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Cropwatch's Argan Oil Bibliography.

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[to be progressively extended].

Contents.

Composition of Argan Oil.

Alaoui A., Charrouf Z., Soufiaoui M., Carbone V., Malorni A., Pizza C. & Piacente S. (2002). « Triterpenoid saponins from the shells of *Argania spinosa* seeds." *J. Agric. Food Chem*. **31**, 4600-4603. Abstract. Two new oleanene saponins were isolated from the MeOH extract of the shell of *Argania spinosa*. They possess protobassic acid and 16α-protobassic acid as aglycons. The disaccharide moiety linked to C-3 of the aglycon is made up of two glucose units; the pentasaccharide moiety linked to C-28 is made up of arabinose, xylose, and three rhamnose units. Their structures were elucidated by 1D and 2D NMR experiments including 1H–1H (DQF-COSY, 1D TOCSY, and 2D HOHAHA) and 1H–13C (HSQC and HMBC) spectroscopy along with mass spectrometry.

Brand H. (2002) "The Unsaponifiable Fraction" *Soap, Perfumery and Cosmetics* Sept 2002 p39-44.

Cayuela J.A., Rada M., Pérez-Camino M.C., Benaissa M., Abdelaziz E. & Guinda A. (2008) "Characterization of artisanally and semiautomatically extracted argan oils from Morocco." *European Journal of Lipid Science and Technology* **110**(12), 1159-1166. Abstract. The present study was conducted to know the possible influence of the seed treatment, method of extraction and geographical origin on the quality and chemical composition of argan oil. Artisanally and semiautomatically extracted argan oils, from roasted and unroasted seeds, from interior and coast areas, were studied. The quality parameters analyzed were

acid value, peroxide value, K232 and K270, triacylglycerols and fatty acid composition, polar compounds, total phenols, tocopherol content and oil stability index (OSI). Seed treatment and extraction method showed a higher influence on quality parameters than geographical area; the quality parameters of the different oils were discussed. The total phenolic content in all analyzed samples was lower than 10 ppm. -Tocopherol was the major tocopherol (84.4-86.4%) with a high contribution to the total tocopherol content (383-485 ppm). The OSI of the argan oil samples were well correlated (R = 0.97) with the tocopherol contents. The argan oil samples obtained from roasted seeds presented higher stability (26-38 h) than the oils from unroasted seeds (16-32 h).

Charrouf Z. & Guillaume D. (2007) "Phenols and polyphenols from Argania spinosa." American J Food Tech. 2, 679-683. Abstract. *Argania spinosa* is a tree specifically growing in Morocco. Its seeds contain two or three oleaginous kernels that are crushed to afford argan oil, an oil of high dietetic value. Cardioprotective argan oil properties have been associated with the presence of various (poly)phenols within the oil. In addition to tocopherols, caffeic acid, oleuropein, vanillic acid, tyrosol and catechol are the main phenols identified so far from argan oil. Resorcinol (-)-epicatechin and (+)-catechin are the main polyphenols. The full (poly)phenol composition of argan oil and of the different parts of the tree, is presently reviewed together with the recent development of argan (poly)phenols as cosmetic ingredients.

Charrouf Z., Hilali M., Jauregui O., Soufiaoui M. & Guillaume D. (2007) "Separation and characterization of phenolic compounds in argan fruit pulp using liquid chromatography–negative electrospray ionization tandem mass spectroscopy." *Food Chemistry* **100**(4), 1398-1401. Abstract. Liquid chromatography (LC) coupled to negative electrospray ionization (ESI) tandem mass spectrometry (MS/MS) was used for the sensitive identification of phenolic compounds in argan fruit pulp. Sixteen compounds were identified, mainly flavonoid glycosides and flavonoid aglycons.

Charrouf Z. & Guillaume D. (2002) "Secondary metabolites from *Argania spinosa* (L.) Skeels." *Phytochemistry Reviews* **1**(3), 345-354. Abstract. *Argania spinosa* (L.) Skeels is a tree that plays a crucial role in the rural and urban economy of Morocco. Not only is the tree used in traditional medicine but its fruits contain almonds used to prepare an edible oil, its leaves are utilized to feed cattle, and its wood is used as fuel. In addition the tree is particularly well-adapted to arid lands and could hence be used to limit the desert progression that is threatening subtropical African countries. Consequently a program aimed at a better understanding of all the aspects and uses of the argan tree is currently being carried out in Morocco. This review summarizes the results gathered so far on the phytochemical and pharmacological activity of *A. spinosa*.

Charrouf Z., Wieruzeski J.M., Fkih-Tétouani S., Leroy Y., Charrouf M. & Fournet B. (1992). “Triterpenoid saponins from *Argania spinosa*.” *Phytochemistry* **31**, 2079–2086. Abstract. Five new oleanane saponins named arganine A, B, D, E and F and two known saponins: arganine C and mi-saponin A were isolated from

the kernel of *Argania spinosa*. The structures of these saponins were elucidated by using 1H NMR, 1H-1H COSY NMR, 13C NMR, FAB mass spectrometry and chemical evidence.

Chimi H. (2005) "Comparative preservation: argan oil and olive oil." *Cahiers Agric*. **14**(5), 467-71. Abstract. This study compares the stability during storage of samples of argan oil (derived from the seeds of *Argania spinosa*, an evergreen of the Sapotaceae family that grows in Morocco) and olive oil, produced by both traditional and industrial techniques. Shelf life of these samples was measured by peroxide values and formation of conjugated dienes after storage in the dark at 35 ± 1°C. Argan oil samples showed more stability than olive oil samples. In addition, oil samples extracted traditionally were less stable than those obtained by industrial techniques for both types of oil. For oil samples extracted by traditional techniques, a peroxide value of 20 meq. O 2/kg and conjugated diene levels resulting in absorbance at 270 nm of 0.30, were reached in 99 days for olive oil and 200 for argan oil. These values were not obtained for industrial samples until 210 and 270 days, respectively. The greater stability of argan oil may be due to the activity of natural phenol compounds and tocopherols and to factors related to the extraction process. The lower stability of the same oils traditionally produced, compared with industrial samples, is related mainly to the failure to comply with processing parameters.

Chimi H.R.M., Cillard J. Cillard, P (1988).” Etude de la fraction phenolique des huiles d’olive vierge et d’argan du Maroc." *Actes Inst. Agron. Vet*. **8**, 17-21.

Chimi H., Cillard J. & Cillard P. (1994) "Autoxydation of argan oil Argania spinoza L. from Morocco." *Sciences des Aliments* **14**(1), 119

Farines M., Soulier J., Charrouf M. & Cave, A. (1984) "Etude de l’huile des graines d’*Argania spinosa* (L.), Sapotaceae.. II. Sterols, alcools, triterpe´niques et me´thylste´rols de l’huile d’argan." *Rev. Fr. Corps Gras* **31**, 443-448.

Farines M., Charrouf M. & Soulier J. (1981). “The sterols of *Argania spinosa* seed oil.” *Phytochemistry* **20**, 2038-2039.

Habibi Y. & Vignon M.R. (2005) "Isolation and characterization of xylans from seed pericarp of *Argania spinosa* fruit." *Carbohydrate Research* **340**(7), 1431-1436. Abstract. Hemicellulose-type polysaccharides were isolated from the pericarp of seeds of *Argania spinosa* (L.) Skeels fruit by sequential alkaline extractions and fractionated by precipitation. Water soluble and water insoluble fractions were obtained, purified and characterized by sugar analysis and 1H and 13C NMR spectroscopy. The water soluble fractions were assumed to be (4-O-methyl-d-glucurono)-d-xylans, with 4-O-methyl-d-glucopyranosyluronic acid groups linked to C-2 of a (1→4)-β-d-xylan. The 1H NMR spectrum showed that the water soluble xylans have, on average, one non-reducing terminal residue of 4-O-methyl-d-glucuronic acid for every seven xylose units. The water insoluble fractions consisted of a neutral xylan with linear (1→4)-β-d-xylopyranosyl units.

Hilali M., Charrouf Z., El Aziz Soulhi A., Hachimi L. & Guillaume D. (2007) "Detection of Argan oil adulteration using quantitative campesterol GC-Analysis" *JAOCS* **84**(8), 761-4. Abstract. Detection of edible oil adulteration is of utmost important to ensure product quality and customer protection. Campesterol, a sterol found in seed oils, represents less than 0.4% of argan oil total sterol content. Quantitative analysis of campesterol by gas chromatography of argan oil and of a mixture of argan oil and readily commercially available vegetable oils, consecutively with sterol separation, was carried out. Our study clearly demonstrated that determination of the campesterol level in argan oil (or oil presented as argan oil) can be proposed as the major analysis method to assess unambiguously argan oil purity up to 98%.

Hilali M., Charrouf Z., El Aziz Soulhi A., Hachimi L. & Guillaume D. (2005) “Influence of origin and extraction method on Argan Oil physico-chemical characteristics and composition.” *J. Agric. Food Chem*. **53**(6), 2081-7. Abstract. Twenty one samples of argan oil of different geographical origin (Tidzi, Tamanar, Benaiznassen, Ait mzal, Ait Baha, Ighrem, Aoulouz) and/or prepared following a different process (traditional, mechanical, or industrial) were collected and their physico-chemical properties analyzed. Sample acidity was found between 0.14 and 1.40%, unsaponifiable matter between 0.34 and 0.79%, saponification value between 180.0 and 199.6, highest peroxide index was 5.72 meq/kg, refractive index (20 °C) between 1.4644 and 1.4705, and UV absorption at 270 nm between 0.228 and 0.605. This study, carried out on randomly selected samples, clearly demonstrates that press extraction does not alter either the chemical composition of argan oil or its physico-chemical characteristics. It also demonstrates that press extraction respects the critical factors reported for traditionally prepared oils and necessary to obtain a beneficial effect on human health (a specific fatty acid balance and high tocopherol and sterol levels). In addition, this study should be useful for the establishement of a national quality standard.

Khallouki F., Spiegelhalder B., Bartsch H. & Owen R.W. (2005) "Secondary metabolites of the argan tree (Morocco) may have disease prevention properties." *African Journal of Biotechnology* 4 (5), 381-388. Abstract. The argan tree (*Argania spinosa* L. Skeels) is native to Morocco, where after the Holly oak it constitutes the second most common tree in the country. Recent studies suggest that dietary argan oil, an endemic seed oil from argan fruits, may have a relevant role in disease prevention, and its consumption could protect against atherosclerosis and cancer. Unfortunately, in less than a century, more than a third of the forest has disappeared. It is therefore imperative to improve the tree's production potential so that it can regain its key position in the agricultural systems of the region. On the basis of ethnobotanical knowledge, researchers are screening metabolites of this rare plant to identify bioactive compounds for the development of new therapeutic agents and food supplements. This includes studies on secondary metabolites with chemopreventive activities. In this review, a complete outline of components (triglycerides, unsaponifiable, phenolic antioxidants and aroma constituents) are described. Finally, a discussion of the

biological functions of the polar and non-polar *A. spinosa* products which have been evaluated using a range of in vitro bioassays are described.

Khallouki F., Younos C., Soulimani R., Oster T., Charrouf Z., Spieglehalder B., Batsch H. & Owen R.W. (2003). "Consumption of argan oil (Morocco) with its unique profile of fatty acids, squalene, sterols, tocopherols and phenolic antioxidants should confer valuable cancer chemopreventive effects.". *Eur. J. Cancer Prev.* **12**, 67-75. Abstract. The aim of this study was to evaluate the fatty acids, tocopherols, squalene, sterols and phenolic antioxidants in three types of argan oil (Moroccan food, Moroccan aesthetic and a French commercial variety) along with a basic comparison with extra virgin olive and sunflower oil. The fatty acid profiles in the argan oils were very similar, with oleic acid (43%) and linoleic acid (36%) and their respective monoacylglycerols predominating. The major vitamer identified was γ-tocopherol with a mean of 483±11 mg/kg, in contrast to α-tocopherol, which is the major vitamer in olive (190±1 mg/kg) and sunflower oil (532±6 mg/kg). The squalene content of the argan oils was very similar with a mean of 313±4 mg/100 g, which is lower than that of the olive oil (499 mg/100 g) but significantly higher than in the sunflower oil (6 mg/100 g). In contrast to olive and sunflower oils in which β-sitosterol is predominant, the major sterols detected in the argan oils were schottenol (mean 147±10 mg/kg) and spinasterol (mean 122±10 mg/kg). The only phenolic compounds other than the tocopherol vitamers which could be readily detected and quantitated were vanillic, syringic and ferulic (probably conjugated to glucose) acids along with tyrosol. In contrast to the extra virgin olive oil (793 mg/kg), the concentration of total phenolic compounds is extremely low (<5.0 mg/kg). Nevertheless, argan oil with its high content of the vitamer γ-tocopherol, squalene and oleic acid is likely to enhance the cancer prevention effects of the Moroccan diet.

Khallouki F. (2003). "Ethnobotanical, phytochemical and pharmacological studies of 3 African medicinal plants containing potent antiradical principles." *PhD Dissertation, University of Metz, Metz, France.*

T.J. Lybbert (2007). "Patent disclosure requirements and benefit sharing: A counterfactual case of Morocco's argan oil". *Ecological Economics* **64,** 12–18. Abstract. This article uses the seemingly promising case of Morocco's argan oil to assess the value of patent disclosure requirements (PDRs) as a policy instrument aimed at improving the sharing of biodiversity benefits. After introducing the disclosure requirements debate and discussing relevant features of the argan oil case, I construct a simple counterfactual by asking: "How would PDRs have changed benefit sharing in the argan oil case?" From this case, three practical considerations emerge that shed a realistic, if cautious, light on the marginal value of PDRs as a benefit sharing mechanism: (1) PDRs require an accompanying national biodiversity regime but their relative value is inversely proportional to regime strength (2) PDRs should be assessed based on the additional compliance incentives they provide and median, not blockbuster, patent values and (3) the alternative to no PDRs and no regime is not zero benefits. While these considerations are inherently country-specific, PDRs should

generally be assessed at the margin rather than in vague conceptual and aggregate ways.

Maurin R., Fellat-Zarrouck K. & Ksir M. (1992) "Positional analysis and determination of triacylglycerol structure of `*Argania spinosa* seed oil." *JAOCS* **69**(2), 141-5. Abstract. The distribution of fatty acids between the sn-1, sn-2 and sn-3 positions of triacylglycerols from *Argania spinosa* seed oil of Morocco has been determined. Saturated fatty acids showed a preference for external positions. The sn-1 position contained slightly more palmitic acid than the sn-3 position, whereas stearic acid was preferentially esterified at the sn-3 position. Linoleic acid occurred predominantly in the sn-2 position with lesser amount evenly distributed between the sn-1 and the sn-3 positions, as generally found in vegetable oils. Oleic acid was distributed with a slight preference shown for the internal position, whereas the distribution between the external positions revealed a slight preference for the sn-1 position. The distribution of the triacylglycerols determined from high-performance liquid chromatography (HPLC) is at variance with that calculated from the 1-random 2-random 3-random distribution theory. This is particularly true for trioleoyl and trilinoleoylglycerols. In contrast, the agreement between theory and experiment is good for triacylglycerols containing two oleoyl and one linoleoyl chains, one oleoyl, one linoleoyl and one palmitoyl chains or one oleoyl, one palmitoyl, and one stearoyl chains.

Mouffak R. (1988) *[Characterization of alimentary vegetable oil by their chemical composition: case of olive and argan oil] Thesis Institut Agronomique et Veterinaire Hassan 2, Rabat (Morocco)* July 1988 Abstract. Etude presentant les caracteristiques des huiles d'olive et d'argan par leur composition en acides gras determinees par chromatographie en phase gazeuse (C.P.G.) ainsi que par leurs composes phenoliques determines par colorimetre et par chromatographie liquide a haute performance

Rahmani M. (2005) "The chemical composition of “virgin” argan oil." *Cahiers Agric*. **14**(5), 461-5. Abstract. The argan tree (*Argania spinosa*) grows endemically in the South-West of Morocco\; its fruits yield an edible oil. Oil extraction remains traditional, although some modernization in the process has been noticed in recent years. A moroccan standard (N.M. 08.5.090) was elaborated in 2003 to define the specifications of “virgin” argan oil. It gives, among other things, the qualitative classification of the oil and its chemical composition. The oil is of the oleic-linoleic type, with a high content of tocopherols (600-900 mg/kg). The sterolic fraction excludes any Δ 5 sterols\; the schottenol represents about 50% of this fraction. The fraction of triterpenic alcohols and methylsterols is represented mainly by tirucallol, β-amyrin, and butyrospermol. Argan oil has been used for centuries by locals for food and body care, and also for the treatment of some pathologies. A better knowledge of its biochemical composition is at the origin of a renewed interest for studies about its nutritional properties or its cosmetic value.

Ray B., Loutelier-Bourhis C., Lange C., Condamine E. Driouich A. & Lerouge P. (2004) "Structural investigation of hemicellulosic polysaccharides from *Argania spinosa*: characterisation of a novel xyloglucan motif." *Carbohydrate Research* **339**(2), 201-208. Abstract. Hemicellulose polymers were isolated from *Argania spinosa* leaf cell walls by sequential extractions with alkali. The structure of the two main polymers, xylan and xyloglucan, was investigated by enzyme degradation with specific endoglycosidases followed by analysis of the resulting fragments by high performance anion exchange chromatography (HPAEC) and matrix-assisted laser desorption ionisation-time of flight mass spectrometry (MALDI-TOF MS). The results show that A. spinosa xylan is composed of a β-(1 → 4)-linked-d-xylopyranose backbone substituted with 4-O-methyl-d-glucuronic acid residues. Xyloglucan oligosaccharide subunits were generated by treatment with an endo-(1 → 4)-β-d-glucanase of the xyloglucan-rich hemicellulosic fractions. MALDI-TOF mass spectra and HPAE-PAD chromatography of the pool of endoglucanase-generated xyloglucan oligomers indicated that A. spinosa cell wall contains a XXXG-type xyloglucan. In addition to XXXG, XXFG, XLXG/XXLG, XLFG fragments previously characterised in various plants, a second group of XXXG-type fragments was detected. The primary structure of the major subunit was determined by a combination of sugar analysis, methylation analysis, post-source decay (PSD) fragment analysis of MALDI-TOF MS and 1H NMR spectroscopy. This fragment, termed XUFG, contains a novel β-d-Xylp-(1 → 2)-α-d-Xylp side chain linked to C-6 of the second glucose unit from the nonreducing end of the cellotetraose sequence. A novel xyloglucan fragment was isolated from *Argania spinosa* leaf cell walls and characterised by a combination of sugar analysis, methylation analysis, post-source decay (PSD) fragment analysis of MALDI-TOF MS and 1H NMR spectroscopy. This fragment, termed XUFG, contains a novel β-d-Xylp-(1 → 2)-α-d-Xylp side chain linked to C-6 of the second glucose unit of the cellotetraose sequence.

Rojas L.B., Quideau S., Pardon P. & Charrouf Z. (2005) "Colorimetric evaluation of phenolic content and GC-MS characterization of phenolic composition of alimentary and cosmetic Argan oil and press cake." *J. Agric. Food Chem.* **53**, 9122-9127 Abstract. The global phenolic content of argan oil and press cake samples (alimentary and cosmetic) was evaluated using the Folin-Ciocalteu colorimetric method and the phenolic composition of argan oil (alimentary and cosmetic) and press cake (alimentary) samples were analyzed by GC-MS after extraction with 80:20 (v/v) methanol:water and silylation. Identification of chromatographic peaks was made by mass selective detection. Nineteen simple phenols were detected, 16 in press cake, 6 in the alimentary oil, and 7 in the cosmetic oil, among which 15 compounds [3-hydroxypyridine (3-pyridinol), 6-methyl-3-hydroxypyridine, catechol, resorcinol, 4-hydroxybenzyl alcohol, vanillin, 4-hydroxyphenylacetic acid, vanillyl alcohol, 3,4-dihydroxybenzyl alcohol, 4-hydroxy-3-methoxyphenethyl alcohol, methyl 3,4-dihydroxybenzoate, hydroxytyrosol, protocatechuic acid, epicatechin, and catechin] were identified for the first time in such materials.

Cancer Prevention.

Bennani H., Fiet J. & Adlouni A. (2009) "Impact de l'huile d'argan sur le cancer de la prostate : étude de l'effet antiprolifératif des polyphénols [Impact of argan oil on prostate cancer Antiproliferative effect study of polyphenols]. *Revue Francophone des Laboratoires* 2009 (416) Suppl. 1, 23-26. Abstract. Diet is one of the environmental factors susceptible to develop or reduce the cancer risk. Several studies have shown that three cancer types (breast, prostate and digestive) can be influenced by diet, especially lipid and antioxidant intake. In this field, our study is dedicated to valorise endemic oil from the south eastern of Morocco. The chemical composition of Argan oil is composed by 99% glyceridic fraction rich in unsaturated fatty acid and by 1% of unsaponifiable fraction containing hydrocarbures, carotenes, tocopherols, sterols and polyphenols. The objective of our work is ti investigate the effect of polyphenols extracted from argan oil on the proliferation of two human epithelial cell lines (PNT1A et PC3) and one epithelial cell lines from dog adenocarcinome (DPC1). We have used the MTT test for evaluating citotoxicity of these molecules and counting of cell nucleus for evaluating the influence of polyphenols on the proliferation of the three cell lines. Our results show that the poluphenols of argan oil exert a dose dependant antiprroliferative action on PC3 and DPC1 cell lines. However, no inhibition effect has been shown on PNT1A cell lines. In conclusion, Argan oil could contribute by it rich composition of polyphenols to the prevention of some cancers such prostate cancer.

Bennani H., Drissi A., Giton F., Kheuang L., Fiet J. & Adlouni A. (2007) "Antiproliferative effect of polyphenols and sterols of virgin argan oil on human prostate cancer cell lines." *Cancer Detection and Prevention* **31**(1), 64-69. Abstract. Background: The aim of our study has to evaluate the antiproliferative effect of polyphenols and sterols extracted from the virgin argan oil on three human prostatic cell lines (DU145, LNCaP, and PC3). Methods: Cytotoxicity, anti-proliferative effects and nuclear morphological changes of cells were analyzed after treatment with sterols and polyphenols. The results were compared to 2-methoxyestradiol (2ME2) as positive control. Results: Polyphenols and sterols of virgin argan oil and 2ME2 exhibited a dose-response cytotoxic effect and antiproliferative action on the three tested cell lines. The antiproliferative effect of polyphenols was similar for the DU145 and LNCaP cell lines; the GI50 (defined as the concentration inhibiting growth by 50% in comparison with the control) was respectively 73 and 70µg/ml. The antiproliferative effect of sterols was 46 and 60µg/ml as GI50 for the DU145 and LNCaP cell lines. For the PC3 cell line, the best antiproliferative effect was obtained by argan sterols with GI50=43µg/ml. On the other hand, the nuclear morphology analyses have shown an increased proportion of pro-apoptotic of nuclei in LNCaP cell treated with IC50 of polyphenols or sterols compared to control cells. Our results show for the first time the antiproliferative and pro-apoptotic effects of polyphenols and sterols extracted from virgin argan oil and confirm the antiproliferative and pro-apoptotic effects of 2ME2 on prostate cancer cell lines. Conclusion: These data suggest that argan oil may be interesting in the development of new strategies for prostate cancer prevention.

Drissi A., Bennani H., Giton F., Charrouf Z., Fiet J. & Adlouni A. (2006) "Tocopherols and saponins derived from *Argania spinosa* exert, an antiproliferative effect on human prostate cancer." *Cancer Investigation* **24**(6), 588-592. Abstract. The aim of our study is to evaluate the antiproliferative effect of tocopherols obtained from alimentary virgin argan oil extracted from the endemic argan tree of Morocco and of saponins extracted from argan press cake on three human prostatic cell lines (DU145, LNCaP, and PC3). The results were compared to 2-methoxyestradiol as antiproliferative drug candidates. Cytotoxicity and antiproliferative effects were investigated after cells' treatment with tocopherols and saponins compared to 2-Methoxyoestradiol as the positive control. Tocopherols and saponins extracted from argan tree and 2-methoxyestradiol exhibit a dose-response cytotoxic effect and an antiproliferative action on the tested cell lines. The best antiproliferative effect of tocopherols is obtained with DU145 and LNCaP cell lines (28 µg/ml and 32 µg/ml, respectively, as GI50). The saponins fraction displayed the best antiproliferative effect on the PC3 cell line with 18 µg/ml as GI50. Our results confirm the antiproliferative effect of 2-methoxyestradiol and show for the first time the antiproliferative effect of tocopherols and saponins extracted from the argan tree on hormone-dependent and hormone-independent prostate cancer cell lines. These data suggest that argan oil is of potential interest in developing new strategies for prostate cancer prevention.

Khallouki F., Younos C., Soulimani R., Oster T., Charrouf Z., Spiegelhalder B., Bartsch H. & Owen R.W. (2003) "Consumption of argan oil (Morocco) with its unique profile of fatty acids, tocopherols, squalene, sterols and phenolic compounds should confer valuable cancer chemopreventive effects." *European j of Cancer Prevention* **12**(1), 67-75. Abstract. The aim of this study was to evaluate the fatty acids, tocopherols, squalene, sterols and phenolic antioxidants in three types of argan oil (Moroccan food, Moroccan aesthetic and a French commercial variety) along with a basic comparison with extra virgin olive and sunflower oil. The fatty acid profiles in the argan oils were very similar, with oleic acid (43%) and linoleic acid (36%) and their respective monoacylglycerols predominating. The major vitamer identified was γ-tocopherol with a mean of 483±11 mg/kg, in contrast to α-tocopherol, which is the major vitamer in olive (190±1 mg/kg) and sunflower oil (532±6 mg/kg). The squalene content of the argan oils was very similar with a mean of 313±4 mg/100 g, which is lower than that of the olive oil (499 mg/100 g) but significantly higher than in the sunflower oil (6 mg/100 g). In contrast to olive and sunflower oils in which β-sitosterol is predominant, the major sterols detected in the argan oils were schottenol (mean 147±10 mg/kg) and spinasterol (mean 122±10 mg/kg). The only phenolic compounds other than the tocopherol vitamers which could be readily detected and quantitated were vanillic, syringic and ferulic (probably conjugated to glucose) acids along with tyrosol. In contrast to the extra virgin olive oil (793 mg/kg), the concentration of total phenolic compounds is extremely low (<5.0 mg/kg). Nevertheless, argan oil with its high content of the vitamer γ-tocopherol, squalene and oleic acid is likely to enhance the cancer prevention effects of the Moroccan diet.

Ecology, Conservation & Economic Importance.

Alouani M. (1997) *Contribution a l'elaboration d'un protocol de production de plantsd'arganier en pepiniere.* Thesis, Université Ibnou Zohr, Agadir, Morocco.

Bani-Aameur F. & Sipple-Michmerhuizen J. (2001) "Germination and seedling survival of Argan (*Argania spinosa*) under experimental saline conditions." Journal of Arid Environments 49(3),533-540. Abstract. Solutions of NaCl at various concentrations (0, 2·5, 5, 7·5 and 10 gl–1) were used to treat argan (Argania spinosa (L.) Skeels) at germination and as container-grown seedlings. We assessed germination percentage, radicle length and dry weight as well as seedling survival and number of days before seedling collapse. Increasing salt concentration did not delay the beginning of germination but it lowered the germination rate and reduced the final germination percentage. At the seedling stage, increasing salinity levels resulted in decreasing growth, increasing ionic toxicity symptoms and reduced survival as compared to the control. Argan did not behave as a salt-tolerant species showing damage at as low as 2·5 gl–1, the upper limit for survival being 7·5 gl–1. However the effect mother-tree was highly significant indicating that much selective potential is probably available for breeding for salt tolerance within natural argan populations.

Bani-Aameur F. (1997) "L'Arganier: Un Candidat à la Domestication", *Working paper, Laboratoire de Recherche sur la Variabilité Génétique, Université Ibnou Zohr, Agadir.*

Barrett C.B. & Lybbert T.J. (2000) "Is bioprospecting a viable strategy for conserving tropical ecosystems?" *Ecological Economics* **34**(3), 293-300. Abstract. Market-based approaches to biodiversity conservation gained popularity in the 1990s. the success of these strategies hinges on, first, the successful creation or expansion of target markets and, second, the beneficial involvement of local stakeholders in these markets so that improved incentives induce conservation. This paper evaluates these two key elements in the case of argan oil commercialization in southwestern Morocco. The principal finding is that even when locals appear well-positioned to reap ex post benefits, one can reject the hypothesis that successful resource commercialization necessarily stimulates local development and reduces poverty.

Bas P., Dahbi E., El Aïch A., Morand-Fehr P. & Araba A. (2005)."Effect of feeding on fatty acid composition of muscles and adipose tissues in young goats raised in the Argan tree forest of Morocco." *Meat Sci.*, **71**: 317-326.

Boscher, C. (1992). *Fragilité et résilience du système agraire de l'arganeraie des Ait Baha vis-à-vis des aléas climatiques. Rapport de fin d'études de l'Ecole Supérieure d'Agronomie Tropicale, Montpellier, 69 pp.*

Bousquet V. (2000). *L'élevage caprin dans le système agraire de l'arganeraie. Rapport de l'Institut Agronomique Méditerranéen de Montpellier, 87 p.*

Boukhobza M. & Pichon-prum N. (1988). "L'Arganier, resources économiques et médicinales pour le Maroc." *Phytotherapy* **27**, 21-26.

Charrouf Z. (1996) "Valorisation des produits de l'Arganier", *Paper presented at Groupement d'Etudes et de la Recerche pour la Promotion d'Essaouira (GERPE), 29-30 September, Essaouira, Morocco.*

Clarius T., Stussi I., Henry F., Pauly G., Benoit I. & Charrouf Z. (2006) "*Argania spinosa*: How ecological farming, equitable trade & sustainability can drive research for new cosmetic active ingredients". *Journal of Polish Society of Cosmetic Chemists* **9**(1), No. 1 (2006).

El Aïch A., Bourbouze A. & Morand-Fehr, P. (2005). "La chèvre dans l'arganeraie. " *Acte de l'Institut Agronomique et Vétérinaire Hassan II*, pp. 136.

Fiat L. (1989). *Les voies d'amélioration de l'élevage caprin dans le système agraire de l'arganeraie de la région d'Essaouira. Rapport de stage, ENSSAA, Dijon, IAM Montpellier, 88 p.*

Koubby F. (1997) *Evaluation de la Documentation sur l'Arganeraie. Agadir, Morocco: Projet deConservation et Développment de l'Arganeraie (GTZ.*

Lopez-Feldman A., Mora J. & Taylor E. (2007) "Does natural resource extraction mitigate poverty and inequality? Evidence from rural Mexico and a Lacandona Rainforest Community." *Environment and Development Economics*, **12**(2), 251-269. Abstract. The potential importance of natural resources for the livelihood of poor rural households has long been recognized but seldom quantified and analyzed. In this paper, we apply poverty and inequality measures to national and community level data sets to explore the impacts of resource extraction on rural welfare. Our findings suggest that natural resource extraction reduces both income inequality and poverty. Results from a simulation analysis at the community level indicate that poverty may be reduced, in the short-run, by increases in the price of a non-timber forest product. ***Cropwatch comments:*** Cites the example of argan oil exploitation in Morocco giving gains for locals and a reduction in poverty.)

Luth D. (2004) "Argan oil: Implications as a geographical indication." *TED Case Studies.*

Lybbert T.J., Wilkes H.L., Barrett C.B., Narjisse H. & Rabat M. (undated) "Commercializing Argan oil in Southwestern Morocco: Pitfalls on the pathway to sustainable development." – can still be seen as an hmtl document at: http://74.125.155.132/scholar?q=cache:8NkBVuo34sQJ:scholar.google.com/+argan+oil+threatened&hl=en&as_sdt=2000

Lybbert T., Barrett C.B. & Narjisse H. (2002) "Does resource commercialization Induce local conservation? A cautionary tale from Southwestern Morocco." *Cornell University Dept. of Applied Economics & Management Working Paper*. Abstract: Ecotourism, bioprospecting and non-timber product marketing have

been promoted recently as market-based instruments for environment protection, but without sound understanding of the resulting net conservation effects. We present evidence on the local conservation effects of recent argan oil commercialization in Morocco, which seems a promising case study in conservation through resource commercialization. Our empirical analysis shows, however, that resource commercialization is not creating strong net conservation incentives because assumptions implicit in the prevailing logic prove incorrect in this case. Generally, the experience of southwestern Morocco provides a cautionary tale about the assumed efficacy of conservation strategies founded on resource commercialization.

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Lybbert T.J., Barrett C.B. & Narjissue H (2002) “"Market-based conservation and local benefits: the case of argan oil in Morocco." *Ecological Economics* **41**(1), 125-144. Abstract. Market-based approaches to biodiversity conservation gained popularity in the 1990s. The success of these strategies hinges on, first, the successful creation or expansion of target markets and, second, the beneficial involvement of local stakeholders in these markets so that improved incentives induce conservation. This paper evaluates these two key elements in the case of argan oil commercialization in southwestern Morocco. The principal finding is that even when locals appear well-positioned to reap ex post benefits, one can reject the hypothesis that successful resource commercialization necessarily stimulates local development and reduces poverty. Most locals participate only superficially in the new and expanded markets for argan oil, and the benefits that do trickle down to local households appear to be regressively distributed, both regionally and between households. The key lies in understanding how opening or expanding markets may induce endogenous product differentiation that easily excludes locals, especially the poor, and how ex ante market access - a variable commonly correlated with wealth - conditions households’ capacity to participate in market-induced producer windfalls.

Lybbert T. (2000). *Local Development and Conservation Consequences of a Bioprospecting-Based Boom: The Case of Morocco’s Argan Oil, M.S. Thesis, Cornell University, Ithaca,NY*.

Lybbert T.J.., Barrett C.B. & Narjisse H. (2001) “Who Benefits from a Bioprospecting-Based Boom? The Case of Argan Oil in Morocco”, Available at SSRN: http://ssrn.com/abstract=257326 Abstract This paper breaks new ground in the literature on bioprospecting by evaluating the local welfare effects associated with the successful bioprospecting-driven commercialization of argan oil in southwestern Morocco. The principal finding is that even when locals appear well-positioned to reap the ex post benefits of a bioprospecting success, one can reject the hypothesis that successful bioprospecting fuels local development and reduces poverty. Most locals participate only superficially in the bioprospecting-based boom and the benefits that do trickle down to local households appear to be regressively distributed, both regionally and between households. The key lies in understanding how opening up to new markets may induce endogenous product differentiation that easily excludes locals, especially

the poor, and how ex ante market access - a variable commonly directly related to wealth - conditions households' capacity to participate in market-induced producer windfalls.

Majourhat K., Jabbar Y., Araneda L., Zeinalabedini M., Hafidi A. & Martínez-Gómez P. (2007) "Karyotype characterization of *Argania spinosa* (L.) Skeel (Sapotaceae)." *South African Journal of Botany* **73**(4), 661-663. Abstract. Argania spinosa (L.) Skeel is an endemic species from Southwest Morocco being the unique representative of the tropical Sapotaceae in this area. The cytology of this species is poorly known in spite of its great socio-economical and ecological interest in these arid and semi-arid zones. The objective of this work is to characterize the karyotype of *A. spinosa* species in somatic cells from root tips. Samples analyzed showed a karyotype constituted for ten pairs of chromosomes (2n = 2x = 20) and the putative karyotype proposed has been of four submetacentric and six metacentric pairs. The four submetacentric pairs were the longest with a mean total length between 1.14 and 1.69 µm and the total length of six metacentric pairs were between 0.59 and 1.03 µm.

Mellado J. (1989) “SOS Sousse: Argan Forest Destruction in Morocco.” *Oryx.* **23**(2), 87-93. Abstract. The Souss Valley in Morocco still has remnants of forest dominated by the argan tree, which is endemic to the Atlantic coast of north-west Africa. The tree is valued for its edible oil and its timber, and the argan forest ecosystem is rich in species. The forest has been exploloted sustainably by man for thousands of years, but modern developments have destroyed or damaged much of it, especially in the lowlands. The author, who worked in the region for three years, is alarmed at the rapidly increasing destruction. He makes a plea for effective protection of the remaining argan forest and for a plan for its sustainable exploitation.

Mohammed G. (1981). *Etude experimentale sur la germination des semences de l’arganier, Thesis, Institute Agronomique et Veterinaire-Hassan II, Agadir, Morocco*

Montague-Jones G. (2007) "Moroccan argan oil cosmetics bound for international markets." *Cosmetics Design-Europe* 27.07.2007. ***Cropwatch comments:*** Trade-based promotional article for Marrakech-based Kaeline company which produces a range of skin care products containing argan oil. Jackie Miles founder of Xandra Renouvelle which sells Kaeline products is reported as saying that by selling Kaeline's products in the US it is fighting female poverty and destitution in Morocco. See Nouaim *et al*. (2002) and articles by Lybbert *et al*. (2002) above for a contrary view. .

El Mousadik A. & Petit R.J. (1996) "High level of genetic differentiation for allelic richness among populations of the argan tree [*Argania spinosa* (L.) Skeels] endemic to Morocco." *Theoretical & Applied Genetics* **92**(7), 832-9. Abstract. Genetic diversity at nine isozyme loci was surveyed in an endangered tree species, the argan tree, endemic to south-western Morocco. The species is highly diverse (3.6 alleles/locus) with populations strongly differentiated from

each other (F ST=0.25). This example is used to illustrate a method for standardizing measures of allelic richness in samples of unequal sample sizes, which was developed for the estimation of the number of species and relies on the technique of rarefaction. In addition, it is shown that the measure of subdivision, ST, obtained when allelic richness is used in place ofh (Nei's index of diversity), is much larger than the F ST [e.g. ST(40)=0.52, where (40) indicates the specified sample used to estimate the allelic richness]. This suggests that rare alleles (which strongly influence measures of allelic richness) have a more scattered distribution than more frequent ones, a result which raises special conservation issues for the argan tree.

Nouaim R., Mangin G., Breuil M.C. & Chaussod R. (2002) "The argan tree (*Argania spinosa*) in Morocco: Propagation by seeds, cuttings and in-vitro techniques." *Agroforestry Systems* **54**(1), 71-81. Abstract. In South-western Morocco, the argan tree (*Argania spinosa*) is basis of a traditional agroforestry system. However, this system is no longer at equilibrium and there is an urgent need to renovate it. The natural reproduction of the tree has become difficult, and most attempts of artificial regeneration have failed. We have assessed three different propagation methods: seedlings, cuttings, and in-vitro micro-propagation. Our experiments, involving several seed collections, showed that germination occurred easily when using young (< 12 months) and large seeds (nut weight > 3 g). Nuts with thin walls germinated better than nuts with thicker walls. Sterilization prevented microbial contamination and improved germination. Vegetative propagation of the argan tree by cuttings was tried using lignified cuttings collected from adult trees or young stems from managed stockplants (three years old). Rooting rate seems to be dependent on genotype, and the best results were obtained from young stems sterilized to avoid fungal contamination. The success of in-vitro micro-propagation is also highly genotype-dependant. We developed a modified medium enabling up to 80–95% rooting rate for some clones. However, other clones were still recalcitrant. Whatever the propagation method used, special attention must be paid to the architecture and growth of the root system.

Nerd A., Irijimovich V. & Mizrahi Y. (1998) "Phenology, breeding system and Fruit development of Argan [*Argania spinosa* , Sapotaceae] cultivated in Israel." *Economic Botany* 52(2), 161-7. Abstract. Argan (*Argania spinosa*) is an evergreen tree native to southwestern Morocco appreciated for its edible, high nutritional oil, extracted from the kernels of the drupe-like fruit. Aspects of its reproductive biology were studied with the aim to domesticate the tree as an oil crop. Flowering offertigated trees cultivated in the Negev Highlands of Israel was confined to the spring months. The flowers were protogynous. Results of different pollination treatments showed that a pollen vector was necessary for pollination and that fruit set was significantly higher in cross and open pollination (7–9%) than in self pollination (0.5%). The lower fruit set obtained in self pollination was related to postzygotic discrimination. Pollen transfer by wind was restricted to short distances. Flies, mainly of the family Calliphoridae, visited the flowers and

were found to be covered with argan pollen. Fruits ripened nine months after anthesis, exhibiting bisigmoidal growth curve.

Nerd A., Eteshola E., Borowy N. & Mizrahi Y (1994). “Growth and oil production of argan in the Negev Desert of Israel.” *Industrial Crops and Products* **2**, 89–95.

De Ponteves E., Bourbouze A. & Narjisse H. (1990). "Occupation de l’espace, droit coutumierer legislation forestiere dans un terroir de l’arganeraie septentrionale au Maroc " *LesCahiers de la Recherche Developpement* 26

De Ponteves E. (1989). "L’ Arganeraie, la chèvre, l’orge: approche du système agraire de l’arganeraie dans la commune rurale de Smimou, Province d’Essaouira, Maroc," *Thesis, Institut Agronomique Méditerranéan de Montpellier, France.*

Rahili M. (1989) "Production de l’Arganeraie', *Paper presented at Formation Forestière Continue, Thème “l’Arganier”, 13-17 March Station de Recherche Forestières, Agadir.*

Zahidi A. & Aameur F.B. (1996) "Conditions de Germination des Amandes de l’Arganier (*Argania spinosa* L. Skeels) ", *Paper presented at La Première Rencontre Nationale des Etudiants Chercheurs en Biologie, Thème La Biologie au Service du Développement, 17-19 December Marrakech*.

General & Uses.

Belarbi-Benmahdi M., Khaldi D., Beghdad C., Gouzi H., Bendimerad N. & Hammouti B. (2009) "Physiochemical & nutritional study of argan oil (*Argania spinosa* L.) in south-western Algeria." *Pigment & Resin Technology* **38**(2), 96-99.

Charrouf Z. & Dubé S. (2000) “Helping Moroccan Women Preserve the Argan Tree at the Gateway to the Sahara” – see http://idrinfo.idrc.ca/archive/ReportsINTRA/pdfs/2000/115599.pdf

Charrouf Z. & Guillaume D. (2008) "Argan oil: Occurrence, composition and impact on human health." *European Journal of Lipid Science and Technology* **110**(7), 632-6. Abstract. Edible argan oil is traditionally prepared by Berber women who manually crunch the roasted kernels of *Argania spinosa* fruits. Unroasted kernels furnish a cosmetic-grade oil. Argan groves are currently shrinking due to unfavorable conditions. To stop this trend, a program aimed at increasing the argan tree economical value is in progress in Morocco. Its concept is that the natives will preserve argan trees only if the major part of the wealth resulting from the argan grove production directly benefits them. Because of its high dietary value, argan oil has appeared as the best derivative to rapidly satisfy such assumption. Consequently, year after year, cooperatives have been implanted to produce argan oil of high quality on a large scale. The delicate hazelnut taste of argan oil, combined with its high level in unsaturated fatty acids, has allowed its swift commercial success and, nowadays, argan oil of standardized quality is marketed worldwide. Moroccan farmers are now beginning to plant argan trees, confirming the full success of this ambitious

program. This review summarizes the methods used to prepare argan oil, its composition, the strategies available to certify argan oil quality, and finally the impact of argan oil on human health.

Elnat G. (2005) “Argan – Oil of the Berber”. *Aromatherapy Times* **1**(67) Winter 2005 pp 26-27.

Fabricant F. (2001). "A New Oil (Keep the Goats Away)" *New York Times*, 3 January 2001

Maurin, R. (1992); “Argan oil, *Argania spinosa* (L.) Skeels (Sapotaceae).” *Rev Fr. Corps Gras* **39**, 139-146.

M'Hirit O.P., Bensyane M,, Benchekroun f., El Yousfi S.M. &. Bendaanoun M. (1998). *L'arganier: une espèce fruitière-forestière à usages multiples*. Pierre Mardaga.

Morse K. (2003) "Argan Oil: A Moroccan Flavor Rediscovered." *Gastronomica* **3**(4), 68–70

Morton J.F. & Voss G.L. (1987). "The argan tree (*Argania sideroxylon*, Sapotataceae), a desert source of edible oil". *Economic Botany* **41** (2): 221–233.

Nouaim R. (2005). *L'arganier au Maroc: entre mythes et réalités. Une civilisation née d'un arbreune espèce fruitière-forestière à usages multiples*. Paris: L'Harmattan.

Nouaïm R., Echairi A., Kaaya M. & Chaussod R. (2007) "Contribution to the domestication of the argan tree for oil production purposes." *Cahiers Agriculture* 16(3), 199-2004. Abstract. A survey conducted in 5 sites in the argan tree forest showed that argan oil represents an important part of the users’ incomes. Nut-breaking is the most time-consuming and tedious step for the women involved in oil production. In 3 sites, the women were capable of distinguishing between those trees that yield nuts easy to break and trees yielding nuts difficult to break. These trees were named F and D, respectively. In each site, fruits were harvested from trees identified as F or D by the users, or at random. Those fruits were characterized by a set of measurements, including the force needed to break the nuts. Our measurements pointed out that the nuts harvested from F trees require a lower break force and have a thinner shell and a higher almond weight/nut weight ratio than the nuts harvested from D trees. These three parameters are proposed as a first basis for selecting argan trees for oil production purposes. The higher almond/nut ratio in F trees implies a higher oil yield than with D trees, for the same amount of nuts. Vegetative propagation of adult trees by cuttings allows selected phenotypes to be preserved in nurseries in the form of micro-mother trees from which mycorrhizal plants can be produced by vegetative propagation in order to set up orchards geared to the production of argan oil

Prendergast H.D.V. & Walker C.C. (1992). "The argan: multipurpose tree of Morocco". *Kew Magazine* **9** (2): 76–85

Yaghmur A., Aserin A., Mizrahi Y., Nerd A. & Garti N. (2001) "Evaluation of Argan oil for deep-fat frying." *Lebensmittel-Wissenschaft und-Technologie* **34**(3),124-130. Abstract. Argan (*Argania spinosa* L.) oil has a high dietetic and culinary value because it consists of high percentage of unsaturated fatty acids, and it is rich in aroma and flavour. The main objectives of this study were to determine the stability of argan oil (55.4% oleic acid and 24.4% linoleic acid) and to compare it to high-oleic olive oil (78.2% oleic acid and 7.9% linoleic acid) and cottonseed oil (19.8% oleic acid and 52.0% linoleic acid) at high temperatures in heating and deep-fat frying conditions. Several quality parameters were tested and compared in time-temperature conditions simulating abuse by heating and deep-fat frying. After frying no change in the contact angle of argan, olive and cottonseed oils was observed, while in other tests (colour index, viscosity, peroxide value, induction period, conjugated dienes content, total polar compounds) the stability of argan and olive oil was better than that of cottonseed oil. Oil uptake of deep-fried potatoes in argan oil was slightly lower than that in olive or cottonseed oil. It was concluded that argan oil can substitute olive or cottonseed oils in deep-fat frying. The aroma, flavour, oxidative stability and the health benefits might 'compensate' for the high cost of the oil. Sensory evaluation of fried french potatoes and their storage stability were not studied, and addition work is needed to evaluate the quality and storage stability of French potatoes fried in argan, olive and cottonseed oils.

Physiological Effects.

Adlouni A., Christon R., Cherki M., Khalil A. & El Messal M. (2008) "The nutritional benefits of argan oil in obesity risk prevention." *Atherosclerosis Supplements* **9**(1), 137-138.

Alaoui K., Lagorce J.F., Cherrah Y., Hassar M., Amarouch H. & Roquebert J. (1998) "Analgesic and anti-inflammatory activity of saponins of *Argania spinoza*." *Ann Pharm Fr* **56**, 220–8.

Baumnann L.S. (2008) "Argan Oil." *Skin & Allergy News* **39**(10), 29.

Benzaria A., Meskini N., Dubois M., Croset M., Némoz G, Lagarde M. & Prigent A. (2006) "Effect of dietary argan oil on fatty acid composition, proliferation, and phospholipase D activity of rat thymocytes." *Nutrition* **22**(6), 628-637. Abstract. Objective. Argan oil is receiving increasing attention due to its potential health benefits in the prevention of cardiovascular risk, but no information to date is available about its possible effect on immune cells and functions. Methods. To address this issue male rats were fed one of five diets that contained fish oil, argan oil, olive oil, coconut oil, or sunflower oil for 4 wk. The fatty acid composition of plasma and thymocyte lipids was then analyzed in relation to the mitogen-induced proliferation and phospholipase D (PLD) activity of thymocytes. Results. The 18:2ω-6 proportion in thymocyte phospholipids from rats fed argan oil was significantly lower than that observed in phospholipids from rats fed

sunflower oil and fish oil but higher than that found in the olive oil and coconut oil groups. Further, a significant positive linear relation was found between thymocyte proliferation and the 18:2ω-6 proportion in thymocyte phospholipids, whatever the diet. The proliferation response of thymocytes to mitogenic activation was also inversely correlated to PLD activity measured in intact thymocytes. Subsequent western blotting experiments indicated that the diet-induced variations in PLD activity mainly reflected variations in the expression of PLD2 protein. Conclusions. On the whole, the present study shows that the effects of argan oil on immune cells are very similar to those of olive oil, and that, as a consequence, argan oil can be used as a balanced dietary supply without marked adverse effects on immune cell function.

Berrada Y., Settaf A., Baddouri K., Cherrah A. & Hassar M. (2000) "Experimental evidence of an antihypertensive and hypocholesterolemic effect of oil of argan, *Argania sideroxylon*." *Therapie* **55**, 375-378. Abstract. The chronic ingestion of 5 ml/kg/d of Argan oil by spontaneously hypertensive rats restores normal blood pressure and induces hypocholesterolaemia. In order to confirm these results *Meriones shawi*, a rodent of the Gerbillideae family, was tested as a second animal model. *Meriones* submitted to a hypercaloric diet and physical inactivity became fat, and exhibited hypertension, dyslipidaemia and hyperinsulinaemia. When treated for two months with the same dosage regimen, decreases in glycaemia, total plasmatic cholesterol, LDL, insulinaemia and systolic and diastolic blood pressures of 4.4 per cent, 14.4 per cent, 32.5 per cent, 26.8 per cent, 28.8 per cent and 30.5 per cent were simultaneously observed. Increases in LDH and of TG of 27.9 per cent and 16.2 per cent respectively were also observed. No effect on body weight occurred. The action of polyunsatured fatty acids of the Argan oil is predominant, but in addition, other constituents play an active part.

Berrougui H., Cherki M., Koumbadinga G.A., Isabelle M., Douville J., Spino C. & Khalil A. (2007) "Antiatherogenic activity of extracts of *Argania spinosa* L. pericarp: beneficial effects on lipid peroxidation and cholesterol homeostasis." *Canadian Journal of Physiology and Pharmacology* **85**(9),918-927. Abstract. Prevention of lipoprotein oxidation by natural compounds may prevent atherosclerosis via reducing early atherogenesis. In this study, we investigated for the first time the beneficial properties of methanolic extract of argania pericarp (MEAP) towards atherogenesis by protecting human low-density lipoprotein (LDL) against oxidation while promoting high-density lipoprotein (HDL)-mediated cholesterol efflux. By measuring the formation of malondialdehyde (MDA) and conjugated diene as well as the lag phase and the progression rate of lipid peroxidation, the MEAP was found to possess an inhibitory effect. In addition, MEAP reduced the rate of disappearance of α-tocopherol as well as the apoB electrophoretic mobility in a dose-dependent manner. These effects are related to the free radical scavenging and copper-chelating effects of MEAP. In terms of cell viability, MEAP has shown a cytotoxic effect (0-40µg/mL). Incubation of 3H-cholesterol-loaded J774 macrophages with HDL in the presence of increasing concentrations of MEAP enhanced HDL-mediated cholesterol efflux

independently of ABCA1 receptor pathways. Our findings suggest that argania seed pericarp provides a source of natural antioxidants that inhibit LDL oxidation and enhance cholesterol efflux and thus can prevent development of cardiovascular diseases.

Berrougui H., Cloutier M., Isabelle M., Khalil A. (2006) "Phenolic-extract from argan oil (*Argania spinosa* L.) inhibits human low-density lipoprotein (LDL) oxidation and enhances cholesterol efflux from human THP-1 macrophages" *Atherosclerosis* **184**(2), 389-396. Abstract. Argan oil is rich in unsaturated fatty acids, tocopherol and phenolic compounds. These protective molecules make further study of its cardiovascular diseases (CVDs) action interesting. Furthermore, no previous study has explored the antioxidant activity of argan oil in comparison with olive oil. The present study was conducted to evaluate the beneficial properties of Virgin argan oil phenolic extracts (VAO-PE) towards CVD by: (A) protecting human (low-density lipoprotein, LDL) against lipid peroxidation and (B) promoting high-density lipoprotein (HDL)-mediated cholesterol efflux. Human LDLs were oxidized by incubation with CuSO4 in the presence of different concentrations of VAO-PE (0–320μg/ml). LDL lipid peroxidation was evaluated by conjugated diene and MDA formation as well as Vitamin E disappearance. Incubation of LDL with VAO-PE significantly prolonged the lag-phase and lowered the progression rate of lipid peroxidation ($P<0.01$) and reduced the disappearance of Vitamin E in a concentration-dependent manner. Incubation of HDL with VAO-PE significantly increased the fluidity of the HDL phospholipidic bilayer ($P=0.0004$) and HDL-mediated cholesterol efflux from THP-1 macrophages. These results suggest that Virgin argan oil provides a source of dietary phenolic antioxidants, which prevent cardiovascular diseases by inhibiting LDL-oxidation and enhancing reverse cholesterol transport. These properties increase the anti-atherogenic potential of HDL.

Berrougui H., Alvarez de Sotomayor M., Pérez-Guerrero, Ettaib A., Hmamouchi M., Marhuenda E. & Dolores Herrera M. (2004) "Argan (*Argania spinosa*) oil lowers blood pressure and improves endothelial dysfunction in spontaneously hypertensive rats." *British Journal of Nutrition*, **92**, 921-929. Abstract. Traditionally hand-pressed argan oil, obtained from *Argania spinosa* seeds, is eaten raw in south-west Morocco; its rich composition of tocopherols, MUFA and PUFA make a study of its actions on risk factors for CVD, such as hypertension, interesting. The effects of 7 weeks of treatment with argan oil (10ml/kg) on the blood pressure and endothelial function of spontaneously hypertensive rats (SHR) and normotensive Wistar–Kyoto rats were investigated. Systolic blood pressure and heart rate were measured every week by the tail-cuff method and endothelial function was assessed by carbachol (10−8 to 10−4m)-induced relaxations of aortic rings and small mesenteric arteries pre-contracted with phenylephrine. Argan-oil administration reduced the mean blood pressure of SHR after the fifth week of treatment ($P<0·05$) and increased ($P<0·01$) the endothelial responses of arteries from SHR. The NO synthase inhibitor, l-N-ω-nitroarginine (3×10−5m) revealed a greater participation of NO in the relaxant effect after the treatment. When cyclooxygenase (COX) was blocked with

indomethacin (10–5m), an involvement of COX products in the endothelium-dependent response was characterized. Enzyme immunoassay of thromboxane B2 showed a significant decrease (P<0·05) in the release of thromboxane A2 in both aorta and small mesenteric artery after argan-oil treatment of SHR. Experiments in the presence of the thromboxane A2–prostaglandin H2 receptor antagonist ICI 192, 605 (10–5m) confirmed this result. Results after incubation with the antioxidants superoxide dismutase and catalase suggested that a decreased oxidative stress might contribute to explain the beneficial effects of argan-oil treatment.

Berrougui H., Ettaib A., Herrera Gonzalez M.D., Alvarez de Sotomayor M., Bennani-Kabchi N. & Hmamouchi M. (2003) "Hypolipidemic and hypocholesterolemic effect of argan oil (*Argania spinosa* L.) in *Meriones shawi* rats." *J. of Ethnopharmacology* **99**(1), 15-18. Abstract. The potential health benefits of various dietary oils in relation to cardiovascular disease and cancer are recently receiving considerable attention. The main proposal of this study is to investigate the effect of dietary argan oil, obtained from seeds of *Argania spinosa* L. (Sapotaceae) endemic from Morocco, on serum lipids composition. Hyperlipidemia was induced by high calorie and cholesterol (HCC) diet administration in 16 rats (*Meriones shawi*, a rodent of the Gerbillideae family). Eight rats were treated with argan oil (1 ml/100 g weight) daily by oral route during 7 weeks (treated group). Control animals were also fed with HCC diet for 7 weeks. After 7-week treatment with argan oil, blood lipoproteins were significantly reduced. Total cholesterol decreased with 36.67% (P<0.01), low density lipoprotein (LDL)-cholesterol in 67.70% (P<0.001), triglycerides in 30.67% (P<0.05) and body weight in 12.7% (P<0.05). High density lipoprotein (HDL)-cholesterol concentration remained unaltered. These results indicate the beneficial effect of argan oil in the treatment of the hyperlipidemia and hypercholesterolemia. This effect will be related with the polyunsaturated fatty acids and other constituents of studied oil.

Cherki M., Berrougui H., Drissi A., Adlouni A. & Khalil A. (2006) "Argan oil: Which benefits on cardiovascular diseases?" *Pharmacological Research* **54**(1),1-5. Abstract. Aim The argan oil, extracted from argan-tree fruits, has been known for its various pharmacological properties and used as a natural remedy since several centuries. In this review, we present a summary of the results obtained from a survey of the literature on argan oil. Data synthesis Various studies conducted in vitro or on human and animal models suggest that argan oil could play a beneficial role in cardiovascular diseases prevention and its consumption could protect against atherosclerosis and cancer via a variety of biological mechanisms. Conclusion Argan oil reduces cardiovascular risk and may be used as anti-atherogenic oil.

Cherki M., Drissi A., Derouiche A., El Messal M., Bamou Y., Idrissi-Oudghiri A., Khalil A. & Adlouni A. (2003). “Influence of argan oil administration on lipid peroxidation and paraoxonase activities in healthy Moroccan men.” *Atherosclerosis Supplements* **4 2**, 282. Abstract.. Background and aim. Due to its

high antioxidant and mono- and polyunsaturated fatty acid content virgin argan oil (VAO) could play a beneficial role in cardiovascular prevention. We were therefore interested in determining whether the consumption of VAO could improve plasma paraoxonase (PON1) activities and antioxidant status in healthy men. Methods and results. Sixty young men were included in this interventional study. They were given a controlled diet for 2 weeks as baseline and then received 25g/day of butter. The group was randomised to two diet group periods of 3 weeks each. The VAO group received 25ml/day of oil and the extra virgin olive oil (EVO) group received the same quantity of EVO as control group. Plasma PON1 activities, antioxidant vitamins and LDL susceptibility to oxidation were measured. The analysis of the results shows that PON1 activities increase significantly in both groups and that lipoperoxides and conjugated dienes formation decreases significantly in VAO and EVO groups compared to baseline values (P=0.001 and P=0.014, respectively). Vitamin E concentration increases significantly only in VAO group (P=0.007). Susceptibility of LDL to lipid peroxidation shows a significant increase in lag phase and a significant decrease in maximum diene production in VAO (P=0.005) and EVO groups (P=0.041 and P=0.005, respectively). ConclusionsOur findings confirm the beneficial effect of EVO on plasma antioxidant status and show for the first time the same effect for VAO supplementation in man. Thus, VAO offers an additional natural food supplement to reduce cardiovascular risk.

Derouiche A., Cherki M., Drissi A., Bamou Y., El Messal M., Idrissi-Oudghiri A., Lecerf J.M. & Adlouni A. (2005) "Nutritional intervention study with Argan oil in man: Effects on lipids and aapolipoproteins." *Ann Nutr Metab* **49**, 196–201. Abstract. Aim: To evaluate whether the consumption of virgin argan oil (VAO) is associated with a change in serum lipids and reduces the risk of cardiovascular disease in healthy Moroccans. Methods: Sixty volunteers consumed butter (25 g/day) during 2 weeks (stabilization period) and were randomly divided into two groups: the treatment group received 25 g/day of VAO during 3 weeks (intervention period), and the control group received 25 g/day of extra virgin olive oil (EVO). Throughout the study, weight, blood pressure, and daily food intake were measured. Serum total cholesterol and low- and high-density lipoprotein cholesterol, triglycerides, and apolipoproteins A-I and B were measured at the end of each diet period. Results: Analysis of food intake showed that the daily diet is isocaloric for the butter regimen (2,537 8 244 kcal/ day) as well as for the VAO and EVO regimens (2,561 8 246 and 2,560 8 253 kcal/day, respectively). Analysis of the lipid intake showed a reduction in saturated fatty acids with VAO and EVO regimens (27 8 1.4 and 26.4 8 3.4%, respectively) as compared with the stabilization period (41.6 8 2.4%). The analysis of serum lipids showed a signifi cant increase in high-density lipoprotein cholesterol and apolipoprotein A-I in both VAO group (8.4%, p = 0.012, and 5.2%, p = 0.027, respectively) and EVO group (17.3%, p = 0.001, and 5.9%, p = 0.036, respectively). However, low-density lipoprotein cholesterol and apolipoprotein B (13.8%, p = 0.037, and 7.8%, p = 0.039, respectively) decreased signifi cantly only in EVO group as compared with the stabilization period, while triglycerides decreased signifi cantly by 17.5% (p = 0.039) only in VAO group. Conclusion: These results confirm the cholesterol-

lowering effect of EVO and show for the first time the triglyceride-lowering effect of VAO in men.

Drissi A., Girona J., Cherki M., Godàs G., Derouiche A, Messal M., Saile R., Kettani A., Solà R. & Masana L. (2004) "Evidence of hypolipemiant and antioxidant properties of argan oil derived from the argan tree (*Argania spinosa). Clinical Nutrition* **23**(5), 1159-1166. Abstract. Background: Virgin argan oil is of interest in cardiovascular risk prevention due to its fat composition and antioxidant compounds. Aims: We investigated with Moroccan subjects the effect of regular virgin argan oil consumption on lipid profile and antioxidant status and the in vitro effect of argan oil minor compounds (tocopherols, sterols and polyphenols) on LDL peroxidation. Design: Healthy subjects (20 men, 76 women) were studied. Sixty-two were regular consumers of argan oil and 34 were non-consumers. Methods: Fasting plasma lipids, antioxidant vitamins and LDL oxidation susceptibility were analyzed. In vitro LDL oxidation by phenolic and apolar compounds of virgin argan oil were performed. Results: Diet composition of argan oil consumers has a higher significant content of polyunsaturated fatty acids than that of non-consumers (8.8±1.0 vs. 6.6±0.9g, $P<0.05$). Subjects consuming argan oil have lower levels of plasma LDL cholesterol (12.7%, $P<0.05$) and Lp(a) (25.3%, $P<0.05$) compared with the non-consumers. In argan oil consumers, plasma lipoperoxides were lower (58.3%, $P<0.01$) and molar ratio α-tocopherol/total cholesterol (21.6%, $P<0.05$) and α-tocopherol concentration (13.4%, $P<0.05$) were higher compared with the non-consumers group. In spite of higher levels of plasma antioxidant and lower levels of lipoperoxides in argan oil consumers, LDL oxidation susceptibility remained fairly similar. A strong positive correlation was observed between increasing phenolic extract, sterol and tocopherol concentrations and the LDL-Lag phase ($P<0.05$). Conclusions: Our findings suggest for the first time that regular consumption of virgin argan oil induces a lowering of LDL cholesterol and has antioxidant properties. This oil offers an additional natural food to reducing cardiovascular risk.

Charrouf Z. & Guillaume D. (1999) "Ethnoeconomical, ethnomedical, and phytochemical study of *Argania spinosa* (L.) Skeels." *Journal of Ethnopharmacology* **67**(1), 7-14. Abstract. Populations of the South-western part of Morocco traditionally use the fruits of *Argania spinosa* (L.) Skeels to prepare an edible oil whose obtainment furnishes, as side product, a cake used to feed the cattle and complemented the forage furnished by the leaves and fruits of this same plant. However, the wood of *A. spinosa* is also used for fuel and the subsequent induced deforestation is nowadays accelerated since populations are generally eager to replace argan-groves by cultures of higher and immediate benefits. Recently, argan tree, that is particularly well adapted to grow in arid lands, has been proposed by several agencies to slow down the desert progress in Northern Africa. In order to promote argan tree reintroduction by the South-western Morocco dwellers, a program aimed to increase the industrial value of A. spinosa is currently carried out in Morocco. A phytochemical study is included in this program. Traditional knowledge as well as the most recent results concerning *A. spinosa* are described in this review.

Mekhfi H., Gadi D., Bnouham M., Ziyyat A., Legssyer A., Aziz M. (2008) "Effect of Argan oil on platelet aggregation and bleeding time: A beneficial nutritional property." *J of Complementary & Integrative Medicine* **5**(1). Abstract. Platelet hyperactivity is one of the most important factors responsible for thrombosis and incidence of cardiovascular diseases. In this study, we investigated the effect of argan oil (0.2, 0.5, 1 and 2 %) on blood platelet aggregation (in vitro and ex vivo) and on tail bleeding time (in vivo) on rats. The in vitro aggregation was monitored after pre-incubation of platelets with argan oil for one minute. The in vivo bleeding time and ex vivo aggregation were performed after 4 weeks of oral treatment (10 ml/Kg/day). Argan oil was found to possess a maximum inhibition of the in vitro (46.4±4.3 %) and ex vivo platelet aggregation induced by different agonists (43.4±5.51 %). The ex vivo aggregation inhibition was not accompanied by a change in the platelets amount, neither in the bleeding time (5.5±0.3 min). These results suggest that argan oil may probably act directly on the common and an ultimate step of aggregation: attachment of fibrinogen to GpIIb/IIIa platelet receptors without affecting platelet adhesiveness to the vascular endothelium. These findings give evidence that the dietary intake of argan oil may be beneficial in the normalization of platelet hyperactivation and in the nutritional prevention of cardiovascular diseases.

Samane S., Noël J., Charrouf Z., Amarouch H. & Haddad P.S. (2006) "Insulin-sensitizing and anti-proliferative effects of *Argania spinosa* seed extracts". *Evidence-based Complimentary & Alternative Medicine* **3**(3), 317-327. Abstract. *Argania spinosa* is an evergreen tree endemic of southwestern Morocco. Many preparations have been used in traditional Moroccan medicine for centuries to treat several illnesses including diabetes. However, scientific evidence supporting these actions is lacking. Therefore, we prepared various extracts of the argan fruit, namely keel, cake and argan oil extracts, which we tested in the HTC hepatoma cell line for their potential to affect cellular insulin responses. Cell viability was measured by Trypan Blue exclusion and the response to insulin evaluated by the activation of the extracellular regulated kinase (ERK1/2), ERK kinase (MEK1/2) and protein kinase B (PKB/Akt) signaling components. None of the extracts demonstrated significant cytotoxic activity. Certain extracts demonstrated a bi-phasic effect on ERK1/2 activation; low doses of the extract slightly increased ERK1/2 activation in response to insulin, whereas higher doses completely abolished the response. In contrast, none of the extracts had any significant effect on MEK whereas only a cake saponin subfraction enhanced insulin-induced PKB/Akt activation. The specific action of argan oil extracts on ERK1/2 activation made us consider an anti-proliferative action. We have thus tested other transformed cell lines (HT-1080 and MSV-MDCK-INV cells) and found similar results. Inhibition of ERK1/2 activation was also associated with decreased DNA synthesis as evidenced by [3H]thymidine incorporation experiments. These results suggest that the products of *Argania spinosa* may provide a new therapeutic avenue against proliferative diseases.

Safety.

Astier C., El Alaoui Y., Benchad, Moneret-Vautrin D.-A., Bihain B.E. & Kanny G. (2009) "Anaphylaxis to argan oil" *Allergy* 2009.