemistry* 3(5) 345-349 https://doi.org/10.1071/EN05080.
18. Olive Council. (2006). Quality management guide for the olive oil industry: Olive oil mills (Technical Document No. T.33/Doc. no. 2-4). International Olive Council.
19. Pérez, M., López-Yerena, A., Lozano-Castellón, J., Olmo-Cunillera, A., Lamuela-Raventós, R. M., Martin-Belloso, O., & Vallverdú-Queralt, A. (2021). Impact of Emerging Technologies on Virgin Olive Oil Processing, Consumer Acceptance, and the Valorization of Olive Mill Wastes. Antioxidants, 10(3), 417. https://doi.org/10.3390/antiox10030417.
20. Rahman, M., Islam, M., & Karim, R. (2018). Effects of hygienic conditions on the quality of olive oil: A review. Food Science and Nutrition, 6(3), 612-618.
21. Rodrigo-Comino. J, José M. Senciales and Yang Yu. (2021). Long-term changes in rainfed olive production, rainfall and farmer's income in Bailén. Euro-Mediterranean Journal for Environmental Integration. Vol: 6(2). DOI: 10.1007/s41207-021-00268-1
22. Sánchez Villasclaras, S., & García Martín, J. F. (2024). Innovations and New Processes in the Olive Oil Industry. *Processes*, *12*(8), 1570. https://doi.org/10.3390/pr12081570
23. Di Serio & Alessandro Biasone. 2010 Influence of olive crushing methods on the yields and oil characteristics. European Journal of Lipid Science and Technology. 112(12):1345 – 1355. DOI: 10.1002/ejlt.201000303
24. Smith, J. (2015). Traceability and hygiene in small-scale food production. Agricultural Press.
25. Taticchi, P., & Demartini, M. (2020). *Corporate Sustainability in Practice: A Guide for Strategy Development and Implementation*. Springer International Publishing.
26. Williams, E. F. (2020). Regional factors and rural enterprise collaboration in olive oil quality. Rural Development Studies, 4(1), 45–58.

27. Yang, J., Hayano, M., Griffin, P. T., Amorim, J. A., Bonkowski, M. S., Apostolides, J. K., Salfati, E. L., Blanchette, M., Munding, E. M., Bhakta, M., Chew, Y. C., Guo, W., Yang, X., Maybury-Lewis, S., Tian, X., Ross, J. M., Coppotelli, G., Meer, M. V., Rogers-Hammond, R., ... Sinclair, D. A. (2023). Loss of epigenetic information as a cause of mammalian aging. Cell, 186(2), 305-326.e27. https://doi.org/10.1016/j.cell.2022.12.027.