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Highlight Article

Argan oil, the 35-years-of-research product

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Argan oil is nowadays a major and internationally well-established actor on the edible-oil as well as cosmetic-oil markets. Nevertheless, argan oil fame is quite recent. Indeed, due to important quality matters, argan oil had remained ignored for years. During all this time, argan oil's numerous pharmacological properties have provided benefit only to the population of the Essaouira and Sous Massa Draa regions, the part of the world where argan oil is exclusively produced. Argan oil's worldwide success is principally the result of a vast multidisciplinary program initiated by the government of Morocco almost 35 years ago. This program, which began by the chemical characterization of argan oil and argan metabolites, has subsequently allowed the establishment of an official, and internationally recognized, argan oil quality norm, together with good preparation pratice guidelines. Because of this norm and these stringent guidelines argan oil has got the trust of customers. This has led to the triggering of its international recognition. Concomittantly, private, governmental and non-governmental organizations have taken great care to ensure that a large part of argan-oil derived wealth was redistributed to the Sous Massa Draa population, principally through the building of woman-managed argan oil preparation cooperatives. This paper relates the major steps of the argan oil saga.

Keywords: Cosmetic / Hypocholesterolemiant / Press oil / Virgin oil

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1 Introduction

Argan oil has been known for centuries in Morocco where it constitutes the basic ingredient and sometimes exclusive source of vegetable fat of the "Amazigh diet" [1]. In addition to a skin healing effect when used externally, traditional knowledge has associated argan oil intake with hepatoprotection and choleretic properties [2]. Therefore, argan oil consumption is recommended to prevent hypocholesterolemia and atherosclerosis [2]. At the present time, argan oil comes in two forms: a cosmetic and an edible form. The former is light-gold color, its taste is bitter and it is externally used. The latter is light yellow-ocher color and presents a pleasant hazelnut taste. Economically, both oil types are particularly prized on their specific segment.

Nowadays, argan oil is prepared by cold pressing argan kernels. Roasted kernels afford edible argan oil, raw kernels deliver cosmetic argan oil. Such preparation process unequivocally categorizes argan oil into the "cold-press oil" type, meaning that argan oil also belongs to the more well-known "virgin oil" type. The meaning and implication of the terms "virgin oil" or "cold press(ed) oil" has already been defined by Matthäus et al. [3]. In brief, "virgin oils" can be obtained using all kind of mechanical procedures, including heating, as long as these procedures do not alter the nature of the oil. The cold-pressed oil label certifies that the oil has been prepared without heating and any other mechanical procedures except pressing. Regarding argan oil, such precision is of great importance since several quantitatively minor but qualitatively major oil constituents are particularly heat sensitive. Because pressing is the only preparative process allowed to prepare cold-pressed oil, its quality is intimately dependent on that of the raw material from which it is prepared: argan kernel in the case of argan oil. Consequently, to certify this quality, the argan oil large-scale preparation -from fruit collect to oil extraction- is now strictly standardized. This paper will focus on the chemical work that was performed for 35 years to reach these quality criteria, we will use a chronological approach.

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2 The early work

It is commonly accepted that argan oil has been known since the time of the Phoenicians, who established trade centers throughout the Mediterranean Sea and along the coast of Morocco. Even though, argan oil was mentioned in several ancient sacred books or records [4], the very first scientific work regarding argan oil was reported in 1926 by Jaccard [5] and in 1927 by Girardet [6]. Dickhart in 1939 reported additional information [7]. However, these authors mainly gave a macroscopic physico-chemical description of argan oil with very little analytic information on its chemical composition. In 1972 Berrada [8], followed in 1974 by Huyghebaert and Hendricks [9] were the first authors to report a detailled – though incomplete-chemical analysis of argan oil and of its fatty acid composition. They particularly observed the high argan oil sterol and unsaturated fatty acid (UFA) content. Likely encouraged by this result, and the possible benefits of argan oil consumption on the human health, the first systematic chemical analysis of argan oil composition was initiated 35 years ago. Results were reported in a series of four papers published between 1981 and 1984 [10–13]. However, those results as well as those of Chimi et al. [14] or Maurin [15] went more or less unnoticed because at that time argan oil was still a local home-made oil whose composition was possibly slightly different from one batch to the other. Therefore, scientific results obtained on laboratory-processed oil (solvent extracted oil) were difficult to translate at the market level. Fraudulent argan oil was also frequently encountered on the local markets.

2.1 The early preparative process

Argan kernels, from which argan oil is prepared are trapped in the fruit of the argan tree [*Argania spinosa* (L.) Skeels]. Because of glacial events dating back to the early quaternary period, the argan tree (family Sapotaceae) is nowadays only endemic in Morocco where it grows over an area of about 8000 km^2 referred to as the argan forest. The argan tree is a slow-growing spiny tree whose life span can exceed 200 years and that is particularly adapted to survive in arid conditions. Indeed, its developed root system is able to reach deeply buried groundwater. Argan tree bears fruit, which, between May and August, once ripe, turns yellow, and falls off the tree. Over the years, argan forest dwellers have developed an argan-tree-oriented way of life [16]. Today, Amazigh (Sous Massa Dra natives) farmers still use argan tree leaves as hanging forage as well as a way to shade domestic cultures [17]. Argan tree ownership is governed by a combination of rural, religious, and traditional laws [4]. Over the centuries, natives have also developed a traditional method to prepare argan oil. The details of this long and painstacking traditional process, which is exclusively performed by women and which starts with fallen ripe fruit collection and finishes with argan dough hand-malaxing, have been already very precisely depicted [18, 19]. If this process has been satisfactory for years to produce argan oil for the family circle, it nevertheless raises strong quality concerns, particularly in terms of preservation, bacteriological safety, traceability, and reproducible chemical composition. Therefore, this process is incompatible with the large-scale production of oil satisfying market requirements.

Additionally, the argan forest had been poorly managed for years, its ecosystem being successively threatened by natural phenomena and excessive human exploitation: over-exploitation of the wood to produce charcoal, overgrazing by goats and/or camels, repeated exceptionally dry seasons, changes in agriculture practices to satisfy the tourist industry. The combination of these factors resulted in a decrease in the renewal of the trees and in the number of young trees, as well as an accelerated soil erosion and an amplified desertification. Because of this accelerated decline, the natural function of the forest in acting as a natural barrier against the advance of the desert, in preventing erosion, and protecting water resources got threaten and the forest endangered.

Aware of the problem, the government of Morocco decided in the early 1990s a large rescue program that culminated with the designation of the argan forest a UNESCO International Biosphere Reserve in 1998, and in 1999 the inclusion of the argan tree to the World Heritage list. In parallel, a vast scientific program aimed at focusing on research, sustainability, and socio-economic development was launched [20, 21]. The socio-economical consequences of this program are frequently discussed in specialized journals [22–24] and will not be further discussed here.

2.2 The search of new outputs

Because of all the above mentioned concerns associated with the large-scale production of high quality argan oil, this latter produce was not initially considered as the first that worthed to be valued to rescue the argan forest. Indeed, the challenge was high and, the argan tree being rich in saponins, a type of compounds was regarded as possessing a higher industrial potential than argan oil, at the time. Therefore, the saponin content of the divers parts of *A. spinosa* was initially investigated. The resulting phytochemical work led to the structural elucidation of an impressively large number of saponins [25–28]. Even though this work is still in progress [29], any of the saponins isolated, so far, ha presented satisfactory properties to envision an industrial output. Since the same conclusion applied for other products isolated from *A. spinosa* parts [30], argan oil was consequently regarded as the only alternative to possibly rescue the argan forest [31].

2.3 The modern preparative process

The key paper regarding the production of high quality argan oil was published in 2005 [32]. Nineteen samples of argan oil

coming from different areas of the argan forest and prepared using the traditional method, by solvent or by cold-press extraction were analyzed. The results demonstrated for the first time, that argan oil physico-chemical properties were not altered by the mechanical stress induced by the cold-pressing of argan kernels. Hence, these results clearly and simultaneously evidenced that (1) argan oil preparative process could be drastically improved, (2) the time consuming hand-malaxing step that followed the addition of water used in the traditional method could be eliminated without modification of argan oil composition, and (3) the problems resulting from bacteriological matters and poor preservation properties could be easily solved. Interestingly, these results also showed that the geographical origin of the fruit had no influence on argan oil quality. Therefore, despite its vast area and diversity of climatic conditions, the argan forest could be considered as a single and homogeneous production area. This result also confirmed later [33]. Because the use of screwless presses meant that the production could be simplified, the quantities produced amplified, and the quality reproducible, these results paved the way for argan-oil large-scale production using a process in which the kernel grinding, dough malaxing, and decantation steps were simply substituted by a single step: kernel pressing [18]. Whereas traditionally prepared argan oil was indistinctly used for cosmetic or nutrition purposes, rapidly, two kinds of argan pressed-oil were proposed: edible argan oil prepared from roasted kernels and cosmetic argan oil prepared from non-roasted kernels. Since the composition of argan oil was now standardized, the writing of an official norm could be envisioned. It got finalized and officially published in 2003 [34] (Table 1).

3 Quality matters

The use of screw presses has ensured that argan oil was possible to produce on a large scale. Nevertheless, to ascertain argan oil commercial success and gain consumer confidence, it was necessary to be able to certify its quality. Therefore, adulteration matters, from which argan oil had suffered for a long time, had to be solved. As mentioned earlier, cold-press oil quality is highly dependent on raw material quality. Because argan oil is produced from the fruit of a tree that is not dosmestically grown, fruit quality is difficult to control.

Table 1. Official description of argan oil [27]

Name			
Extra virgin	Virgin	Pure	Lampante
Acidity* <0.8%	<1.5%	<2.5%	>2.5%
Peroxide I* ≤15	≤20	≤20	–
K_{270} ≤0.35	≤0.35	≤0.45	–
Physicochemical parameters			
Density at 20°C: 0.906–0.919 Saponification index: 189.0–199.1 Iodine index: 91.0–110.0 Refraction index at 20°C: 1.463–1.472 Unsaponifiable matters ≤1.1%			
Composition			
Fatty acid (%)	Sterols (% total sterols)	Tocopherols (% total tocopherols)	
Myristic acid ≤0.2 Pentadecanoic acid ≤0.1 Palmitic acid: 11.5–15.0 Palmitoleic acid ≤0.2 Heptadecanoic acid: traces Stearic acid: 4.3–7.2 Oleic aid: 43.0–49.1 Linoleic acid: 29.3–36.0 Linolenic acid: ≤0.3 Arachidic acid ≤0.5 Gadoleic acid ≤0.5 Behenic acid ≤0.2	Schottenol 44.0–49.0 Spinasterol 34.0–44.0 Δ-7-Avenasterol 4.0–7.0 Stigmasta-8-22-dièn-3b-ol 3.2–5.7 Campesterol ≤0.4% Cholesterol ≤0.4% Total ≤220 mg/100g	α-Tocopherol: 2.4–6.5 β-Tocopherol 0.1–0.3 γ-Tocopherol 81.0–92.0 δ-Tocopherol 6.2–12.8 Total 600–900 mg/kg	

*Acidity expressed in oleic acid, peroxide index expressed in $mEqO_2$/kg oil.

Therefore, solving argan oil quality question necessitated to be able to give an answer to two questions: Is commercialized argan oil a mixture of argan and cheap oils? And: Is commercialized argan oil really high quality argan oil?

3.1 Adulteration by other vegetable oils

Several methods have been proposed to certify that commercialized argan oil is not blended, so far. Some methods are based on the detection of a selected component that is lacking or is very minor component of argan oil but that is found in larger quantity in most of vegetable oils. Hence, campesterol that is a phytosterol found in large quantity in most vegetable oils except argan oil, has been proposed to be an efficient adulteration marker [35]. Indeed, addition of vegetable oils into argan oil would inevitably result in the production of argan oil presenting a abnormally high campesterol content. Campesterol detection can be used to certify that argan oil does not contain soya-bean, rapeseed, sunflower, apricot, peanut, hazelnut, sesame, or olive oil with a confidence level up to 98%. Kaurene, 3,5-stigmastadiene, or pheophytin-A are other sterols that have also been proposed as detection markers [36]. Their usefulness has only be demonstrated to detect adulterations with olive or sunflower oil. Discriminant analysis of trace element composition has also been suggested as an alternative method to detect adulterated argan oil by addition of cheaper vegetable oils as sunflower, olive, or soya-bean oil [37, 38]. The possible use of infrared spectroscopy, or of high-performance liquid chromatography combined with evaporative light scattering detection has also been reported [39, 40]. Both methods have been shown to be particularly useful to detect adulterations based on fraudulous addition of sunflower or soya-bean oil.

3.2 Low quality argan oil elimination

Traditionally prepared argan oil is certainly not a low quality argan oil. However, its preservation properties are lower than those of press-extracted oil. Therefore, methods identifying the extraction method are useful. Metal content determination has been suggested as a quality criteria to discriminate mechanically pressed oil from traditionally prepared oil [41]. Low quality argan oil can be defined as an oil prepared from argan kernels that have not been properly obtain; most of the time, from goat-digested fruit, a "forbidden" practice that affords an oil with low preservation property and a modified taste. Detection of low quality argan oil is a difficult task since regular minor components are generally similar to -or in the margin of error of- that of high quality argan oil. Therefore, methods designed to detect argan oil adulteration by cheap oils are useless to detect low quality argan oil. Introduction of goat-digested fruit in argan oil preparative process has been shown to modify argan oil odorant composition [42]. If the detection and quantification of these odorants can be a difficult task, sensory evaluation performed by a trained panel has been shown to be a very efficient method to detect such process misconduct [43]. For the sensory evaluation of argan oil, negative descriptors are "fusty," burnt, rancid, and "roquefort cheese" [44].

The use of goat-digested fruit is not the only deficient method that leads to low quality argan oil. Any factors altering fruit quality should be eliminated. Therefore, a full set of good preparation recommandations has been definied resulting from several scientific studies. Hence, argan fruit should collected in mid-summer, at the end of the ripening period [45]. If fruit is collected well ripen, fruit form could be a useful marker to produce naturally enriched argan oil. Indeed, apiculate fruit would produce a δ-tocopherol rich oil, whereas spherical and fusiform fruit yield an oil rich in linoleic and oleic acid, respectively [46].

Then, fruit should be sun-dried between 10 and 14 days to preserve kernels quality [47]. If not rapidly processed, kernels should be stored at 5°C and protected from sunlight [48]. To prepare edible argan oil, kernels should be roasted at 110°C for 15–30 min [49]. Roasting leads to the formation of volatile compounds responsible for edible argan oil taste and flavor. Forty volatiles have been identified, quantified and their formation kinetic studied over 30 min [50]. Interestingly, roasting time modulation should lead to the production of argan oil presenting a variety of taste [50]. The respect of these conditions allows the production of an oil presenting good thermal stability [51] and preservation properties and

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whose shelf-life exceeds 2 years [52]. Such good preservation profile results likely from argan oil chemical composition. It is indeed a rich source of powerful anti oxidants among which are tocopherol and polyphenols [53] but also Coenzyme Q10 and melatonin, but not Coenzyme Q9 [54]. The high phospholipid content of edible argan oil has also led to suggest that phospholipids could actively participate in argan oil preservation [55].

4 Conclusions

The success of argan oil is a result of its high quality and of course of its pharmacological properties. This fast growing domain is frequently reviewed [1, 2, 56–62]. Therefore, this aspect has not be detailed here.

The authors have declared no conflict of interest.

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