

Main achievements of research in improving and developing Moroccan date postharvest valorization: A review

Harrak Hasnaâ ⁽¹⁾

hasnaa.harrak@inra.ma

1: Agro-Food Technology and Quality Laboratory, Plant improvement and Quality Research Unit , Regional Center of Agricultural Research of Marrakesh, National Institute of Agricultural Research, Avenue Ennasr, BP 415 Rabat Principale, 10090 Rabat, Morocco

Abstract

Date, a strategic product of Moroccan oases contributing between 20 and 60 % in the income of farmers, is now recording a high production exceeding 140,000 tons, due to the expansion of date palm cultivation in the framework of Green Morocco Plan (GMP). Therefore, there has been a need to strengthen and substantially improve the postharvest valorization of Moroccan dates. The work carried out by the National Institute for Agricultural Research (INRA, Morocco) contributes to the objectives of this valorization by accomplishing effective research activities in favor of dates, making it possible to reduce postharvest losses, to improve quality, to diversify date products, to generate added value, and to facilitate access to the market. The undertaken activities approach was in accordance with national date palm strategies including GMP, based on an appropriate valorization addressing scientific, technical, and development aspects, highly requested at the downstream of the date chain value. Hence, the accomplished activities have contributed to a better technological valorization of dates through achievements that have further involved various actors concerned with preserving biodiversity and local know-how of dates, highlighting their typicity and notoriety, carrying out their development projects successfully, establishing and respecting their quality standards, and satisfying consumer preferences. These research achievements have provided concrete and modern solutions, capable of contributing to a real enhancement of dates while taking into account their specificities and those of their *terroirs* for a sustainable development of Moroccan oases.

Key-words: *Phoenix dactylifera*, date fruit, quality, local know-how, processing, labeling

Revue des principaux acquis de la recherche dans l'amélioration et le développement de la valorisation post-récolte des dattes marocaines

Résumé

La datte, produit stratégique des oasis marocaines contribuant à hauteur de 20 à 60 % dans la formation des revenus des phœniciculteurs, enregistre désormais une production record en dépassant 140 000 tonnes, en raison de l'expansion de la culture du palmier dattier dans le cadre du Plan Maroc Vert (PMV). Il y avait donc une nécessité de renforcer et d'améliorer substantiellement la valorisation post-récolte des dattes marocaines. Les travaux menés par l'Institut National de la Recherche Agronomique (INRA, Maroc) contribuent aux objectifs de cette valorisation en réalisant des activités de recherche efficaces en faveur des dattes permettant de réduire les pertes post-récolte, d'améliorer la qualité, de diversifier les produits à base de dattes, de générer une plus-value et de faciliter l'accès au marché. Leur approche est en concordance avec les stratégies nationales du palmier dattier incluant le PMV, basée sur une valorisation appropriée abordant des aspects scientifiques, techniques et de développement, hautement sollicités à l'aval de la chaîne de valeur des dattes. A cet effet, les activités réalisées ont contribué à une meilleure valorisation technologique des dattes à travers des acquis ayant impliqué davantage les différents acteurs soucieux de préserver la biodiversité et le savoir-faire local des dattes, de mettre en avant leur typicité et notoriété, de mener à bien leur projets de valorisation, d'établir et de respecter leur normes de qualité et de satisfaire les préférences des consommateurs. Ces acquis de recherche ont fournis des solutions concrètes et modernes, à même de contribuer à une véritable valorisation ou une agro-industrie des dattes tout en tenant compte de leurs spécificités et celles de leurs terroirs pour un développement durable des oasis marocaines.

Mots-clés : *Phoenix dactylifera*, datte, qualité, savoir-faire local, transformation, labellisation.

أهم إنجازات البحث في تحسين وتطوير تـمـين التـمـور المـغـربـية ما بعد الجـني

حسـناء الحـراق

ملخص

يعتبر التمر منتجاً استراتيجياً للواحات المغربية حيث يساهم بنسبة 20 إلى 60 ٪ في تشكيل دخل المزارعين، ويسجل حالياً إنتاجاً قياسيًّا يتجاوز 140 ألف طن وذلك بفضل التوسع في زراعة النخيل في إطار مخطط المغرب الأخضر (م.م.أ). وفي هذا الصدد، كانت هناك حاجة إلى تعزيز وتحسين تـمـين التـمـور المـغـربـية ما بعد الجـني. يساهم العمل الذي يقوم به المعهد الوطني للبحث الزراعي بالمغرب في تحقيق أهداف هذا التـمـين من خلال إجراء أنشطة بحثية فعالة لصالح التـمـور من أجل التقليل من الضياع ما بعد الجني، وتحسين الجودة، وتنويع منتجات التمر، وخلق قيمة مضافة والدفع بالتسويق. يتماشى نهج هذه الأنشطة مع الاستراتيجيات الوطنية الخاصة بالنخيل بما فيها م.م.أ، استناداً إلى تـمـين مناسب يتناول الجوانب العلمية والتقنية والتنمية المطلوبة بشدة في سافلة سلسلة قيمة التمر. ولتحقيق هذه الغاية، ساهمت الأنشطة التي تم تنفيذها في تـمـين تكنولوجي أفضل للتـمـور من خلال الإنجازات التي انخرط فيها بشكل كبير العديد من المتدخلين المهتمين بالحفاظ على التنوع البيولوجي والمعارف المحلية للتـمـور، وإبراز جودتها وشهرتها، وتحقيق مشاريعها التـمـينية بشكل جيد، وبوضع واحترام معايير الجودة الخاصة بها وإرضاء تفضيلات المستهلكين. قدمت هذه النتائج البحثية حلولاً ملموسة وحديثة، قادرة على المساهمة في تـمـين حقيقي أو صناعة غذائية للتـمـور مع مراعاة خصوصياتها وخصوصيات منشئها من أجل تنمية مستدامة في الواحات المغربية.

الكلمات المفتاحية: فينيكس دكتلفيرا، تمر، جودة، معارف محلية، تصنيع، ترميز

Introduction

Moroccan date production, which was estimated at 143,000 tons for the 2019-2020 campaign and qualified as a record quantity, ranks highly among the national tree crops and it is the engine of the agricultural economy of date palm regions. Indeed, this production is predominant and substantial element for cash flow as it contributes between 20 and 60 % in farmer annual income, allowing about two million oasis inhabitants to continue to live in a hostile environment. The economic and social importance of date production in Morocco is, therefore, far from being negligible (INRA, 2011; Ghouibi, 2021).

Thus, in the last two decades, especially the last ten years in the framework of the GMP, date domestic production has become of great interest from the administration, profession, and research with the establishment of numerous sustainable development and research programs, and structuring measures targeted at the preservation of the phoenicultural heritage, the development of the date industry and consequently, its market value. These efforts aimed to overcome constraints of the date postharvest sector, presented below, widely identified or reported in several works (Harrak and Chetto, 2001; Harrak *et al.*, 2000; 2001; Zirari *et al.*, 2003; Harrak, 2004a; 2004b; 2004c; Harrak and Chetto, 2005; Chetto *et al.*, 2005a; 2005b; Harrak *et al.*, 2005a; Harrak, 2007; INRA, 2011).

The constraints of the date postharvest sector include the predominance of dates of low and medium commercial quality. In addition, a large part of this production is used as cattle feed, while it could be used for human consumption if it is valued by an appropriate transformation. However, processing date of low marketable quality occupies an unsatisfying place in the national date sector.

Dates of good commercial value are also facing many problems that can devalue them, especially inadequate harvesting, hygiene, presentation, and packaging. The storage, which is not properly in some cases, may cause the alteration of dates and their damage by insects and microorganisms. Inadequate treatment against enemies of stored dates (especially moths) significantly depreciates the date production.

Furthermore, Moroccan oases are well known for the know-how of their inhabitants in the management and preservation of local resources especially date which benefits greatly from this know-how. This stems not only from religious, environmental, cultural, and social reasons, but also because this fruit is an important food and medicinal resource for the oases population. Indeed, palm oases have an ancestral know-how of preserving and processing dates in various products (juice, syrup, vinegar, powder, paste, etc.), developed over time especially by women. These products are characterized, in addition to their nutritional and organoleptic qualities, by therapeutic properties due to the use of medicinal and aromatic plants (MAP) in their preparation. Nevertheless, this traditional know-how is less valorized and risks being forgotten.

Therefore, the research aiming the valorization of date-fruits and the development of date products strengthen ongoing actions in safeguarding the genetic heritage of the date palm and rebuild the national palm grove. This valorization is, in fact, able to contribute to the conservation of genetic resources of date palm by attenuating market forces that push farmers to grow only cultivars of high commercial value to the detriment of a wide range of other cultivars, of low market value certainly, but with very interesting processing suitability. The conservation of these resources would help the farmer to find opportunities for its production which can be oriented towards appropriate processing technology.

Similarly, traditional preparations of dates, using the know-how of oases women, require archiving, valorization, and promotion of their consumption by their insertion in modern culinary art. In addition, significant tourism potential of oases added to diaspora living in different regions of Morocco and abroad, militates in favor of a local product based on dates with “Oasis” or “Quality linked to origin” labels. The identity of the obtained products from the traditional know-how confers an added value related to their authenticity and their particular characteristics.

Thus, the socio-economic impact of the date valorization is significant in job creation, generation of high-income for producers through the various date products, and tourism promotion. Besides, the date valorization may stimulate additional consumption of this fruit, which would have a beneficial impact on the economy of Pre-Saharan areas and therefore, ensure the maintaining of oases population, the poorest at the national level and pulling the large share of its revenue from date palm, in a challenging environment.

It is in these environmental, technological, socio-economic, and marketing contexts that enroll the research, research development, and development activities on date valorization which they were carried out during more two decades within the framework of INRA research programs and of numerous fruitful collaboration works with INRA (Regional Center of Agricultural Research of Marrakesh) at national and international levels. The objective of this review is to present these activities, to disseminate and to capitalize on their knowledge and achievements for supporting the importance of date production in Morocco and contributing to raise date production to the level of strategic products in Morocco.

Main research and research development activities on date postharvest valorization

The date chain is called to occupy a preponderant place in the Moroccan agricultural landscape through the preservation of the phoenicultural heritage and its promotion, with the enhancement of date quality and typicity. This can offer a diversified range of products "date and date-based products" with high added value, competitive on the national market, and able to emerge on the international market. As a result, agricultural research has a predominant role in providing scientific, technical, and professional communities with data, methods, and processes for the sustainable development of this local product "Dates". To this end, research activities are scheduled with a national dimension to provide this information to ensure better valorization and promotion of the Moroccan date. The main research and research development activities on date valorization aim at adding value, through quality improvement, diversification and labeling of date products (Harrak, 2010b; 2010c; 2016; 2018). They concern the following topics:

- Study of the date typicity, nutritional, sensory, and commercial qualities, and technological suitability for preservation and processing;
- Contribution to date labeling by developing distinctive signs of origin and quality (known by SDOQ from French: Signes distinctifs d'origine et de qualité). The three labels of SDOQ are: protected geographical indication (PGI), protected appellation of origin (PAO) and agricultural label (AL).
- Study of date processing based on oasis local know-how and development of date new products and date preservation and storage processes.
- Documentary and exploratory studies through the analysis of date postharvest valorization and the study of date marketing in Morocco.
- Transfer of technologies, technical assistance and trainings in the field of date postharvest valorization benefiting to engineers, technicians, students, and professional organizations of women and farmers in Moroccan oases.

These activities can be qualified as a research work:

- Carried out on a vital sector for oases population, living on a vast territory of Morocco, strongly proven for several years by natural, economic, and social constraints that have significantly impeded their development;
- Undertaken on a *terroir* product "Date" enjoying at the national level of great interest based on development strategies;
- Having scientific, technical, and marketing characters helping valorization of all date categories of low, medium, and high commercial value, with obvious implications for improvement of Moroccan date competitiveness and sustainable development of date producing regions;
- Innovative in the methodological and operational approach: providing explanations about oasis family processes, and proposing concrete and modern improvements. Such approach is able to promote the traditional date products on the regional, national, and international markets, while preserving the local know-how.

Valuable research achievements in improving and developing Moroccan date postharvest sector

Typicity and quality of dates

Typicity and quality of Moroccan dates. This topic consisted in the study of nutritional, technological, organoleptic, and commercial qualities of more than thirty major native Moroccan date cultivars (Fig. 1). About sixty of physical and physicochemical parameters, bioactive compounds, and sensory attributes were studied. This expertise in the field of date quality allowed to INRA to be solicited to contribute to the establishment process of national and international date standards, especially *Codex Alimentarius* standards (Harrak, 1999; Harrak *et al.*, 2003; Harrak and Hamouda, 2005; Harrak *et al.*, 2005b; 2005c; Salmaoui *et al.*, 2006; Lebrun *et al.*, 2007; 2010; Harrak, 2013a; Harrak, 2014; Alahyane *et al.*, 2019; Harrak, 2020a; Alahyane *et al.*, 2022). Some physical, physicochemical and biochemical date criteria of the main Moroccan varieties are presented in table 1.

Establishment of INRA date sensory panel. In the current market context giving a strong interest to local product and products with “Origin” label, the development of a sensory cartography of these products is essential. The date, *terroir* product par excellence and currently enjoying a great interest at the national level for the development of SDOQ, now boasts a sensory panel (Fig. 2). To the best of our knowledge, this panel, established in 2009 at INRA in Marrakesh, represents a first for the date palm sector in Morocco and in other phœnicicultural countries (Harrak, 2015; Harrak *et al.*, 2015; INRA, 2018; Harrak, 2020b). Through sensory attributes including pertinent descriptors specific to dates that are typically perceived through the five sense organs, this panel has contributed to attend the dynamic of SDOQ development through the determination of sensory profile and typicity of date fruits (e.g. PGI “Dates Bouittob of Tata”) and to give relevant factors that underpin both in date processing and in development of date new products.



Figure 1. Dates of some studied Moroccan cultivars.

Table 1. Some physical, physicochemical and biochemical data criteria of twenty Moroccan cultivars (Harrak, 1999; Harrak *et al.*, 2003; Harrak *et al.*, 2005b; Harrak, 2007).

Variety	Volume (cm ³)	Specific density (g/cm ³)	Brix (°Bx)	Total titratable acidity (g citric acid/100 g)	pH	Ash (g/100 g dry matter)	Protein (g/100 g dry matter)	Calcium/ Phosphorus ratio
Aguellid	8.22	0.93	76.30	0.310	5.8	2.51	3.30	0.61
Ahardane	8.22	0.96	74.72	0.210	6.3	2.39	2.58	0.94
Boufeggous	15.30	1.16	63.85	0.240	6.4	1.95	3.35	0.91
Bouijjou	10.20	0.94	80.91	0.470	4.9	2.14	2.34	1.23
Bouittob	5.02	1.05	74.17	0.277	5.9	2.66	2.90	1.12
Bourhare	9.45	1.00	76.22	0.260	5.8	2.07	2.08	0.51
Bouskri	8.00	0.94	74.43	0.165	6.6	2.37	2.58	1.20
Bouslikhène	5.00	0.74	82.80	0.290	6.0	2.66	2.69	1.29
White Bousthammi	5.47	1.20	76.10	0.177	6.1	2.33	2.25	0.51
Black Bousthammi	5.04	0.96	73.66	0.175	6.4	2.24	2.23	1.39
Bouzeggar	6.72	0.97	71.88	0.200	6.5	1.89	2.30	0.94
Iklane	7.95	0.93	73.14	0.247	5.9	2.40	1.99	1.03
Jihel	10.17	0.92	76.80	0.230	5.9	2.31	2.40	0.57
Mah-Elbaid	6.12	1.20	64.74	0.170	6.4	2.14	2.59	0.68
Mejhoul	18.32	1.20	67.56	0.220	6.7	2.01	2.75	0.75
Mest-Ali	6.97	0.99	77.29	0.250	6.2	2.16	2.47	1.06
Oum-N'hal	9.15	0.92	77.77	0.370	5.4	2.37	2.62	1.30
Outoukdim	6.97	0.83	77.04	0.425	5.2	2.53	4.22	0.74
Sair-Layalate	6.12	1.02	75.73	0.283	5.3	2.13	2.70	1.07
Tadment	9.57	0.82	75.57	0.230	6.2	2.14	2.31	1.20



Figure 2. Sequence of sensory analysis undertaken by the INRA date sensory in sensory analysis laboratory of INRA in Marrakesh.

Among the sensory attributes, 36 aromatic notes were perceived in Moroccan dates by INRA date sensory panel. Some date varieties are characterized by specific aroma which they are intense and persistent. The 10 main aromatic notes perceived by nasal route, are fruity, floral, cereals, woody, caramel, herbal, chocolate, green, carob and licorice; and the 14 main aromatic notes perceived by retro-nasal route, are honey, caramel, fruity, floral, chocolate, cereals, licorice, lemon, carob, almond, woody, herbal, walnut and mint. Figures 3 and 4 also present date sweetness and fibrous criterion score medians attributed by the INRA date sensory panel to dates of 13 main Moroccan varieties (Harrak *et al.*, 2015).

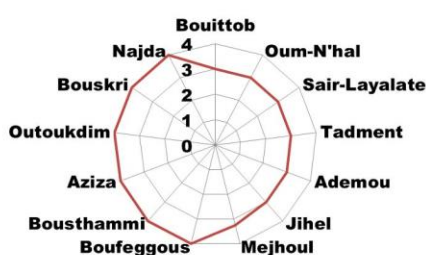


Figure 3. Date sweetness score medians of 13 Moroccan varieties (Harrak *et al.*, 2015).

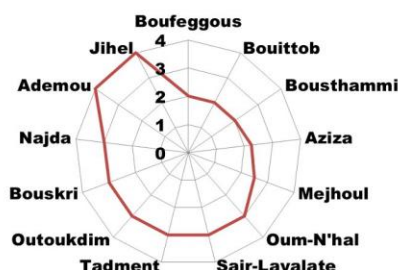


Figure 4. Date fibrous criterion score medians of the mesocarp internal part (rag) of 13 Moroccan varieties (Harrak *et al.*, 2015).

Development of distinctive signs of origin and quality of Moroccan dates

Date fruits produced by palm trees anchored in specific *terroirs* represent an economic and social issue. They are the result of their natural environment and traditional farming practices developed through the centuries. This topic aims at developing date SDOQ established in 2008 by the Ministry of Agriculture and Marine Fisheries (Law No. 25-06 and Decree 2-08-403 of 28/12/2008 concerning SDOQ of food and agricultural and fisheries products, and Decree 2-08-404 of 28/12/2008

concerning the composition and mode of operation of the National Commission of SDOQ). According to this law, SDOQ is a collective system accessible to producers and manufacturers of agricultural products with a specific quality allowing the recognition and protection of local products.

The research activities achievements concern the development of PGI “Dates Bouittob of Tata”, PGI “Dates Outoukdim of Toudgha Tinghir” and PGI “Dates Black Bousthammi of Drâa” for protection, valorization, and recognition of the long tradition of dates Bouittob produced in Tata oases, dates Outoukdim produced in Toudgha Tinghir oases, and dates Black Bousthammi produced in Drâa oases, respectively. These studies focused on the collection of geographic, agronomic, cultural, and organizational information on Tata, Toudgha and Drâa oases, and the typicity determination of dates Bouittob, Outoukdim, and Black Bousthammi. Therefore, different date quality parameters were deeply studied. The recognition by the Ministry of Agriculture, Fisheries, Rural Development, Water, and Forests (MAFRDWF) of these PGI were obtained in 2013, 2017 and 2018, respectively for “Dates Bouittob of Tata”, “Dates Outoukdim of Toudgha Tinghir”, and “Dates Black Bousthammi of Drâa” (Harrak, 2013a; INRA, 2018). INRA has also contributed to the preparation of codes of practices of PGI “Dates Jihel of Drâa” and AL “Dates Najda”, and to improving the code of practices of PGI “Dates Assiane of Figuig” which were recognized by the MAFRDWF in 2014, 2015 and 2019, respectively (Fig. 5; Fig. 6) (Harrak, 2017; Harrak, 2020c).



Figure 5. Logo (in French and Arabic) of the protected geographical indication according to the law No. 25-06 of distinctive signs of origin and quality of food and agricultural and fisheries products.



Figure 6. Protected geographical indications of a) “Dates Bouittob of Tata”, b) “Dates Outoukdim of Toudgha Tinghir”, and c) “Dates Black Bousthammi of Drâa”.

Archiving, assessment and improvement of date traditional know-how

Contribution to archiving traditional know-how of date processing. Moroccan oases are rich in date genotypes diversity. A total of 453 native cultivars have been cataloged by INRA which they are estimated to account for less than one-half Morocco's date palms; the rest, some 55 percent, are represented by seedling dates (INRA, 2011). This heritage is characterized by the very interesting suitability for processing and preservation due to the diversification of their physical, physicochemical, biochemical, and sensory characteristics. Indeed, we find dates of different consistencies (soft, semi-soft, and dry), with different organoleptic properties (different tastes, flavors, colors, etc.), very variable fiber and sugar contents, etc. Dates are also characterized by their cosmetic and therapeutic aptitudes in addition to their cultural and religious significance. To this end, efforts were carried out by the oases population for a long time in order to valorize traditionally a part of their date production or at least, satisfy their consumption in different forms through an ingenious know-how. So, oases have ancestral women know-how of date processing into various products, locally appreciated: juice, syrup, vinegar, paste, flour, etc. Nevertheless, the transmission of this traditional knowledge substantially regressed, and the valorization of these local date products remains insufficient (Zirari *et al.*, 2003; 2005; Harrak, 2018; Harrak *et al.*, 2018).

In order to safeguard this know-how, INRA has established a detailed collection of various traditional preparations including illustrations of practical demonstrations of some of these preparations done by oases women. The methodology adopted for archiving and analyzing the local knowledge was based on a participatory diagnosis conducted with the oases population predominantly women. More than thirties of traditional preparations were identified. These preparations are often associated with MAP which provide the properties of flavoring, preservation, and medication. These traditional date products can be justifiably regarded as *terroir* products and deserve to be promoted. Are presented below some of thirties local date products, which the names can differ for the same product from oasis to oasis (Fig. 7):

- Abboud: Balls of date prepared with date paste flavored with MAP and coated with rancid butter (*smen*).
- Belliâ: Allonged balls of date prepared with date paste flavored with anise seeds and mixed with *smen* or butter or olive oil.
- Lhrissa or Takka: Dry date flour or meal which can be mixed with barley flour, dry fruits, and MAP.
- Sellou or Tahamart: Date balls prepared with date paste, maize flour, *smen*, anise, and sesame seeds.
- Tyni n'oud: Date paste mixed with *smen*.
- Tyni n'zit: Date paste mixed with olive oil.
- Tahlaout or Robb or Debse: Date syrup.
- Tassabout or Takachoult or Chakoua or Mriss: Sparkling and flavored juice prepared with dates and an aqueous extract of MAP (thirties plants can be used). An abundant foam is formed during the juice preparation, reminiscent of soap, hence the name Tassabout (which means soap in the Moroccan Berber language).
- Tassabout or Toummit: Paste prepared with dates, maize flour, durum wheat flour, olive oil, and MAP. This paste is shaped into a sausage shape. As for juice, this paste probably reminiscent of traditional soap, hence the name Tassabout.

To analyze perfectly these traditional preparations, diagnosis and practical demonstrations have allowed their rigorous technical description. This description has focused on determining date palm genotypes, ingredients, materials, processes, etc. used in different preparations.

The rich biodiversity of the date palm and the diversity of date local traditional know-how attest to the vivacity of a very ancient tradition of date palm that must be considered as a chance for the future. Indeed, the preservation and valorization of traditional know-how signify conservation of social and cultural identity of the oases population. They also mean the safeguarding of the date palm biodiversity by encouraging farmers to grow, alongside high commercial value cultivars, a wide range of cultivars of high technological suitability. Safeguarding and valorization of these products will also allow returning to natural label of *terroir* products and reconnecting with a traditional diet considered tastier and natural (Harrak, 2007; Harrak, 2018; Harrak *et al.*, 2018; INRA, 2018).



Figure 7. Some Moroccan traditional date products based on oases women know-how: a) Tyni n'oud b) Tyni n'zit c) Belliâ d) Lhrissa e) Toummit f) Tahlaout.

Valorization of traditional know-how of date processing. Commercial exploitation of traditional date products on the market requires the addition of complementary know-how in stabilizing, packaging and in improving the overall quality of these products. Thereby, improving family processes could involve the usual steps of manufacturing, and eventually the introduction of new operations to stabilize and to facilitate commercialization (Harrak, 2007; Harrak *et al.*, 2009; Atfaoui *et al.*, 2013; Mounir *et al.*, 2015). Two traditional date products were identified as a promising product to be further developed, based on their organoleptic qualities and therapeutic

virtues, and they were deeply studied in order to valorize them: date paste Tassabout (or Toummit) and date juice Tassabout (or Takachoult).

Valorization of date paste Tassabout.

The research work aimed to evaluate and improve the traditional process of making Tassabout date pastes of Tata oases in order to safeguard this know-how and to promote the commercialization of these locally appreciated products. These pastes, prepared mainly by dates added to maize and wheat flours, olive oil, and some MAP, were picked out in the Tata oases and evaluated by studying physical, physicochemical, and microbiological parameters. To improve the quality of these pastes, a deep research was undertaken using Bouittob and Black Bousthammi varieties. The study concerned process adjustment, physical, physicochemical, microbiological, and sensory characterizations, and storage stability evaluation of the paste during a period of 12 months. Processing traditional paste using the improved process has resulted in very satisfying product in terms of physical, physicochemical, microbiological, and sensory criteria with optimal storage conditions and appropriate packaging for preserving hygienic quality and semi-soft texture of the paste. Furthermore, technology transfer of this improved traditional paste to date valorization cooperatives in Tata oases is forecasted (Fig. 8) (Harrak, 2013b; Harrak *et al.*, 2016; INRA, 2018; Harrak *et al.*, 2018). Figures 9, 10 and 11 confront the medians of scores attributed by the INRA date sensory panel to some sensory criteria of Tassabout improved pastes of Bouittob and Black Bousthammi dates (Harrak *et al.*, 2018).



Figure 8. Improved date paste called “Tassabout” or “Toummit”.

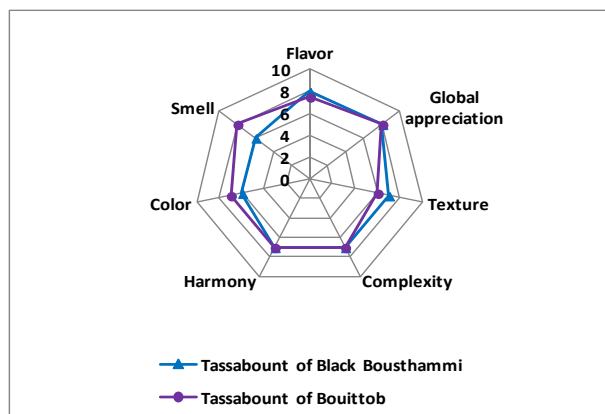


Figure 9. Score medians of the appreciation of Tassabount improved pastes of Bouittob and Black Boushammi dates (Harrak *et al.*, 2018).

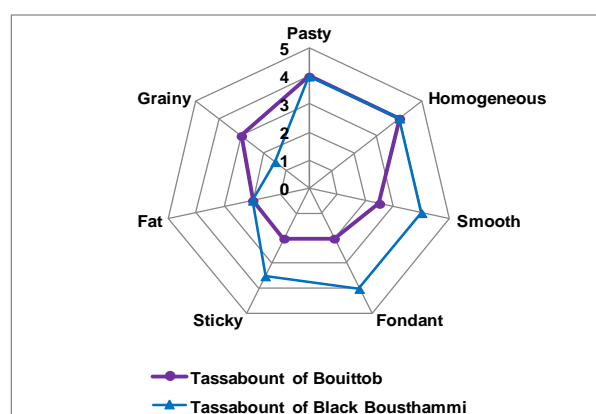


Figure 10. Score medians of the perceived texture in the mouth of Tassabount improved pastes of Bouittob and Boushammi dates (Harrak *et al.*, 2018).

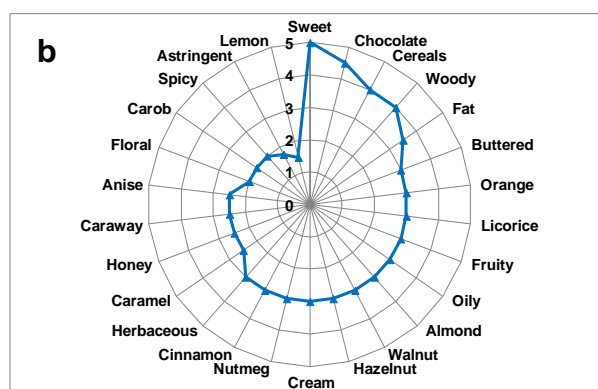
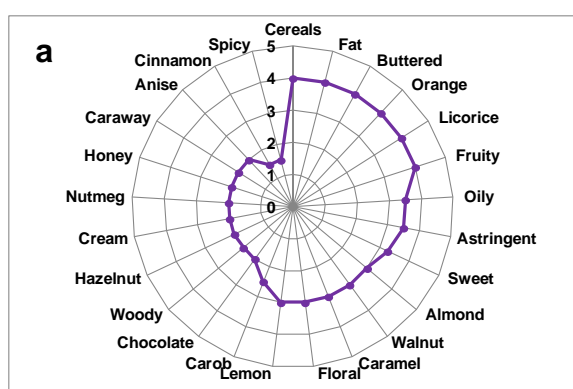


Figure 11. Score medians of perceived flavors in Tassabount improved pastes of Bouittob (a) and Black Boushammi (b) dates (Harrak *et al.*, 2018).

Valorization of date juice Tassabount.

In view of its promising applications, the juice Tassabount can get out of household manufacturing and consumption to emerge as a local product for a wider market. Such valorization requires a deep description and understanding of the different steps of the traditional juice processing. So, the research work aimed to evaluate and improve the traditional process of making the juice Tassabount by contributing to the analysis of the family preparation process by studying juice characteristics and the main physical, physicochemical, biochemical, and microbiological phenomena occurring during the preparation of the extract of MAP used in the preparation of Tassabount. The research has also led to the acquisition of technological control of juice Tassabount processing (at laboratory and pilot scales) for the transfer of this technology to small and medium-sized enterprises (Fig. 12) (Harrak, 2007; Harrak *et al.*, 2012; Harrak, 2018; INRA, 2018).



Figure 12. Improved date juice called “Tassabout” or “Takachoult”.

Some physical, physicochemical and biochemical criteria of Tassabout improved date juice are presented in table 2.

Table 2. Some physical, physicochemical and biochemical criteria of Tassabout improved date juice (Harrak, 2007).

Criteria		Mean values
Dry matter (g/100 g)		21.43
Brix (°Bx)		20.0
Total titratable acidity (meq/100 mL)		5.0
pH		4.36
Insoluble suspended solids (g/100 g)		14.73
Density (kg/m ³)		1070
Water activity		0.98
Color parameters	L*	29.31
	a*	8.79
	b*	17.45
Total polyphenols (g Gallic acid equivalent/100 g Dry matter)		569.47

Development and adaptation of modern industrial date fruit processing

For better valorization of dates of low and medium commercial quality including dates eliminated by sorting in date packing units, the research work on date processing have permitted developing and adaptation of processes of date jam, marmalade, flour, paste, etc. These products can be consumed directly or used for baking and confectionary. The developed products meet quality standards and are characterized by high nutritional and organoleptic qualities. Some of the developed processes were transferred to date processing cooperatives in different Moroccan oases in the framework of solidarity transfer of technologies. This research work was justified by the added value to generate for dates, the diversity of date products to ensure in the market and the profession request in the oases. Are presented below some results of three research works relating to date flour, jam, and seed oil (Harrak and Jaouan, 2010; INRA, 2018; Harrak, 2019).

Date flour.

The research work aimed to assess the suitability of Moroccan dates for processing into flour and determine nutritional, organoleptic, and commercial qualities of this product. Six varieties of dates were studied: Ademou, Bouijjou, Bouskri, Bouslikhene, Jihel and Oum N'hal (Fig. 13). This work has highlighted the high suitability of Bouskri and Bouijjou varieties for processing into flour. Beside high processing yields reaching 75.3 %, the date flours showed interesting characteristics in terms of nutritional and organoleptic qualities. For storage stability, time and temperature had a noticeable effect on the physicochemical properties of the flour. The sensory evaluation of date flour was very encouraging and showed that this flour is a promising product to enrich and / or to flavor food preparations.



Figure 13. Date flour of three Moroccan cultivars: Ademou, Bouskri, and Bouijjou.

Date jam.

The research work has resulted in different types of jams, marmalades, and similar products like jam without added sugar, date butter, etc. using several varieties like Black Boushammi, Bouslikhene, Saïr-Layalate, etc. (Fig. 14). Some of the adapted technologies were transferred to date processing cooperatives in different Moroccan oases. Other studies have contributed in the evaluation and upgrading of prerequisite programs and the evaluation of the quality of date jam produced by some cooperatives. These studies were interested first in the diagnosis of prerequisite programs to determine non-conformities and provide appropriate corrective actions according to the requirements of good hygienic practices of production and manufacturing. Then, they have concerned the evaluation of physicochemical, organoleptic, hygienic, and commercial qualities of date jams produced by these cooperatives, according to national and international standards of jam quality. A comparative study between the jams produced by these cooperative and those produced in the INRA laboratory in Marrakesh was done in order to recommend the INRA technology. The established assessments allowed the presentation of principles of good manufacturing practices and corrective measures, to address non-conformities with the rules of the hygienic, commercial, organoleptic, and physicochemical qualities, were proposed in order to establish a methodology for overcoming deficiencies. Thus, recommendations were proposed for the production of a safe, nutritious and tasty jam.

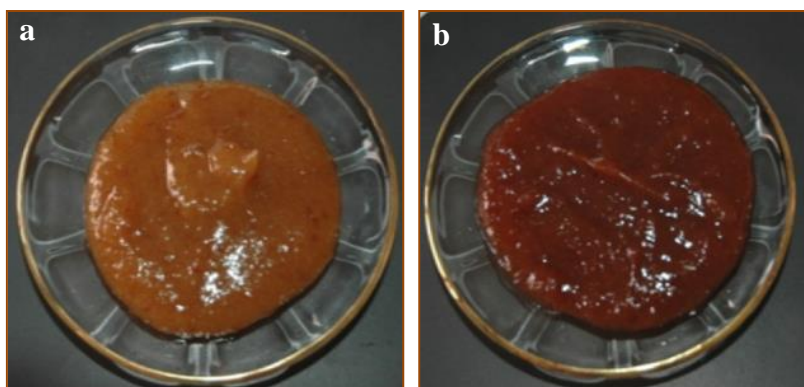


Figure 14. Very appreciated date jam of (a) Boufeggous, and (b) Bouslikhene cultivars produced using INRA technology.

Date seed oil.

This research work aimed to establish a catalog of physicochemical and biochemical criteria of the date seed oil of thirty Moroccan cultivars (Fig. 15). The results have shown that this oil has a great potential deserving more investigation for valorization in pharmaceutical and cosmetic industries. In fact, this oil is characterized by its richness in saturated fatty acids (lauric, myristic, palmitic, and stearic acids). It has also high oleic acid content comparable to argan and sesame oils, and it is about three times higher than prickly pear seed oil. Its linoleic acid content is comparable to olive oil. This date seed oil is also characterized by a good stability due to its fatty acid composition and quality parameters.



Figure 15. Date seed oil of three Moroccan cultivars: (a) Bouslikhene, (b) Oum N'hal, and (c) Black Bousthammi.

Adaptation of date preservation processes

Moroccan date production is damaged annually up to 30 % by insects (especially moths). The damage incurred in the income of farmers and their living standard. In addition, quality standards available now for 12 Moroccan date varieties, and presentation requirements according to consumer preferences, are rarely met. Indeed, with some exceptions, good and medium quality dates are distributed in inadequate packaging, and a large proportion of the production is sold without recourse to marketing techniques to highlight natural characteristics, and cultural and history values linked to the context of date production in oasis areas. View the

economic importance of this aspect, the research activities have sought an efficient method of disinfection at the request of the date packing cooperatives. For this purpose, the research work has concerned the study of the date preservation by heat treatment of some Moroccan khalts and cultivars (Boufeggous, Jihel, Bouittob, Bouskri, and Najda) to determine the effect of this treatment on moth mortality and certain physical and physicochemical quality parameters while determining the treatment scales for the destruction of moth and the preservation of date quality. The adapted heat processes were transferred to date packing cooperatives in different oasis (Hilal *et al.*, 2005; INRA, 2018).

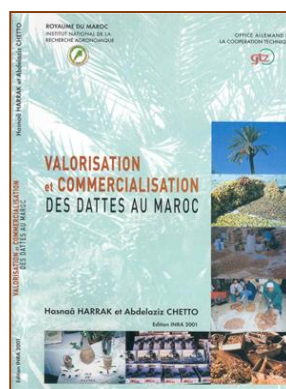
Sharing knowledge and technology transfer for improving and developing Moroccan date postharvest valorization

Sharing knowledge

The research conducted by INRA in cooperation with national and international collaborators on the date valorization of dates has contributed in enriching the national and international literature on the date palm and especially in fulfilling the gap in scientific, technical, and organizational information, relating to quality and valorization of Moroccan dates. In addition, these publications have served and still serve as models for national and international date palm development efforts. The main books edited or co-edited by INRA are presented below. These books together, provide detailed information of essential and complementary aspects of Moroccan date fruit characteristics and industry during two decades.

Valorization and commercialization of dates in Morocco

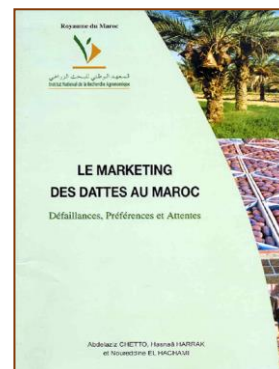
(*Valorisation et commercialisation des dattes au Maroc*), authored by Harrak and Chetto (2001). This book presents a diagnosis of the situation of date valorization and marketing in Morocco, essential for technical, economic, and organizational improvements. This document also evokes practical aspects allowing the improvement of certain techniques and processes of date valorization. Indeed, it was first presented the history of the date palm, the importance of the phoenicultural sector at global and national levels, and the characteristics of the date palm cultivation in Morocco. It then approached the aspects of date valorization and marketing in Morocco by describing the current states of harvest and post-harvest technologies and of date marketing circuits, and by presenting date treatment, packaging, and transformation units in Morocco. In this regard, this study has led to a better knowledge of the failures of valorization and marketing which hamper consumer satisfaction and income generation. The book also presented organisms and organizations involved in the date palm sector in Morocco and problems of this sector. It resulted in a series of recommendations for improving and developing this sector. It highlighted that in order to really implement the various recommendations, it is necessary to unite various actors (organisms, organizations, industrialists, traders, and farmers) around the project to boost the date market. This study were actualized, completed, and



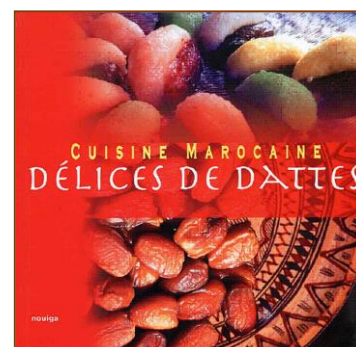
published in Arabic in 2005 under the title: Study of marketing of dates, date industry and exploitation of dates and date palm by-products in the Kingdom of Morocco (دراسة (تسويق التمر وتصنيعها واستغلال مخلفات النخيل والتمور ومنتجاتها العرضية بالمملكة المغربية (Harrak and Chetto, 2005).

The marketing of dates in Morocco: Failures, Preferences and Expectations (*Le marketing des dattes au Maroc : Défaillances, Préférences et Attentes*), authored by Chetto, Harrak and El Hachami (Chetto *et al.*, 2005b). This book has led, via a “consumers and traders” survey covering major Moroccan cities (Casablanca, Rabat-Sale, Marrakesh, Fes-Meknes, Tanger-Tetouan, and Agadir) in particular to:

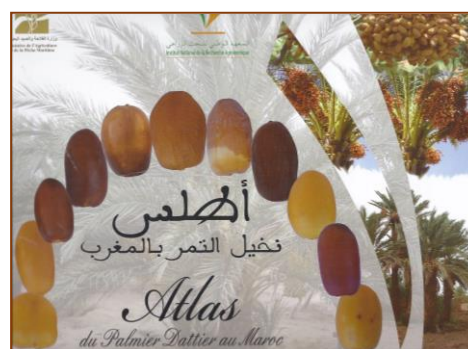
- The knowledge of preferences and requirements of consumers in term of intrinsic qualities of the date and in term of “packaging”;
- The knowledge of preferences and requirements of traders in terms of quality, handling, packaging, and storage;
- Diagnosis of failures of the commercialization that hamper the consumer satisfaction;
- A series of measures that will boost the valorization and commercialization of dates, as well as the strategic elements necessary for their implementation.



Moroccan cuisine - Date delights (*Cuisine marocaine - Délices de dattes*), authored by Zirari, Harrak, Ouberhou, Outlioua, Boussaguia, Ben Salah and Radi (Zirari *et al.*, 2006). This work brings together a number of traditional preparations, cooking recipes, pastry making, and industrial preparations, all based on dates, allowing the preservation of this product, its promotion and its insertion into modern culinary art. Indeed, the Moroccan palm grove is rich in ingenious traditional know-how of date transformation. Furthermore, the introduction of the date in modern culinary art, in addition to these historical facts, is also justified by the quantitative importance of dates of low commercial quality presenting constraints of marketing and the significant tourist potentialities of the area giving rise to the need to have an original consumer product to present in different forms.



Date Palm Atlas of Morocco (*Atlas du Palmier Dattier au Maroc*), prepared by El Idrissi Ammari, Sedra, Zirari, Essarioui, Sabri, Anjarne, Abahmane, Bouguerfaoui, Boujnah, Harrak, and Benzine (INRA, 2011). This atlas provides a baseline analysis of major native Moroccan date cultivars and their zones of cultivation. It notes that 453 native cultivars have been cataloged. The date cultivars are estimated to account for less than one-half Morocco's date palms; the rest,

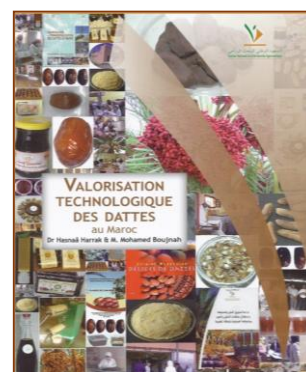


some 55 percent, are represented by seedling dates. An introductory chapter gives a general overview of date fruit production along with a set of descriptors to characterize cultivars, including one related to bayoud disease resistance. The core section of the atlas is comprised of descriptions of the major cultivars, including four categories: superior, as selected by INRA, primary, secondary and rare. A final section of the atlas contains a brief summary about plantation establishment and management. To a large extent, concentrated date palm research, led by INRA, has been necessitated by the urgent need to deal with the devastating effects of bayoud disease, a soil-borne fungus (*Fusarium oxysporum* f.sp. *albedinis*) which was first reported in Morocco in 1870. This atlas presents also some achievements of INRA research program in the field of date valorization. It was re-edited by INRA in 2013.

Technological Valorization of Dates in Morocco

(*Valorisation Technologique des Dattes au Maroc*), authored by Harrak and Boujnah (2012). This book includes various scientific and technical aspects of date valorization, addresses modern industrial date preservation and processing and INRA research achievements in these areas. It begins with a detailed description of the fruit at its different stages of development along with the nutritional, technological, organoleptic, and commercial properties of the major commercial and noncommercial Moroccan cultivars.

Technology of fruit processing for preparing an assortment of fruit derived products for baking and confectionary, as well as flour, syrup, jam, preserves, sugar, vinegar and alcohol, in addition to the use of date seeds, is deeply presented. The book also widely reviewed harvest, pest control, storage, packing, and marketing. In line with the national strategy for the development and valorization of local products and for recognizing the long tradition of producing and consuming dates in Morocco, the book also reflects the efforts of research and development for labelling dates and traditional date-based preparations using SDOQ. The need for Moroccan date classification standards is identified as a key factor to facilitate marketing. The book also presents the INRA efforts in terms of scientific and technical assistance to professional organizations in Moroccan oases for building skills and encouraging them to set up date processing and packing units.



Practical manual - Technological valorization of dates:

Quality, Hygiene and Process (*Manuel pratique -*

Valorisation technologique des dattes : Qualité, Hygiène et

Procédés), authored by Harrak (2019). This book brings

together in a relevant way the technical, practical, and

regulatory aspects, now highly sought after by the scientific,

technical and professional communities concerned by the

technological valorization of dates. It contains examples,

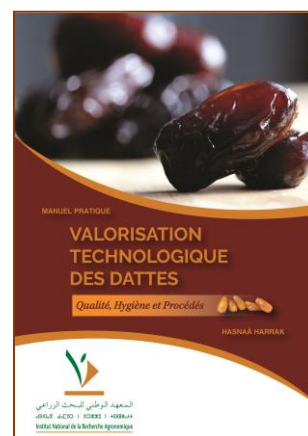
concrete cases and recommendations, the fruit of successful

experiences at national and international levels, for more

involvement of all actors concerned by date development,

anxious to carry out their projects, to comply with the laws in

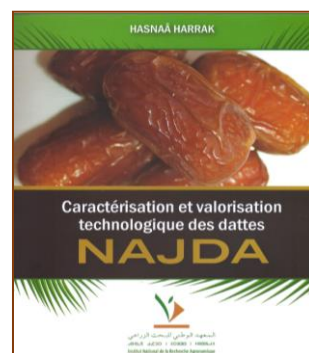
force, to respect the quality standards demanded by the



market and to satisfy consumer preferences. In fact, this manual relates, in a simple way, aspects of quality and good manufacturing and hygiene practices in the food industry. It also presents processes of transformation and preservation of dates. Particular interest is given to Moroccan and international laws and standards relating to these different aspects, the majority of which have been imposed during the past ten years.

Characterization and technological valorization of Najda dates

(*Caractérisation et valorisation technologique des dattes Najda*) authored by Harrak (2020a). This scientific and technical book is a synthesis of various research and research and development activities in terms of characterization and technological enhancement carried out for more than twenty years on dates of the Najda variety because of its specificities and its contribution in the reconstitution of the national palm grove based on quality and resistant cultivars to bayoud disease. In fact, Najda is the result of the first research work carried out by INRA on the selection of date palm clones resistant to bayoud and having good date quality among populations obtained from natural seedlings. It is one of the eight varieties resistant to bayoud, one of the twelve varieties with a specific standard and one of the nine varieties having been recognized by a SDOQ. Quantitatively, the date palm of Najda variety was multiplied to hundreds of thousands of *in vitro* plants and it is now planted in different Moroccan oases. This book describes various aspects related to typicity and quality criteria of Najda dates, their quality standard, their labeling as well as technological practices necessary for a better date valorization. In addition, this book presents an original comparison of Najda dates with those of bayoud resistant varieties as well as with those of the main Moroccan varieties, which has shown that Najda dates offer market potential that must be exploited and enhanced. This book also presents a series of recommendations and practical guidelines that are able to capitalize on the achievements and better enhance and promote Najda dates.



Technology transfer and technical assistance to date valorization units

The valorization of some conclusive research achievements were realized through technology transfer and technical assistance for the benefit of development agencies and professional organizations in different oases (extension organisms, cooperatives, associations, and farmers) allowing them to succeed in their date valorization projects and permitting Moroccan oases to move progressively to the production of date products of high commercial quality (Fig. 16). The date valorization units (small plants) and development organisms have received trainings and technical assistance on the various aspects of date valorization. These aspects include quality in agro-food industries (definition, standards, controls, etc.), good manufacturing practices (hygiene, organization, etc.), date treatment, processing and packing; and quality parameters of date products including shelf-life, hygienic and organoleptic criteria. Furthermore, some date packaging and processing units received further assistance for their implementation through contribution to their design according to the

manufacturing diagrams and hygienic rules, and determination of technical specifications and characteristics of the equipment required for different production lines, etc. (Harrak, 2010a; Harrak, 2017; INRA, 2018).



Figure 16. INRA technical assistance and practical trainings to the benefit of members of date units of different Moroccan oases.

Conclusion

The date industry is now called upon to occupy an emeritus place in the Moroccan agricultural landscape through the preservation of its heritage and an appropriate valorization of its production. Such valorization requires the availability of scientific and technical data, methods, and specific processes adapted to national date production. Therefore, agronomic research plays a preponderant role in providing this information to various actors for a better valorization of this oasis *terroir* product. The research work carried out by INRA aimed to contribute in increasing the efficiency and level of qualification of scientific and technical beneficiaries as well as professional groups allowing them to fully master aspects of date quality and technology, to be able to succeed in their research, quality control or production activities in the field of date technological valorization.

The research, research development and development achievements presented in this review have made it possible to fill several gaps. They have also generated successful stories through the development of skills of oases women, date producers and date professional organizations. In fact, the accomplished activities have contributed to a better technological valorization of dates through achievements that have further involved various actors concerned with preserving biodiversity and local know-how of dates, highlighting their typicity and notoriety, carrying out their development projects successfully, establishing and respecting their quality standards, and satisfying consumer preferences. These research achievements, having benefited from national and international recognition, have provided concrete and modern solutions, capable of contributing to a real enhancement of dates while taking into account their specificities and those of their *terroirs* for a sustainable development of Moroccan oases.

The research actions proposed in terms of technological valorization and the agro-industry of dates within the framework of INRA medium-term research program (PRMT) 2021-2024 constitute a coherent and rewarding continuity of research achievements in this field of previous PRMTs. They take into account the new national Green Generation strategy 2020-2030 and the development program of the date palm sector, which fit perfectly into oasis development programs and represent a major element in the diversification of oasis economic activity and its effective integration into the national economy.

Conflicts of interest

The author declares no conflicts of interest.

Acknowledgements

The author gratefully acknowledges the valuable technical and financial supports of INRA collaborators (organizations, institutes, projects, programs, agencies, networks, etc.). She also sincerely appreciates the effective cooperation of oases women, date producers and date professional organizations (federations, cooperatives, associations, and economic interest groups). She would also like to extend her thanks to the technical staff and the date sensory panel of Agro-Food Technology and Quality Laboratory in Regional Center of Agricultural Research of Marrakesh (INRA) and to all colleagues and persons who have collaborated during the development of this work.

Bibliographic references

- Alahyane A., Harrak H., Ayour J., Elateri I., Ait-Oubahou A. and Benichou M. (2019). Bioactive compounds and antioxidant activity of seventeen Moroccan date varieties and clones (*Phoenix dactylifera* L.). South African Journal of Botany. Vol. 121. p. 402-409.
- Alahyane A., Harrak H., Elateri I., Ayour J., Ait-Oubahou A., Benichou M. and Abderrazik M. (2022). Evaluation of some nutritional quality criteria of seventeen Moroccan dates varieties and clones, fruits of date palm (*Phoenix dactylifera* L.). Brazilian Journal of Biology. Vol. 82. e236471. 12 p.
- Atfaoui K., Ennassiri H., Ismaili Alaoui M., Hamouda A. and Harrak H. (2013). Valorisation des produits des oasis marocaines : Amélioration des procédés de préparation du vinaigre et du sirop de dattes. In Programme de Recherche - Bilan et perspectives. Programme MCA-Maroc. Projet Arboriculture Fruitière. Consortium National de Recherche en Agriculture (IAV Hassan II, INRA, ENA, ENFI). p. 79-80.
- Chetto A., Harrak H. and El Hachami N. (2005a). Etude exploratoire de la commercialisation des dattes au Maroc : Ses défaillances et les attentes des commerçants. In Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 167-175.
- Chetto A., Harrak H. and El Hachami N. (2005b). Le marketing des dattes au Maroc : Défaillances, Préférences et Attentes. INRA Edition. Rabat. 96 pages.
- Ghouibi A (2021). Récolte record de dates pour la champagne 2020-2021. Médias24. Agriculture. Edition 23/11/2021. <https://medias24.com>
- Harrak H. (1999). Etude des aptitudes technologiques des principales variétés de dattes marocaines : Caractérisation physique, physico-chimique et biochimique. Mémoire de titularisation. INRA. Marrakech, 156 p.
- Harrak H. (2004a). Atelier Régional sur le Développement du Palmier dattier dans la Péninsule Arabique. Mission report. ICARDA. Abu-Dhabi United Arab Emirates, 29-31 May 2004. 15 pages.
- Harrak H. (2004b). Date postharvest valorization in Morocco: Present status and research activities. In Summary Proc. of a Regional Workshop. Date palm Development in the GCC Countries of the Arabian Peninsula (ICARDA/APRP, MAF, UAEU, GCC). Abu Dhabi United Arab Emirates, 29-31 May 2004. p. 40-42.
- Harrak H. (2004c). Projet de recherche sur la valorisation des sous-produits du palmier dattier au Maroc. In Projet Régional sur la valorisation des sous-produits du palmier dattier. OADA. Algiers Algeria, 12-14 October 2004. 15 pages.
- Harrak H. (2007). Archivage, analyse et amélioration du savoir-faire traditionnel oasien : Cas du jus de dattes. Doctoral thesis (Agronomic and Veterinary Institute Hassan II, Rabat). 233 pages.
- Harrak H. (2010a). Assistance technique de l'INRA aux coopératives des dattes dans les oasis marocaines. Pack info. N° 89. p. 46-47.
- Harrak H. (2010b). La datte marocaine : Vers la valorisation. Food Magazine. N° 27. p. 44-45.
- Harrak H. (2010c). Valorisation des dattes. Agriculture du Maghreb. N° 44. p. 72-75.
- Harrak H. (2013a). Dattes Bouittob de Tata : Projet d'Indication Géographique Protégée. In Programme de Recherche - Bilan et perspectives. Programme Millenium Challenge Account (MCA - USA/Maroc), Projet Arboriculture Fruitière, Consortium National de Recherche en Agriculture (IAV Hassan II, INRA, ENA, ENFI). p. 77-78.

- Harrak H. (2013b). Evaluation de la qualité des pâtes de dattes traditionnelles Tassabount et Toummit, produits de terroir des oasis de Tata. In Programme de Recherche - Bilan et perspectives. Programme MCA-Maroc, Projet Arboriculture Fruitière, Consortium National de Recherche en Agriculture (IAV Hassan II, INRA, ENA, ENFI). p. 84-85.
- Harrak H. (2014). Report of Consultancy Mission on Dates Post-Harvest and Processing. Project UTFN/SAU043/SAU "Establishment of an International Date Palm Research Centre in KSA", Sub-Program: "Sustainable Crop Production and Good Agricultural Practices". FAO. Saudi Arabia, 13 December 2013 - 12 January 2014. 30 pages.
- Harrak H. (2015). Rapport de mission relative à la participation au « 11th Pangborn Sensory Science Symposium ». Gothenburg Sweden, 23-27 August 2015, 21 pages.
- Harrak H. (2016). La recherche agronomique au service de la datte, produit de terroir des oasis marocaines. In Recueil des résumés. Programme scientifique. Thème : « La recherche scientifique au service des Produits de Terroir ». Session 1 : « Produits de Terroir, l'aval d'une filière ». 4^e Edition du Salon national des produits de terroir. Agadir Morocco, 26-30 May 2016. p. 6.
- Harrak H. (2017). Rapport de la mission de consultation en chaîne des valeurs des dattes dans le cadre du Projet FAO-GCP/MOR/044/GFF : Conservation de la biodiversité et atténuation de la dégradation des terres par une gestion adaptable des systèmes du patrimoine agricole. Figuig Morocco, 11-19 February 2017. 54 pages.
- Harrak H. (2018). Les préparations traditionnelles à base de dattes des oasis marocaines : Un patrimoine à préserver et à valoriser. Horizons Maghrébins - le droit à la mémoire. Manger au Maghreb - Partie IV : Par les mots, les légumes et les fruits. N° 79. 34^e année. p. 29-44.
- Harrak H. (2019). Valorisation technologique des dattes. Qualité, hygiène et procédés. Manuel pratique. INRA Edition. Rabat. 124 pages.
- Harrak H. (2020a). Caractérisation et valorisation technologique des dattes NAJDA. INRA Edition. Rabat. 68 pages.
- Harrak H. (2020b). De l'importance de la cartographie sensorielle pour caractériser les produits de terroir. Analyse sensorielle : un outil puissant au service de l'innovation. Food magazine. N° 130. p. 39.
- Harrak H. (2020c). Développement d'un Signe Distinctif d'Origine et de Qualité de la variété Assiane et valorisation des dattes de Figuig. In Rapport synthétique des réalisations. Atelier de clôture. Projet GCP/MOR/044/GFF « Conservation de la biodiversité et atténuation de la dégradation des terres par une gestion adaptable des systèmes du patrimoine agricole ». Rabat Morocco, 24 February 2020. p. 32-33.
- Harrak H. and Boujnah M. (2012). Valorisation technologique des dattes au Maroc. INRA Edition. Rabat. 157 pages.
- Harrak H. and Chetto A. (2001). Valorisation et Commercialisation des dattes au Maroc. INRA Edition. Marrakech. 222 pages.
- Harrak H. and Chetto A. (2005). Etude de la commercialisation des dattes, de l'industrie dattière et de l'exploitation des sous-produits du palmier dattier et des dattes au Royaume du Maroc. INRA Edition. Rabat. 195 p.
- Harrak H. and Hamouda A. (2005). Etude de quelques critères de qualité des principales variétés de dattes marocaines. In Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 554-557.
- Harrak H. and Jaouan F. (2010). Processing dates of low market value into flour: Evaluation of quality and storage stability. In Proc. 4th Int. Date palm Conference. A. Zaid and G.A. Alhadrami eds. Acta Hort. Vol. 882. p. 593-602.

- Harrak H., Ameziane E.A. and Chafik M.S. (2001). Actions pour l'amélioration et la valorisation de la dattes marocaine. In Actions pour l'amélioration et la valorisation de la dattes marocaine. Micro-projet « Contribution à l'amélioration de la commercialisation des dattes au Maroc ». gtz, INRA, ORMVA/TF, ORMVAO. Morocco. 86 pages.
- Harrak H., Boujnah M. and Hamouda A. (2003). Caractérisations physique et morphologique des principales variétés de dattes marocaines. AlAwamia. N° 107. p. 59-76.
- Harrak H., Chetto A. and Ameziane E.A. (2000). Etat actuel des technologies post-récolte des dattes au Maroc. In Proc. Session de formation sur la technologie post-récolte des dattes. Réseau de Recherche et du Développement du Palmier dattier. Ras Al-Khayma United Arab Emirates, 20-27 June 2000. 4 p.
- Harrak H., Chetto A. and El Hachami N. (2005a). Consommation des dattes au Maroc : Caractéristiques et exigences des consommateurs. In Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 141-148.
- Harrak H., Hamouda A. and Nadi M. (2015). Sensory analysis of date fruits (*Phoenix dactylifera*): An important discipline for the date palm sector in Morocco. In Delegate programme booklet - 11th Pangborn Sensory Science Symposium. Gothenburg Sweden, 23-27 August 2015. P1.222.
- Harrak H., Hamouda A. and Nadi M. (2016). Evaluation et amélioration de la qualité des pâtes traditionnelles de dattes Tassabout et Toummit, produits de terroir des oasis de Tata. In Actes du workshop international - Gestion Intégrée et Durable des Territoires Oasiens. Tome 1 : Systèmes de productions agricoles et valorisation des produits. Bouaziz A., Hammani A. and Kuper M. eds, Zagora Morocco, 15 - 19 April 2016. p. 265-282.
- Harrak H., Hamouda A. and Nadi M. (2018). Evaluation et amélioration de la qualité des pâtes traditionnelles de dattes, produits du terroir des oasis. Cah. Agric. Vol. 27. 15001. 7 p.
- Harrak H., Hamouda A., Boujnah M. and Gaboune F. (2005b). Teneurs en sucres et qualités technologiques et nutritionnelles des principales variétés de dattes marocaines. In Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 108-115.
- Harrak H., Lebrun M., Ismaïli Alaoui M.M., Sarter S. and Hamouda A. (2012). Physicochemical, biochemical and microbiological phenomena of the medicinal and aromatic plants extract used in the preparation of the Tassabout date juice in Morocco. In Botany. John Mworio Edition. Rijeka. p. 85-106.
- Harrak H., Lebrun M., Ismaïli Alaoui M.M., Senhaji A.F. and Hamouda A. (2009). Vers une valorisation du savoir-faire local des oasis : Cas du jus de dattes. Fruits. Vol. 64 (4), p. 253-260.
- Harrak H., Reynes M., Lebrun M., Hamouda A. and Brat P. (2005c). Identification et comparaison des composés volatils des fruits de huit variétés de dattes marocaines. Fruits. Vol. 60 (4). p. 267-278.
- Hilal A., Harrak H., Fatni A. and Sekkat A. (2005). Etude de l'influence de la technique de désinfestation par le four « Gonet » sur certains critères de qualité des dattes. In Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 56-64.
- Lebrun M., Billot C. and Harrak H. (2010). Le nez électronique : Un outil pour la caractérisation du palmier dattier. In Biotechnologies du Palmier dattier. Colloques et séminaires. Aberlenc-Bertossi F. ed. IRD. Montpellier France. p. 151-155.

- Lebrun M., Billot C., Harrak H. and Self G. (2007). The electronic nose: A fast and efficient tool for characterizing dates. *Fruits*. Vol. 62 (6). p. 1-6.
- Mounir M., Atfaoui K., En-Nassiri H., Hamouda A., Harrak H., Delvigne F., Thonat P. and Ismaili Alaoui M. (2015). Application des biotechnologies pour la valorisation des produits des oasis Marocaines : Préparation du vinaigre aromatisé et du sirop de dattes. In *Recueil des résumés et présentations - Le 1^{er} Symposium International de l'Agroécologie Oasienne "SIAO 2015" : L'Agroécologie, patrimoine et avenir des oasis*. Erfoud Morocco, 15-17 October 2015. p. 55.
- National Institute for Agricultural Research (INRA) (2011). *Atlas du Palmier Dattier au Maroc*. INRA Edition. Rabat. 197 pages.
- National Institute for Agricultural Research (INRA) (2018). Valorisation technologique des dattes. In *Le Centre Régional de la Recherche Agronomique de Marrakech au service du développement agricole durable. Synthèse des principaux acquis de recherche (2013-2018)*. INRA. Marrakesh. p. 40-44.
- Salmaoui S., Harrak H., Amine A. and Ellassassi S. (2006). Détermination de quelques caractéristiques physico-chimiques et biochimiques de quelques variétés de dattes marocaines. In *Congrès International de Biochimie*. Agadir Morocco, 9-12 May 2006. p. 343-346.
- Zirari A., Outlioua K., Harrak H., Chetto A. and Alaoui Rachidi M. (2003). Réhabilitation de la diversité génétique du palmier dattier dans la palmeraie de Fezouata. Rapport de l'atelier de Diagnostic Participatif. Projet « Gestion Participative des Ressources Génétiques du Palmier dattier dans les Oasis du Maghreb » RAB 98G31-IPGRI/PNUD/FEM. Zagora Morocco, 21-26 April 2003. 103 pages.
- Zirari A., Chetto A., Harrak H., Alaoui Rachidi M. and Outlioua K. (2005). Réhabilitation de la diversité génétique du palmier dattier dans la palmeraie de Fezouata. In *Actes du Symposium International sur le Développement Agricole Durable des Systèmes Oasiens*. Boulanouar B. and Kradi C. eds, Erfoud Morocco 08-10 March 2005. p. 167-176.
- Zirari A., Harrak H., Ouberhou A., Outlioua K., Boussaguia F., Ben Salah S. and Radi F. (2006). *Cuisine marocaine - délices de dattes*. Nouiga Edition, Tanger, 72 pages.