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The Impact of Diffusion on the Adoption of an Olive Oil Extraction Technique with a Continuous Two-Phase System without Pollution: Case of Study in Two Mediterranean Regions, Bouira in Algeria and Cordoba in Spain

Labdaoui D.[1], Hadj Smaha D.[1], Larid M.[1], Gomez A.C.[2]

[1]University Abdelhamid Ben Badis, Mostaganem-Algeria, Faculty of Natural Sciences and Life.
[2] School of Agricultural Engineering and Forestry, University of Cordoba-Spain

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ABSTRACT

In the Mediterranean Basin, the olive growing sector has a great effect on the rural economy, the regional heritage, and the environment. Based on an investigation conducted respectively on a sample of two olive oil growing areas (Bouira in Algeria and Cordoba in Spain), a comparative study has been the subject of a diagnosis of the state of the olive oil factories, their functioning mode, their impact on the quality of oil, the recovery of waste (pomace and margins) that they produce on the environment, as well as the prospects of adoption of a two-phase extraction system which is considered as ecological. The results have shown that in the region of Cordoba, the adoption of this model by olive oil factories since the 1990s has witnessed unprecedented progressive evolution which has a tendency to generalize. Although this system is within the scope of technologies called "clean ", and because of the lack of popularization and consciousness-raising, it is still unknown in the zone of Bouira in Algeria. The research has also shown that we should move towards the use of innovatory and more appropriate techniques to allow the production of quality oil, water and energy saving, reduction of pollution from the source, and have to be increasingly used by the factories concerned with environmental issues, and desirous of keeping their share in the market. Therefore, it is necessary for the competent authorities to become conscious of the sustainable development of the sector

KEYWORDS: Olive-oil factories, pollution, margins, two-phase system, adoption and diffusion.

INTRODUCTION

The analysis of the relationship between the technique and the economy or between the technological evolution or the economic development goes necessarily through innovation. According to Schumpeter (1934), this concept in economy is defined as a historical and irreversible change in the productive process of factories; strictly speaking, it is the establishment of a new function of production. Every study which attempts to establish the relationship between the economic and social change on the one hand, and the scientific and technological activities on the other hand implies a series of hypotheses on the form of innovation to be defended all along the implied system. Nonetheless, to realize these proposals to the maximum, the accumulation of empirical studies and the formulation of theories of diffusion and of adoption should be essential [12]. This diffusion is also eased on a territory when all the conditions are met for the emergence of a real territorial system of innovation [7][8]. To that effect, the oil producing sector, in particular that of the extraction of olive oils has known a series of technical and organizational transformations during these recent years, which have overtaken the rate of development ever reached. To this end, the sector of oil-processing industry has to be cared for, since obtaining olive oils results in to two important sub-products: the pomace and the margins which are less valorized, especially in Algeria. The clearest example in this situation is the diffusion and adoption by oil factories of a continuous system of extraction of olive oils which is more ecological, called the two-phase system without the production of margins, which is a sub-product obtained after extraction of oils of olive, whose annual world production is estimated between 25 to 40 million/m^3, namely, 90 % located at the level of the Mediterranean Basin, and among the sector which contributes to this high production is the industry of oils of olives, notably the machines which function with the system of three-phase using an important quantity of hot water [13]. The margins constitute a very serious environmental problem, especially for the countries with a high olive oil growing industry, because of its polluting impact on environment by the presence of an important amount of phenolic component made of toxic elements for the microorganisms which are useful to the fertilization of soil. This toxicity is due to the presence of long chain free fatty acids, and components not easily deteriorated, such as the phenolic components which are in great concentration responsible of phytotoxic acts and antimicrobials of soil [9], whose quantity is of 3gr to 5gr. l^{-1} [1]. As these substances are not easily degradable, their polluting power is represented by two important values, that is the CDO (chemical demand in Oxygen) and the BDO (biological demand in Oxygen) and which can reach respectively 200 $gr.l^{-1}$ and 100 $gr.l^{-1}$ [4]. However, the majority of olive oil factories throws their pollutants away in nature at the level of sanitary sewers or well stocked in the basins in the air, which gives bad

***Corresponding Author:** Labdaoui D., University Abdelhamid Ben Badis, Mostaganem-Algeria, Faculty of Natural Sciences and Life.

smelling, or sometimes used as fertilizers without any control, affecting the groundwater. The margins are also composed of 40 % to 50 % of vegetation water contained in the olive fruit and the added water when mixing takes place [13]. However, their chemical composition is influenced by several factors, namely variety, maturation, the period of stocking before extraction and the model of extraction [2]. To this end, our research consists in diffusing a new technological innovation in the food processing sector named the continuous two-phase system which has known in Spain an unprecedented record in the principal producing areas of olive oils, notably in the region of Andalusia, in particular in the province of Cordoba. This method of two-phase system saves up water and energy and does not produce margin, hence it is considered as non-polluting [9].

This is why, it is important to analyze the process of adoption and diffusion of this process, called clean technology and the technological dynamic which has an effect on the oil-producing sector from the plantation to the production of olive oils and the valorization of sub-products (pomace and margins).

2. MATERIALS AND METHODS

2.1. Presentation of the study zones:

Possessing similar natural particularities with an oil-producing agricultural area, both of the zones of study of Bouira (Algeria) and Cordoba (Spain) are located in the west of the Mediterranean Basin on a semi-arid area. Having the reputation of producing olive oil with their important number of olive oil factories, they distinguish themselves with their technological level in the extraction systems of olive oil.

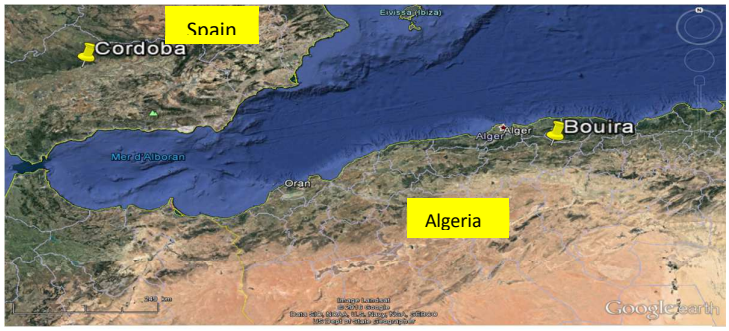

Fig.1- Location of study areas (Google earth, 2016)

2.2 Principles of extraction of olive oils:

The ideal objective of every extraction method consists in producing the most important possible quantity of oil without altering its original quality. However, if the quality does not have to be modified, it is necessary to only use physical or mechanical methods to extract oil, avoiding chemical and enzymatic reactions which can change its natural composition. The scheme of extraction which has been recently elaborated comprises four principal operations:

1.The cleaning of fruit (defoliation, cleaning of olives)
2.Preparation of the paste (grinding and mixing)
3.Separation of the solid (pomace) phase
4.Separation of liquid phases (oil/ vegetation water)

2.2.1. The Systems of Extraction

Olive oil is obtained by the trituration of pericarps of fruit, and not of their grains, in a specific oil windmill. The amount of oil varies according to the region, the variety (cultivar), the stage of maturity to the crops and the local agronomic practices. During these recent years, this general process of manipulation of olives has known technological developments which rely on complete mechanization of the process, the increase in the work capacity and the specialization of the process of extraction to reduce the cost, and to ameliorate the quality of olive oil [5]. These systems also help the elimination of the maximum of polluting products, namely the margins.

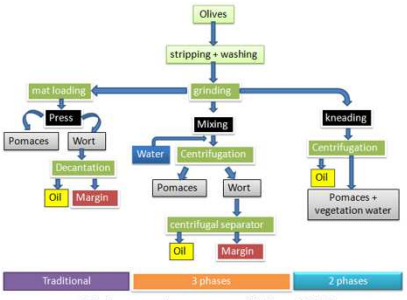

Fig.2: extraction systems of olive oil [11]

The machines which are used include the horizontal centrifuges (oil extractors) which operate at an angular speed, 3000 times bigger than the natural gravitational acceleration. The centrifuge (oil extractor) in content (Fig. 02) comprises the following steps: the stripping and cleaning, the grinding of olives, the mixing of olive paste, the centrifugation with or without addition of water for the system at three or two-phases respectively.

2.2.2. Innovation in the extraction systems:

The following table represents schematically the history of the different methods of innovation used in the field of extraction of olive oils completed by a comparative study between the principal modes of extractions realized by [14]. He clearly shows all the technical, socio-economic and environmental parameters which have made the oil factories opt or not for the latest innovation.

Table 01. Innovation, description and characteristics of the different methods of extraction

Innovation	Description	Characterization
The Hydraulic Press (beginning of the 20th century)	• Solid-Liquid Separation • Formation of mat loading • Liquid-Liquid Separation • Decantation (or / and) centrifugation	• Innovation of the process; • Dynamically continuing; • Of a " Push" type; • Time and energy saving; • The use of a lot of labor force
The Ameliorated Press System (1970s-1980s)	• Mat loading of synthetic material • Automatic displacement of mat loading.	• The Innovation of the continuing process ; • Of a "Pull" type; • Labour force and capital saving (compared to the previous) • Better quality of oil ; • Slight innovation of production ; • Alteration of oils after exposition of the paste to the air; • Average consumption of water ; • Oils being rich in antioxidant ; • The obtained oil is often acid , owing to the non-respect of hygiene rules; • Important risk of contamination; • The free fatty acids contained in the olive oil produced by this system can give a low resistance to this oil; • Low production of pomace (28 %).
Continuous System at 03 Phases (1973)	• Simultaneous Separation • Centrifugation • Addition of hot water for dilution • Production of big quantity of effluent liquid (margins)	• Innovation of the process; • Dynamically continuing; • Of a "Push –Pull" type; • Energy and time saving; • Labour force and capital saving; • The use of a lot of water and electric energy; • Contamination : The production of an important amount of margins ; • Lean oils in antioxidant ; • Low acidity; • Risk of contamination ; • Average production of pomace (48 %).
The Continuous System at 02 Phases (1992)	• Closure of an exit in the decanter of the centrifugation. • No addition of water • No production of margins incorporated to the pomace • Some difficulties of manipulation and treatment "vegetation water- pomace"	• Innovation of the process in continue; • Of a "Pull" type; • Stimulation in investment (30-40 % of subsidies in Spain); • Time and electric energy saving. • No contamination effect; • Best capacity of production; • No alteration; • No use of hot water which helps energy saving; • Oils being rich in antioxidant; • Low acidity; • No contamination; • Stabilized oil because of its high antioxidant content; • High production of wet pomace (60 %).

2.2.3. Methodological Approach:

- In this preliminary approach, we have adopted a rational tuning through a behaviorist analysis of individuals, namely the farmers, particularly, the olive oil farmers, and the olive oil factory managers, and the agriculture services of environment and quality control**.** Since the concept of adopting an innovation is considered as a system of communication as defined by Rogers (1995) [15], who supports it by the fact that the diffusion is a process of communication through which an innovation is communicated through canals in time and space between the members of a determined social system.
- Bibliographical synthesis and interviews with experts in different sectors on the evolution of the adoption of new ecological extraction system at two phases in particular, and their socio-economic and environmental impacts have been undertaken.
- A comparative study based on an investigation held on a representative sample of olive oil factories located in two Mediterranean olive oil zones: 111 in Bouira in Algeria (2010-2015) and 82 in Cordoba in Andalusia, in Spain (1997), has allowed us to appreciate the degree of diffusion of this new model of extraction of olive oils and its impacts on the sustainable development of the sector. To collect all the necessary information, a questionnaire has been elaborated and distributed to the olive oil factories of two zones of study which have accepted to answer them respectively with 111 out of 140 in Bouira and 82 out of 152 olive oil factories in Cordoba.
- The objective of the work is to analyze in details the process of adoption of this innovation in Spain, to evaluate the perception of these characteristics by the adopters and to study its evolution in time and space, according to the characteristics (dimension and localization) of the concerned factories and also to analyze the causes of the lack of knowledge of this respectful system for the environment by the Algerian olive oil manufacturers and consequently the possibilities of its adoption.

III. RESULTS AND DISCUSSIONS:

3.1. The Results of the investigation:

According to the questionnaire we have elaborated at the level of both study zones and following the received responses, the obtained results show clearly the parameters which have pushed the olive oil factories to opt or not for the new two-phase system.

3.1.1. The new process of extraction of olive oils: The knowledge of this process and its adoption by the olive oil manufacturers have presented the best appreciation at the level of Cordoba (98 %) since the 1990s, whereas it remains unknown in Bouira.

3.1.2. The innovative process: It was created in 1992 by Spanish researchers [3], and has the main objective of limiting the big production of margins. During the same year, the factory Fuentes Cardona, distributor of Westfalia offered to the olive oil industry market a centrifugation installation described as ecological and capable of elaborating olive oil extra-virgin without adding hot water to the decanter, and at the same time without the production of margins [3]. At the same time, the factory Pieralizi presented a study on the advantages and some drawbacks of this new system compared to the other existing systems (Fig.2) [6]. To that effect, the Spanish olive oil manufacturers were conscious of this phenomenon which spoils the environment and this new system, the two-phase system can be considered as added value at the level of environment, accountability and quality of the obtained product. The rate of 98 % is the result of work undertaken by different media, notably the newspapers, the advertisements, the days of popularization, of consciousness-raising and information through the different services such as the Agriculture Board, the Agriculture Chamber, the universities, the research institutes, the information centers, the machine makers such as the Pieralizi and Wastfalia factories, and the researchers in the field. However, in Algeria, the totality of the olive oil manufacturers, in particular those of the region of Bouira ignore the existence of this new technique and its advantages, with the exeption of some administrative executives in the field. The lack of knowledge is due to the lack of information about this new system by the olive oil manufacturers'. This answer justifies the investigations undertaken by different researchers who confirm that the production of olive oil by the press system and the three-phase system gives a great quantity of margins (see page 3 of the article).

3.1.3. The degree of implementation of this new system: As mentioned above, until the end of 2015, no olive oil factory in the region of Bouira had used this new technique for the reasons mentioned above. Conversely, according to our investigation, realized at the end of 1997 in Spain, an important rate evaluated at 77 % of olive oil manufacturers installed this system in their factories. Consequently, this adoption is due to the good knowledge of this process in terms of accountability, quality of olive oils and especially the protection of the environment.

3.1.4. The principal reasons for its adoption: The reasons behind its adoption are ecological for 62 % (absence of margins) and economical and ecological for 30 % (ecology, saving in water, electricity and labor, with a better accountability and quality of oils). The rest, which means 08 %, is constituted by the olive oil manufacturers who did not answer this part of the questionnaire. These results corroborate the findings of Fernandez et *al.* (1995) [10].

3.1.5. The principal motives of its non-adoption: For the Algerians, the reasons are the lack of knowledge of this system, the ignorance of its advantages and drawbacks, and the lack of environmental information and

consciousness-raising. Conversely, for the Spanish, 59 % of olive oil manufacturers consider the cost of investment is as high, 17 % judge it not necessary for their olive oil manufactures, and 7 % think that the new technique is too risky for their factories. Finally, the remaining 7 %of olive oil manufacturers say that the time is not appropriate to establish this new process. However, the opinion of the non-adopters does not correspond to the conclusions of the majority of researchers.

3.1.6. The sources of information of this new technique: In Algeria (Bouira), this system is almost unknown by the managers of the olive oil factories. The olive oil manufacturers look for useful and necessary information to introduce this new process at the level of their units. Contrary to the Spanish producers (Cordoba), the investigation realized in 1997 demonstrated that information is obtained respectively by the machine makers and distributors (42 %), publications (17 %), other olive oil factories (14 %) and by personal contacts with the experts and technicians (10 %). The popularization of managers of machine makers gave an important result in the adoption of this new system.

3.1.7. The sources of consultation: Among these sources, there are advisory agents such as the technicians, and experimentation institutes (32 %), the other olive oil manufacturers (22%) and the machine makers and distributors (16 %).

3.1.8. The process of evaluation: In Algeria, since the technique is unknown, no demonstration session has been undertaken. Conversely, in Spain, a rate of 69 % of olive oil manufacturers has responded having attended days of popularization**,** information, consciousness-raising and demonstration by specialists of the sector. For this reason, it has been noticed that a considerable record of adoption has been reached.

3.1.9. The influence of other olive oil factories in the final decision for the adoption of the new system: A rate of 60 % of Spanish factories has responded favorably, showing a considerable influence of other olive oil factories in the adoption of this new process.

3.1.10. Year and percentage of adoption by region in the region of Cordoba: The following maps of the region of Cordoba show clearly the percentage of adoption by region and by year. The analysis of these maps depicts an impact of the importance of the neighborhood together with the olive oil growing sector vocation of certain regions on the decision of adoption from the first year and even lately for some important regions in olive area and olive oil manufactures.

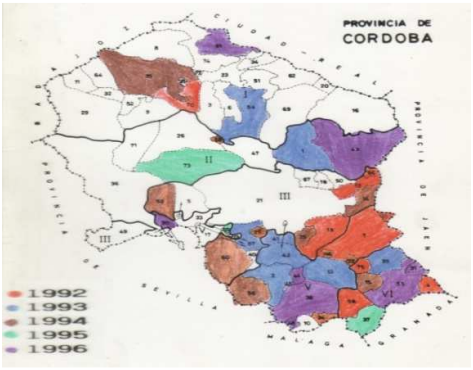

Fig.3: The year of adoption by region

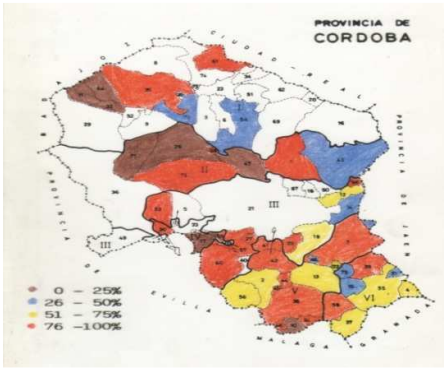

Fig4: Percentage of adoption by year

3.1.11. The duration of the individual period for the adoption of the new system: The following scheme (Fig.5) shows clearly the individual period of adoption of different olive oil factories at the level of the zone of Cordoba, and which amounts at a rate of 65 %. They adopted this process rapidly, in a period of less than two years. This signifies clearly that the message of media was transmitted without any difficulty to the owners of olive oil factories and that the olive oil manufacturers in general are conscious of the problem of margins and its environmental impacts.

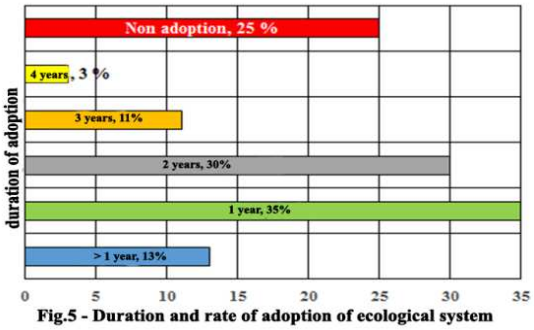

Fig.5 - Duration and rate of adoption of ecological system

3.1.12. Perspectives of implementation of this new innovation: In Algeria, as it is an unknown process by the owners of olive oil factories and according to an investigation realized, 31 % of the owners hope to install this system of two-phases provided that they would be well-informed technically and economically of its advantages and drawbacks. In 1997, 23 % of those who did not adopt this technique in Cordoba hoped to install it in the short term. Henceforth, it is necessary for producers to consult the researches of Nianouaki et *al.* (2006) [14] and Hammadi (2006) [11] on the advantages and drawbacks of this system.

3.1.13. The valorization of the two-phase system in relationship with the three-phase system:

According to both investigations, the Algerian owners (the zone of Bouira) have always opted for the three-phase system because they have no knowledge about the two-phase system. Nonetheless, for the Spanish olive oil factories (the region of Cordoba), the answer is illustrated in Figure 06. Concerning the production cost factor **(PC)**, the answer is mostly favorable, even for the olive oil factories which have not adopted this process, except for an insignificant percentage which has curiously expressed a negative view. This supposes that these producers do not see the significant difference for them between the previous system and the new process, or they have no interest in environmental issues. Some olive oil factories, adopting the two-phase system refrained from giving their opinions because they did not use the three-phase system since they moved directly from the discontinued system of the press to the two-phase system. On the basis of their investigation, Fernandez et *al.* (1995) [10] also came to the same conclusion. Nevertheless, as far as the factor of oil accountability **(OA)**, there was a positive result evaluated at 53 % by the adopters and at 42 % by the non-adopters. This is also justifed by the researches of Diaz Alonzo et *al* (1993) [6]. For the perception of the oil quality **(OQ)**, with this new process, 44 %, opt for the best quality and 40 % do not see any difference. This shows that the quality of oil obtained with this new technology is the best, which is backed up by the investigations of Niaounaki et *al*., (2006) [14].

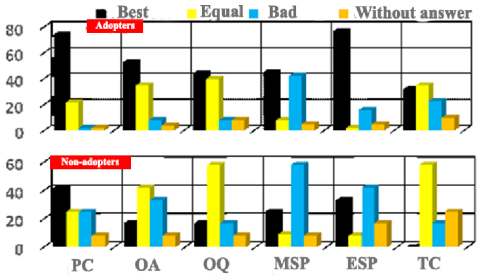

Fig 6.- Olive oil manufacturers' opinions (result of the investigation)

Concerning the manipulation of sub-products (MSP), this variable measures the existing difference between the manipulation of pomace which is incorporated with water vegetation (wet pomace) produced by the two-phases system, and the production of pomace alone and margins produced only by the three-phases system. To that effect, the adopters gave the following answers: the "equal answer" represents the minority with 8 %, which denotes that these producers do not see the difference between these two systems. Nevertheless, the "extreme answers" which are composed of the "best answers" and the "bad answers" are of 45% and 42 % respectively. It is possible that some answers were based on the understanding that the manipulation of sub-products meant their elimination. Nonetheless, among the non-adopters, the "bad opinion" prevails with a rate of 58%, compared to the "best answers" with 25%. This can be also considered as a fundamental motive for certain olive oil factories for not having adopted this ecological process. These answers correspond to the findings of Nefzaoui (1991) [13], and Nouaki (2006) [14]. As far as the opinion of the elimination of the sub-products **(ESP)**, this variable measures the valorization of the encountered difficulties for the elimination of margins which are inexistent in the two-phase system, and produced in great quantity in the three-phase system. As it was expected and referred to by all the researchers, it is the fundamental motive which pushed these factory owners to adopt the two-phase system. Figure N°6 reflects the results found by different researchers. The answers favor the new system with 77%, which correspond to the results of Nouanouki (2006) [14]. However, the non-adopters, who represented 33%, consider that this process creates another problem in the manipulation of the sub-product, which is the wet pomace. As far as 'the equal and bad answers' of the adopters are concerned, they represent a minority with 16%and 02% respectively. This opinion can be explained by the fact that these olive oil factories have low dimension and production. For the non-adopters, the 'bad answers' are of 42 %, and the "equal answers" are of 8 %, which shows that these producers are not interested in the protection of the environment, or in this system.

Concerning the last factor which corresponds to the technical complexity **(TC)** of this method, there is a majority opinion evaluated at 35 % of adopters, and that this complexity is for both systems. However, a percentage relatively appreciable, evaluated at 10 % for the adopters and 25 % for the non-adopters, did not give any response, which supposes that a certain number of olive oil factories, which did not opt for this process did not dare express their judgment without having realized their own experience. Others did not want to express their opinion because they moved directly from the discontinued system of the press to the new two-phase process, a conclusion that Fernandez et *al.* (1995) [10] came to.

IV. CONCLUSION

From this study, the application of the innovative two-phase process for the extraction of oils in the development of the oil growing sector shows that the rate of its diffusion remains very high in Spain (Cordoba). This was caused by two types of demand, one being a proper trendsetting development of technology and another cyclical related to the moment when the zone of Andalusia was affected by a period of drought and pollution problems. This new technology, non-productive of margins, being water and electricity saving and totally respectful of environment is still unknown in Algeria (Bouira).

In general, regarding the perception of the characteristics of this innovation, the view of the adopters coincides with that of the experts on a better accountability and an exceptional quality of produced oils, and the non-production of margins. On the other hand, the non-adopters hope to establish it in the future.

Concerning the process of adoption in Spain, in particular (Cordoba), the biggest innovators are the regions with a great olive growing vocation with a certain hierarchical effect of neighborhood in the spatial diffusion. The estimate of the potential of adoption turns around 100 % in the zones of high density and of 60 % in the zones of low density.

As far as the possibility of its introduction in Algeria, and in particular in the region of Bouira, it is the duty of the competent authorities to expose this new technology by the popularization and the consciousness-raising of olive oil manufacturers for the sustainable development of the olive oil growing sector to take advantage of the Spanish experience.

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