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Original Research Article

Analysis and Quality Control of Bio-actives and Herbal Cosmetics: The Case of Traditional Cooperatives from Fes-Meknes Region

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ABSTRACT

Consumers are increasingly turning to organic cosmetic products. Faced with this enthusiasm, many cooperatives have specialized in biocosmetics. This study aims to analyze the operational strategies of 25 cooperatives involved in natural ingredient cultivation and cosmetics formulation, through extensive surveys and interviews, the study seeks to elucidate market positioning, product offerings, and consumer preferences among these cooperatives. Financial reliance on personal resources, impediments to certification processes, and consumer shopping preferences are among the primary objectives explored. The results reveal that a significant majority (66%) of cooperatives depend on personal finances, with financial constraints hindering certification efforts and impacting sales. Consumer preferences favor traditional retail outlets like supermarkets and parapharmacies over online platforms. Quality labels and dermatological advice emerge as pivotal factors influencing consumer purchasing decisions. Furthermore, a randomized sample assessment evaluates product quality, encompassing sensory, microbiological, and physical stability tests, alongside heavy metal contamination analysis via the Inductively Coupled Plasma Atomic Emission Spectroscopy method. Cream formulations exhibit variable stability, with water activity significantly affecting microbial growth; products with lower water content demonstrate enhanced stability. Additionally, hydrolat quality profiles display varying levels of microbiological contamination, while essential oils demonstrate moderate quality with fluctuating acidity levels.

This research sheds light on the operational dynamics of cooperatives within the natural products sector, offering insights into market dynamics, product quality, and consumer preferences. The findings underscore the imperative of resource optimization, certification facilitation, and consumer education in enhancing cooperative competitiveness and sustainability within the natural products market.

***Keywords*:** Cooperative, Natural ingredients, Cosmetics Formulation, Market positioning, Quality control, Quality labels.

Introduction

The demand for natural cosmetic ingredients, such as vegetable oils, hydrolats and essences, is increasing. [1] Herbal and plant extract-based organic cosmetics have made significant waves in many first world countries. The natural organic ingredients of these cosmetics strongly position them as eco-friendly products. Promoting organic cosmetics is a relatively recent development in the business world, motivated essentially by growing consumer awareness of the environment.[2] In the Fes-Meknes region of Morocco, the biogeographical position boasts a wide diversity of botanicals and a rich ecosystem. The region has therefore long been involved in traditional medical practices and has acquired expertise in phytotherapy.[3] In fact, this practice is seen as an alternative means of improving the living standards of the region's population.[4]

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From this perspective, medicinal and aromatic plants (MAP) constitute a highly promising sector to create business and revenues through the valorization of these resources. The region of Fes Meknes is a case in point, where the creation of cooperatives operating in the MAP development sector has been aimed at preserving the natural capital. The success in this sector, however, depends on cooperatives demonstrating a commitment to the values of social, economic, and environmental sustainability.[5] Even with this potential, cooperatives face significant barriers in marketing their bioactive and producing cosmetic products. Difficulties regarding quality standards and compliance with international regulations, the absence of a standardized quality approach specific to this market inhibits further progress.[6] Certification becomes crucial in ensuring product marketing.[7] Organizations such as Cosmetic Organic and Natural Standard (COSMOS), Cosmetic Biologic (COSMEBIO) and Ecocert have developed standards for natural and organic cosmetics. These standards aim to guarantee a high proportion of organic or natural ingredients in products, while limiting the use of synthetic elements and chemical processes.[8] Notwithstanding the promising potential of cooperatives involved in the development of medicinal plants, they face major challenges in bringing their bioactive and cosmetic products to market. Major obstacles such as ensuring quality standards and compliance with international regulations hamper their market expansion. The lack of standardized methods for guaranteeing quality exacerbates the situation, underlining the crucial importance of certification in gaining consumer confidence. Against this backdrop, this study seeks to draw

up a general overview of the entrepreneurial landscape in the field of promoting botanical resources via cosmeceuticals production, with a focus on identifying market dynamics in the Fes-Meknes region. To investigate this in more detail and to provide sufficient data on this issue, cooperatives were visited and interviewed around Fes-Meknes. This study comprises three key dimensions. The first axis centers on the comprehensive examination of cooperatives, encompassing their economic performance, production dynamics, and adherence to product certification standards. The second axis delves into consumer perspectives, elucidating their preferences and decision-making processes concerning natural cosmetic products. This includes insights into brand loyalty, product preferences, and purchasing habits. The third axis concentrates on evaluating the quality of cooperative products, encompassing formulation integrity and the purty of active ingredients. Assessment criteria encompass sensory attributes, physical and chemical stability, as well as potential microbial or heavy metal contaminants. Additionally, active ingredients undergo rigorous scrutiny, evaluating parameters such as acid index, refractive index, saponification index, and density to ensure product efficacy and safety. Achieving these objectives in this study, will provide valuable information on the offerings of cooperatives in the Fes-Meknes region and the demands of Moroccan consumers. The study population being well characterized and substantial, the results can be accurately extrapolated to assess the entrepreneurial landscape of medicinal plant valorization in various Moroccan regions. In addition, a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis will identify strengths and weaknesses, enabling the strategic approach necessary for the success of this vital business sector to be articulated.

Materials and Methods

Study area

The cooperatives we visited were in the northern region of Morocco, more specifically in the Fes-Meknes region. Covering seven provinces: Sefrou, El Hajeb, Ifrane, Moulay Yaacoub, Taounate, Boulemane, and Taza. The coordinates of the center of the Fes-Meknes region are 34°N and 5°W (Figure 1). The region has a surface area of 5,849 km2, or 5.7% of the nation, and a population of 4,236,892, 60.52% of whom live in urban areas. With a high poverty rate of 13.8%, in a Mediterranean to continental climate.[9] Local economy depends mainly on agriculture and manufacturing.[10] Yet the recent years of severe drouth have had a serious impact on agriculture.[9,11]

Interviews and data collection

Investigations were carried out on cooperatives in the Fes-Meknes region during the period from April to June 2022, covering the 7 provinces of the region and considering the consent of the cooperative to be part of the study, i.e. a total of 25 active cooperatives (Table 1). Information was provided on the cooperative's contact details, source of funding, annual income, level of the manager education and average age of the members. Further questions concern the plants grown and the part of the plant used for extraction, types of products produced, production equipment and availability of product certification, etc.

Surveys were prepared using the Google Forms platform, to facilitate comprehensive data collection. Furthermore, the data acquisition was executed either by our research team during direct interviews or autonomously by respondents (Consumer / representative of each cooperative), and aligning with their individual inclinations. For consumer-targeted surveys, dissemination occurred through diverse channels, including social media platforms and face-to-face interactions within academic settings and coffee shops. Notably, the geographic scope of the study encompasses Moroccan consumers broadly, without specific regional constraints.

Consumers' opinions and requirements regarding these products were considered. Questions were asked about their personal satisfaction levels, favorite brands, and the criteria for selecting a cosmetic product. A total of 250 responses were received. Subsequently, the amassed survey responses were meticulously collated and subjected to rigorous analysis utilizing Microsoft Excel. The presentation of findings adopts a quantitative approach, with data represented as percentages relative to the total questionnaire population.

The practices, attitudes and knowledge of cooperative members regarding their formulation and extraction expertise will be analyzed by means of inspections and assays carried out on their products, collected through random sampling during our survey and field visits. The sampled products are grouped into four categories: - Emulsions, oils, hydrosols, and traditional formulas. The samples were then stored in a refrigerator and tested in early July 2022.

Quality control of emulsions

Sensorial analysis

Sensorial analysis is the subject of several reference standards and manuals, to determine texture, color, and odor of the product. The method developed by[12] was implemented with slight changes. Briefly, a panel of 10 internal scientists are involved, using the following descriptors : dense, white, bright, fluid, whitening, greasy, filmogenic, smooth, spicy, etc. Both female and male panelists participated in the evaluation process. The results were visualized using a Radar chart. Panelists were instructed to assess odor, texture, appearance, and consistency descriptors for each sample without handling.

Stability

Chemical stability refers to ensure that the co-existence of formulation ingredients doesn't interact with each other affecting the emulsion quality. 1g of each simple was diluted in 9g of hot distilled water and measured with a pH Meter (Ph Metre JENWAY 3510, UK). Water activity is assessed by measuring the weight of the sample before and after drying in 50°C (Memmert Gmbh + Co, Model U, Germany) incubation for 48 hours. A centrifugation (Mikro 220 | 220 R, Hettich, Germany) of 3000 Revolutions Per Minute (RPM) during 30 min, was used to examine the physical stability under accelerated time. Microbiological analyses were carried out according to the method described in.[13]

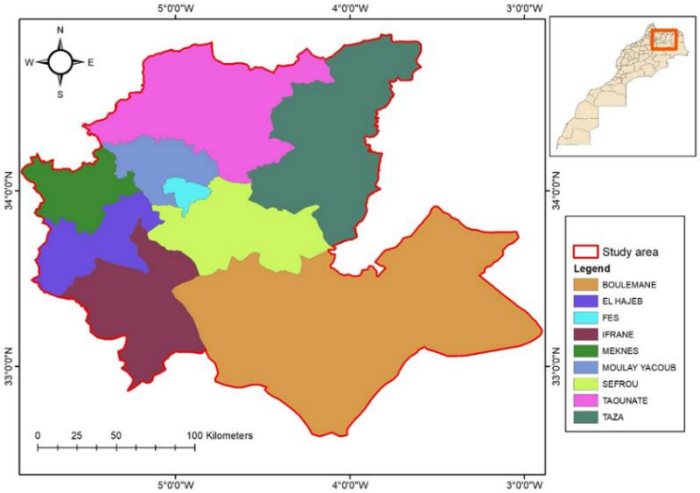


Figure 1: Geographical location of the study region of the Cooperatives visited and surveyed

(a) (b)

Figure 2: Methods of extracting botanical oils and essences: (a) Steam distillation at Aachab Beni Zeroual cooperative, Taounate (b) Cold extraction at Farah cooperative, Fes.

Table 1: Distribution by province of cooperatives visited and samples details

Province	Number of coops visited	Cooperative Name	Samples
FES	6	Cooperative Mano	S_{24} : Orange blossom hydrolat Lot N°1
			S_{26} : Rose hydrolate
			S_{25} : Orange blossom hydrolate Lot N°2
		Cooperative Flamme	N.s 1
		Cooperative Kenz Bladi	S_{11}: Moisturizing cream
			S_{9}: Anti-aging cream
			S_{22}: Aloe vera gel
		Cooperative Aloa Biben	S_{38} : Rosemary EO
			S_{39} : Spearmint EO
			S_{40} : Lavender EO
		Cooperative Rawdat Al-azhar	Kohl arabic
			Boukhour Serghina
			Moroccan Ghassoul
		Coopérative I Bio	S_{4}: Solar screen
			S_{3}: Moisturizer cream
			S_{1}: Cream Blush
			S_{2}: Body lotion
			S_{29}: Hand cleansing soap
			S_{33}: hair serum
			S_{14}: Traditional soap
			S_{15}: Hair conditioner
			S_{21}: Orange blossom hydrolat
		Cooperative Farah	S_{22}: Rose hydrolat
			E_{23} : Oregano hydrolat
			Boukhour Serghina
MEKNES	4	Cooperative Nair	N.s[1]
		Cooperative kounouz ssaiss	N.s[1]
		Cooperative Bio Zahhra	N.s[1]
		Cooperative Dar lkhir	N.s[1]
		Cooperative Ennajah	N.s[1]
IFRAN	3	Cooperative Inssaf	S_{8}: Foot care cream
			S_{6}: Moisturizing face cream
			S_{7}: Cream of paprika
			S_{13}: Cream of nettle
		Cooperative Azizel	S_{42}: Rose hydrolat
			S_{27} : Camomile hydrolat
			S_{28} : Thyme Hydrolat
TAOUNATE	3	Cooperative Aachab Beni Zeroual	S_{34}: Bitter almond VO
			S_{31}: Cannabis VO
		Cooperative Aznoud	N.s[1]
		Cooperative Slass Bio	N.s[1]
		Cooperative Idiwa	N.s[1]
BOULMANE	5	Ikhwa Bio	N.s[1]
		Cooperative Ahl misseur	S_{5}: Moisturizing cream
			S_{10}: Face mask

			S_{12}: Scrub
			S_{30}: Mixture of 10 VO
			S_{18}: Face serum
			S_{19}: Rosemary hydrolat
		Cooperative Dar lbeldi	S_{41}: Rose hydrolat
			S_{16}: Apple cider vinegar
			S_{17}: Sesame VO
			S_{20}: Blush serum
			S_{36}: Sweet almond VO
		Cooperative Riham	S_{37}: walnut VO
			S_{32}: Rosemary EO
TAZA	2	Cooperative Merzoug	S_{35}: Thyme EO
		Cooperative Anajah	N.s[1]
		Cooperative Ain siaj	N.s[1]
SEFROU	2	Cooperative arome agay	N.s[1]

[1]Not sampled.

Total Plate Count (TPC) test is to estimate, by enumeration, the presence of bacteria in the sample, by adding the sample to Luria-Bertani (LB) medium favorable to bacterial growth or Yeast Extract Peptone Glycerol (YPG) medium favorable to fungal growth, and malt extract medium for mold growth, to detect contamination more easily. 10 g of sample were dissolved in 90 mL of sterile distilled water under agitation (AM4 Digital PRO, CerAlTop™ plate,VELP Scientifica, Italy) for 45 min, followed by a 1 mL diffused on a petri dish of each medium. The LB medium was incubated at 37°C for 24h, those of YPG and malt extract were incubated at 25°C for 5 days. The total concentration of suspended microbial cells in creams is expressed in Colony-Forming Units per gram (CFU /g).

Quality control of bio-actives

Oils

Mechanical cold extraction (Figure 2a) is widely used in the cooperatives studied to extract vegetable oil from seeds due to its simplicity of use. The oil samples including *Cannabis sativa, Sesamum indicum, Juglans regia, Prunus amygdalus dulcis* and *Prunus amygdalus var. Amara*. were analyzed to determine parameters such as acid number, saponification number, relative density, and refractive index.

Essential oil samples, extracted via steam distillation (Figure 2b) and covering *Rosmarinus officinalis, Thymus vulgaris, Lavandula angustifolia* and *Mentha piperita*, were also tested for density, refractive index, and acidity values. All physicochemical parameters were determined according to European Pharmacopoeia (Ph. Eur.) methods as described in Barak *et al* (2023)[14]

Hydrosols

Hydrodistillation is the main technique used by these cooperatives to extract hydrosols. The distillation apparatus used for these extractions is shown in Figure 3. A 40-liter alembic is usually used to collect hydrosols exclusively without being separated with its essence. As aromatic hydrosols are primarily composed of water, the potential for contamination by bacteria, fungi, or yeast is substantial. Microbiological analyses were conducted on the collected samples to ensure the absence of contamination, are conducted as outlined above in emulsions stability.[15] For , pH values (Ph Metre Jenway 3510, UK), density (Pycnometre Gay-Lussa 10mL, Glassco, India), and refractive index measurements (Digital Refractometer RX-5000α, Atago, Japan) were carried out using the European Pharmacopoeia (Ph. Eur.) methods.[14] The maximum limit for mesophilic aerobic bacteria, fungi and yeasts has been set at 100 CFU/mL.[15]

Heavy metals quantification

Metallic contamination in plant-based cosmetics can potentially lead to adverse effects on the skin. In this analysis, all samples including creams (8), scrubs (3), hydrolats (10), soap (3), serums (4), vegetable oils (4), aloe vera extract (1) and apple cider vinegar (1) were subjected to an analysis for both Pb and Cd metals by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). All samples have been analyzed using ICP-AES Horiba Scientific Jobin Yvon , Ultima Expert, French, equipped with a peristaltic pump for sample introduction. The measured spectral lines included Pb: 220.353 nm and Cd: 214.441 nm. RF power was set to 1000 W, plasma gas flow to 15 L/min, and atomization gas to 0.7 L/min argon. A 9-point calibration within a range of 0 to 5 mg/L was performed for element concentrations. The wavelengths used for Cd and Pb are 214.441 nm and 220.353 nm respectively. Calibration of the instrument was carried out using certified standard solutions.

Figure 3: Hydrodistillation apparatus utilized by cooperatives in the Fes-Meknes region. The process involves placing plant material (5) within the alembic pot (1) containing water, followed by hermetic sealing with a tight lid (2). Upon heating (4), steam is generated, which effectively carries the aromatic constituents from the plant material. These constituents are then condensed within the condenser (3), resulting in the collection of hydrosols.

SWOT analysis

Using a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, businesses may evaluate their internal strengths and weaknesses, external opportunities, and prospective threats. While "opportunities" and "threats" are external elements over which the organization has only limited control, "strengths" and "weaknesses" relate to internal qualities over which the organization has direct control. By identifying a business's competitive advantages, areas for development, chances to take advantage of, and dangers to be on the lookout for,[16] a SWOT analysis aims to assist that organization in making educated decisions.[17] This study is used to inform strategic planning for natural cosmetics' cooperatives in the Fes-Meknes region or across all Moroccan cooperatives.

Data analysis

The data derived from triplicate experiments were subjected to thorough analysis utilizing Microsoft Excel and Origin 2024. Mean values and standard deviations (SD) were calculated, followed by the application of ANOVA and Tukey tests to ascertain any significant differences ($p < 0.05$) among the observed variables.

Results and Discussion

Cooperatives market analysis

Moroccan cooperatives play a significant role in the valorization of natural products, contributing to the development of the local market and providing economic opportunities for communities.[34,35] In this study, we have analyzed various aspects that characterize these cooperatives, ranging from their financial sources, revenues, educational level of managers, average age of members, marketing methods, plants used, final manufactured products, production equipment, quality control, and certifications. Appreciating this information is essential for understanding the position of Moroccan cooperatives in the production of cosmetic products and their impact on the national market.

Firm economics

Among the cooperatives surveyed, 65.3% rely on personal resources as their main source of finance. 16.8% resort to family resources. 8.9% use microcredit, while one cooperative (3%) uses a bank loan and two receive financial support from the Provincial Department of Agriculture (5.9%) (Figure 4a). The Forsa program is not used as a source of finance by any of the cooperatives interviewed. Forsa program aims to provide financial support to cooperatives and small businesses in Morocco, particularly in rural areas.[18] However, in some cases, these cooperatives are unable to generate sufficient income, limiting their growth potential. As presented in Figure 4b. 52.7% declare they have no income, as 44% have an annual income of less than 5,000 dirhams. By contrast, 3.3% declared an annual income of between 10000 and 20000 dirhams. No cooperatives reported an annual income of more than 20,000 dirhams. Efforts are needed to improve their financial performance and promote market access and demand for their products. Our examination reveals a diverse range of financial approaches adopted by cooperatives, reflecting their resourcefulness and adaptability in securing funding. While a majority resort to self-financing, a notable proportion also rely on familial support, microcredit, or governmental aid. The absence of utilization of the Forsa program raises intriguing questions about the perceived efficacy or accessibility of such funding avenues within the cooperative landscape. This warrants a deeper exploration into the underlying factors influencing cooperative decision-making regarding financial strategies and potential barriers hindering their engagement with external funding opportunities. This raises the possibility that there are barriers to accessing traditional forms of financing for these cooperatives. In Morocco, small, and micro-enterprises face limited access to credit, and significant portions of the population, particularly women, individuals in rural areas, and young adults, still encounter challenges in accessing financial services.[18] Some cooperatives face significant financial challenges, with a substantial portion reporting insufficient income. Urgent measures are needed to improve financial performance and stimulate market demand for their products.

Skills programs that can be understood by managers of all levels of education are needed to ensure a strong and diverse cooperative community. 8% of the 25 cooperatives' leaders had no education, 11% a primary education, 14% a college education, 17% a secondary education and 50% a postgraduate education (Figure 5a). Those led by university graduates are more frequent and offer a level of knowledge that can be promoted, while less-educated leaders may be closer to the traditional values of the region. The youngest team members can provide new perspectives and innovative ideas, boosting marketing development and overall performance. No cooperative has members under the age of at least 18. In all, 8% have members aged between 19 and 25 years, 16% between 26 and 30, and 28% between 31 and 40. 48% are over 41 years (Figure 5b). Cooperatives from different backgrounds and ages may prove particularly effective in creating a dynamic balance between experience and new ideas. Regarding their marketing methods, most cooperatives 43.4% (19/25) used direct contact with customers, and 20.2% (9/25) declared the use of e-commerce, a minor portion for cooperatives that have their own stores. Of these, 9.1% depend on national stores while a relatively small number, 7.1% (3/25) declared supermarkets as a marketing method (Figure 5c).

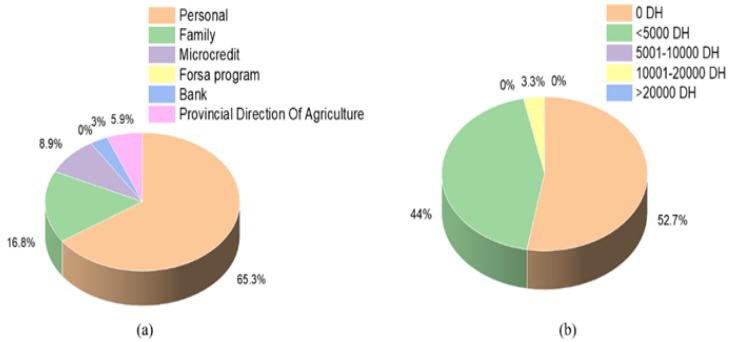
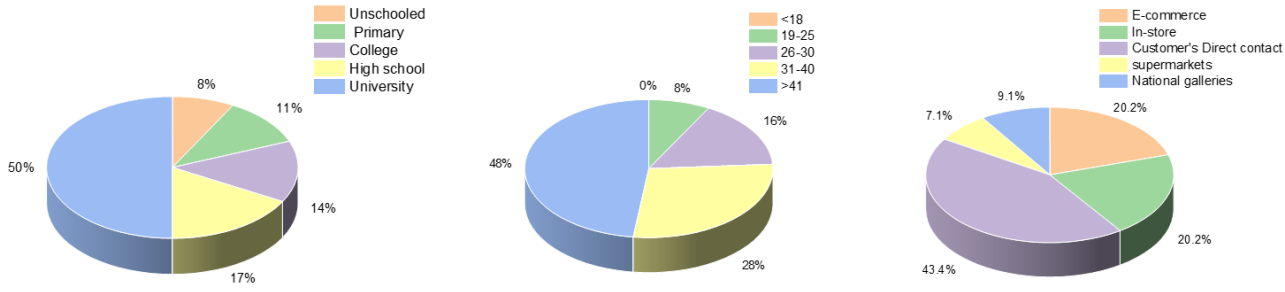


Figure 4: Financial status of the cooperatives: (a) Main financial support (b) Annual income.



(a) (b) (c)

Figure 5: Cooperative dynamics: (a) Managerial education (b) Member demographics (c) Marketing strategies.

This underlines the multidimensional nature of marketing, which goes beyond mere customer satisfaction.; it encompasses the creation of desires through appealing packaging and product environments.[36] Nonetheless, cooperatives are encouraged to explore alternative marketing channels, such as supermarkets and para-pharmacies, to enhance overall revenues and stimulate sales. Effective marketing strategies are essential, utilizing visual approaches to convey the natural origins of the product. Promotional activities may include special offers, and it is crucial to advertise on social media platforms, particularly Facebook and Instagram.[2] Presently, beauty influencers dominate the cosmetics market.[8]

Skill development programs are required for cooperative managers. Leadership varies in educational background, ranging from no formal education to advanced university degrees, thus offering diverse expertise. Moreover, cooperative members are predominantly older, with an absence of members under 18 years of age and a majority over the age of 41 years, as shown in figure 5b. Indeed, a blend of ages and backgrounds promotes synergy between experience and innovation.

Production

Product quality depends on the suitability of the raw materials used, the extraction, formulation, and manufacturing processes.[19] Figure 6a below indicates the diversity of products offered by the cooperatives, with the option for participants to select several ranges. The results showed that 44.6% of cooperatives specialize in the production of extracts such as vegetable oils, essential oils or hydrolats. A further 18.8% are manufacturing creams, 20.8% detergents, while a minority are formulating traditional recipes such as kohl, bakhoor serghina, ghassoul, or medicinal plant farming, representing 7.9% of the total. Interestingly, traditional recipes may be of interest to customers looking for products with cultural significance. As per the manufacturing environment (Figure 6b), 72% of cooperatives conduct their formulation processes in dedicated workshops, while 16% operate from home, 8% within the store premises, and 4% at another cooperative.

The quality of the final product is highly contingent on the manufacturing environment, with potential risks of microbial or chemical contamination if proper hygiene standards are not maintained. Among these cooperatives, 46% use artisanal equipment, 37% employ extraction machinery, and 17% utilize laboratory glassware (Figure 6c). Artisanal equipment typically includes traditional hand blenders and sieves for vegetable oil extraction.

Table 2 presents the responses regarding the plants utilized for extraction and formulation purposes. A total of 24 plant varieties were identified . *Rosa damascena*, *Origanum vulgare* and *Citrus aurantium* are the three plants most frequently used by cooperatives in the Fes-Meknes region for cosmetic preparations, as indicated by 9, 11 and 8 participants respectively. Some participants also mentioned lesser-used plants such as *Anacyclus pyrethrum*, *Pelargonium graveolens*, *Calendula sp* and *Ruta graveolens*. In terms of plant parts, 35% of cooperatives use flowers, 31% leaves, 14% aerial parts, 6% roots and 14% stems (Figure 6d). Plant-active molecules can be found in different parts of the plant, each containing a specific concentration of secondary metabolites. In our analysis of the practices of the cooperatives studied, we found a preference for using flowers and stems for their extractions, particularly of hydrolats and essential oils. This preference is explained by the fact that these parts of the plant are richer in terpene molecules, compounds responsible for the plant's fragrance.

Product quality features several facets of its determinants, which includes factors such as supply, processing, and production methods. Cooperatives offer a wide range of products adapted to consumer needs and preferences. While many are specialized in extracts, oils and hydrolats, others focus on creams, detergents or traditional recipes imbued with cultural significance. This diversity reflects a nuanced understanding of market demands and a flexible approach to product development. *Rosa damascena*, *Origanum vulgare* and *Citrus aurantium* are highly prized plants in cosmetics formulations, as the flowers and stems are the most extracted parts due to their abundance of terpenes, the key components of their fragrance and therapeutic qualities. The production setting is also critical in ensuring product integrity and sustainability. Furtermore, most cooperatives operate in workshops, where strict quality control measures are difficult to apply throughout the production process. A substantial proportion, however, also work from home or on the cooperative's premises, thus reinforcing the importance of flexibility and cost-effectiveness in the manufacturing landscape. In turn, this underlines the need for customized solutions to meet specific challenges and optimize production efficiency in different operating contexts. The manufacturing environment plays a critical role in ensuring the integrity of end products.Thus, if correct hygiene practices are not followed, contamination is more likely to occur, possibly compromising product safety and efficacy. Various types of equipment are used in these cooperatives to facilitate the production process. Artisanal equipment, consisting of traditional hand mixers and sieves, is commonly used by almost half of the cooperatives surveyed. In addition, a large proportion use extraction machines, while a smaller percentage use laboratory glassware. In this case, the National Initiative for Human Development (INDH) serves as a significant financial source for acquiring modern extraction machines.

ISO 22716 requires measures to be taken to comply with Good Manufacturing Practice (GMP).[37] Cooperatives members must be clearly organized, to avoid any confusion as to their official roles. Responsibilities throughout the process, from production to dispatch, must be transparently defined, requiring adequate training and appropriate documentation. Equipment must ensure product protection, with regular maintenance, frequent cleaning, and prevention of mixing or contamination of products and raw materials. Equipment must be designed to prevent contamination, even during transport, with regular maintenance and calibration. Purchasing of raw materials and packaging must comply with strict quality standards.

Table 2: Plants used for extraction and formulation in herbal cosmetic cooperatives

Plant	Headcount(%)
Rosa damascena	12
Citrus aurantium	11
Syringa vulgaris	3
Salvia rosmarinus	9
Argania spinosa	3
Origanum vulgare	15
Thymus vulgaris	7
Verbena officinalis	1
Mentha pulegium	4
Calendula sp	1
Salvia officinalis	3
Ruta graveolens	1
Pistacia lentiscus	1
Anacyclus pyrethrum	1
Lavandula angustifolia	5
Pelargonium graveolens	1
Cannabis sativa	3
Nigella sativa	1
Opuntia ficus-indica	1
Eucalyptus globulus	1
Chamaemelum nobile	5
Urtica	4
Lawsonia inermis	1
Myrtus communis	12

A strong supply chain and constant communication are crucial to resolving problems quickly. Purchasing and store receiving must follow strict guidelines, to be carried out only by specially trained employees. The quality of the water used in distillation and extractions must be guaranteed by specific tests. To create a high-quality cosmetic product, precise documentation of the manufacturing process, raw materials, equipment, and formula is required. The specification of quality control points, as well as the precise labeling and numbering of each batch for identification purposes, are also of key importance.

Certification

Products marketing is influenced by its quality. Quality problems requiring complete rejection from the market, as obvious quality defects, like phase separation, are easily noticed by consumers.[20] Yet. Not all cooperatives have carried out quality control tests on their products, only 20%. 80% of the rest have not (Figure 7a). These cooperatives reported difficulties in satisfying certification requirements. For small cooperatives, obtaining certification can be a long and costly process. However, a single cooperative is certified by the Ministry of Health, while three other cooperatives have obtained certification from the National Office of Food Safety (ONSSA) (Figure 7b).

For small cooperatives, obtaining certification can be a long and costly process. However, a single cooperative is certified by the Ministry of Health, while three other cooperatives have obtained certification from the National Office of Food Safety (ONSSA). To register cosmetic products in Morocco.[38] the requirements for safety, the Directive's instructions on ingredients and labelling must be respected. The producer, packager or importer of the product must declare his activity and have qualified personnel to supervise quality control and product safety assessment. The registration file is divided into two parts, an administrative and a technical part, including elements such as cooperative identity, product details and a certificate of free sale. The technical part covers product composition, ingredients specifications, microbiological details, analysis results, etc.

Consumers 'attitudes towards natural cosmetics

Patterns in cosmetics purchasing behaviors

In response to the question “Usually, from where do you buy your cosmetics? (Figure 8a). Supermarkets (32.7%) and pharmacies (30.7%) are the most popular outlets for skincare products. Then followed by a significant number of consumers buy cosmetics from Para pharmacies and cooperative’s store (12.9%). Likewise, a small percentage of consumers (11%) purchasing cosmetics online, indicating a preference for in-store purchases. Regarding the question, «Which kind of cosmetics do you buy? Cleansing gels (36%) and creams (28%) represent the best-selling products. Plant extracts, oils, hydrolats and vitamins were used by 13% of those surveyed (Figure 8b).

Quality labels and advice from a dermatologist were the main factors in purchasing decisions, with scores of 21% and 19% respectively. Cost came out on top too, with 18% of the population taking it into consideration before deciding to buy. Attractive packaging was the least important factor (9%) (Figure 8c).

Opinions on the favorite cosmetic brand

As shown in Figure 9a, Nivea (10%) and La Roche-Posay (10%) are consumers' favorite industrial brands, closely followed by CeraVe (8%) and Vichy (8%). Other brands, such as The Ordinary, Oriflame, Dove, L'Oreal, SVR, Avène, Yves Rocher, ACM, Uriage, and Bioderma, were also mentioned, but by a smaller number of respondents. Garnier and Sephora had the smallest number of respondents, underlining the importance of brand reputation and recognition in consumers' purchasing decisions. La Roche-Posay, a renowned skincare brand, owes its popularity to its dermatologist-backed commitment, use of soothing thermal water, formulations tailored to sensitive skin, optimal tolerance, emphasis on scientific research, and frequent endorsements by dermatologists. In essence, the brand's success is rooted in its dedication to effective dermatological solutions for diverse skin needs.

A preference for Moroccan cosmetics is evident. As an answer to the question, do you want a cosmetic product made in Morocco or an imported cosmetic product? with 59% of consumers choosing Moroccan products and 41% choosing imported products (Figure 9b). This preference may be due to several factors, particularly the popularity of natural and organic ingredients used in these products. Morocco is known for its rich tradition of medicinal plants and essential oils, which are often used in such products. The access to and availability of products, which may be more expensive or difficult to obtain. Consumer purchasing decisions in the cosmetics industry are influenced by various factors, notably quality labels, and dermatologist recommendations, indicating a growing emphasis on product safety and effectiveness. Cost is also a significant consideration, reflecting consumers' desire for value. Packaging aesthetics, while important, rank lower in priority. There's a rising trend towards natural and organic ingredients, reflecting a broader shift towards sustainability and health awareness. Brand popularity, such as Nivea and La Roche-Posay, is driven by trust and innovation, with the latter's success attributed to its focus on dermatologist-backed formulations and scientific research. Moreover, Moroccan cosmetics are preferred over imports due to cultural heritage and accessibility, alongside the appeal of natural ingredients. These factors collectively shape consumer choices in the cosmetics market.

Quality control of emulsions

Sensorial analysis

Sensory analysis offers a comprehensive understanding of the distinct characteristics of cosmetic products. It was performed on samples ranging from S1 to S13, as depicted in Figure 10. Several samples, such as S1, S3, S4, S5, S9, S11, and S12, exhibit a creamy texture. S10 and S6 stand out with their "crispy" texture, while S1, S4, S8 and S13 share a "buttery" characteristic. On the other hand, S4, S6, S7, S9, S10, and S13 display a "dense" texture. S1 possesses a distinct "pliable" quality, and S9 and S12 show an "elastic" nature. Greasiness is associated with S7, S11, and S13, while S8 and S10 exhibit a "grainy" texture.

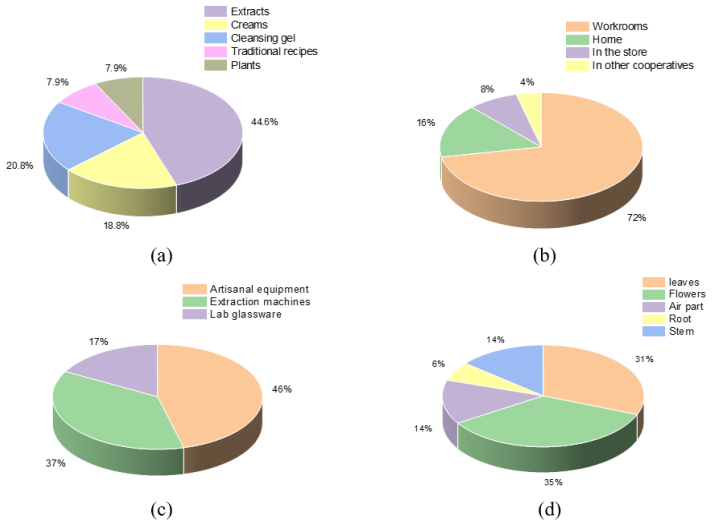


Figure 6: Operational features: (a) Operational sites (b) Product offerings (c) Machinery and equipment (d) Plant parts use

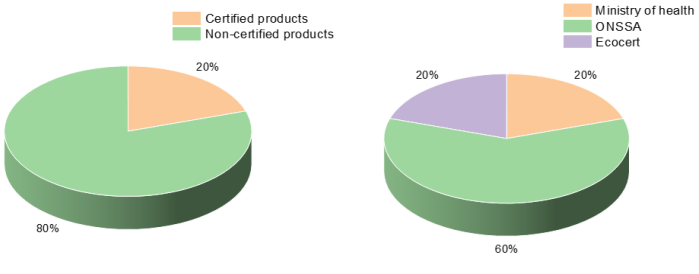


Figure 7: Certification Status: (a) Availability (b) Certifier organism.

In terms of appearance, S4, S5, S9, S11, S12 and S13 have a "bright" appearance, while S4, S5, and S9 display a "white" color. S2 and S8 are characterized as "dull," and S3, S4 and S8 have a "matte" appearance. S5 and S12 are described as "shiny."

Certain samples have distinct odors. S2, S6, S7, and S13 displaying a "spicy" fragrance. S5, S8, S11, and S13 are associated with an "herbal" scent, while "floral" is primarily found in S11, and "fruity" is connected to S9.

The consistency of the samples varies significantly, with "fluid" attributes linked to S2, S8, S11, and S12. "Watery" consistency is observed in S2 and S12, "viscous" in S5 and S6, and "silky" in S5 and S11.

S1, S6, S7, S11, and S13 are described as "glossy," while "smooth" textures are evident in S1, S2, S3, S5, S6, S7, S9 and S12. "Filmogenic" propertie is found in S8.

Insights to support effective product development, quality control and marketing strategies, by allowing personalized approaches to respond to specific consumer preferences and expectations. Sensory marketing, engaging customers' senses during the buying process, plays a crucial role in this. Establishing a brand image, identity, and sensory signature is essential, as they influence consumers' perceptions and enhance brand memorability. Creating a pleasant atmosphere in the point-of-sale increases the frequency of shop visits and influences consumers' subconscious, leading to impulsive purchases and increased loyalty.[36]

Stability

Developing a skincare product involves the careful consideration of multiple factors, including water activity, physical stability of the formulation, the pH value and microbiological quality.[21] Physical stability pertains to a cosmetic product's ability to maintain its structure and texture over a defined period. High physical stability implies that the product remains free from separation, sedimentation, or alterations in appearance when subjected to typical storage and usage conditions.[22] In our study, cream formulations displayed varying degrees of stability, with some being categorized as stable and others as unstable as shown in Figure 11a. Several samples, including S2, S3, S4, S6, S8, and S10, exhibited issues primarily concerning physical stability. These products necessitate formulation adjustments involving the selection of appropriate emulsifiers and co-emulsifiers to mitigate the risk of instability.

To preserve the skin's natural microflora, it is essential to maintain a pH balance below 5.0 in cosmetic products, as closely as possible with the skin's native pH. This pH harmonization fosters an optimal skin environment for the natural microflora, thereby maintaining skin equilibrium and reducing the risk of adverse skin disorders.[23] pH in the range of 4.5–6.0 are considered gentle on the skin to avoid irritation or negative reactions.[22] In our study, pH values were found to range from 5.10 to 8.23 (Figure 11b). Among the tested samples, S1, S5, S9, and S10 exhibited both chemical and physical stability. Water activity and pH values are well-suited to their formulations. A high-water activity level can facilitate microbial growth, while a lower level may result in a dry and less pleasant product. A considerable variation in water activity, ranging from 1% to 81.5%, is observed among the samples (Figure 11c). Elevated values can suggest the presence of effective preservatives or a well-balanced combination of hydrating ingredients. As for water activity, it fluctuates notably across the samples, spanning from very low (S13) to high (S8).

Overall, the microbiological analysis of cosmetics cream samples reveals considerable variability (Figure 11d). Some samples, such as S1, S2, S6, S7, S11 and S13, show satisfactory microbiological quality, characterized by the absence of yeast, and acceptable levels of bacteria and fungi. These results suggest adequate hygiene during the production process. However, several samples raised concerns. Samples S3, S5, S8 and S10 exceeded 1000 CFU/g, the limit for Aerobic mesophilic bacteria. contamination levels may be associated with the high level of water activity. Higher water activity, as observed in this sample, creates an environment conducive to microbial growth, which explains the bacterial contamination. S8 also showed a high yeast count of 1086.7 CFU/g. These results suggest bacterial and fungal contamination, requiring further investigation to identify potential sources of contamination.

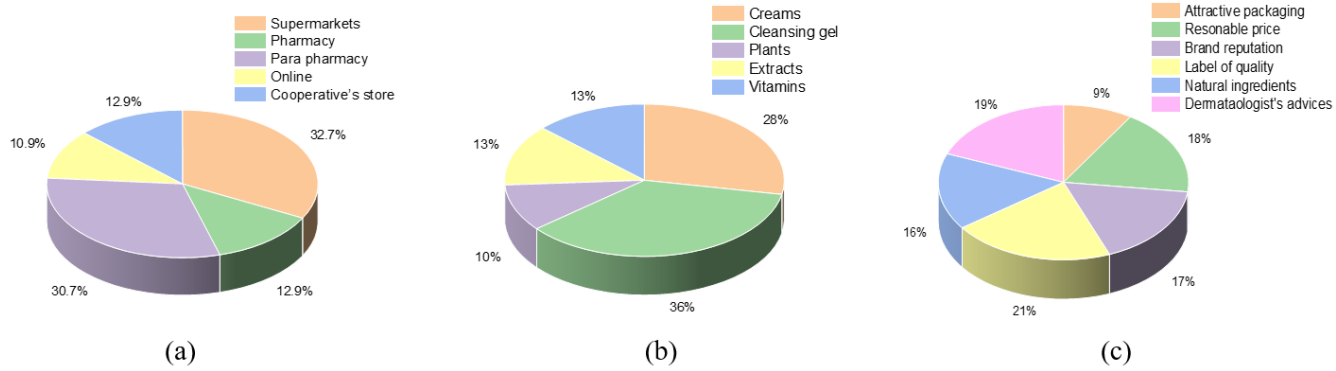


Figure 8: Market Dynamics: (a) Sourcing (b) Preferences (c) Decision factors.

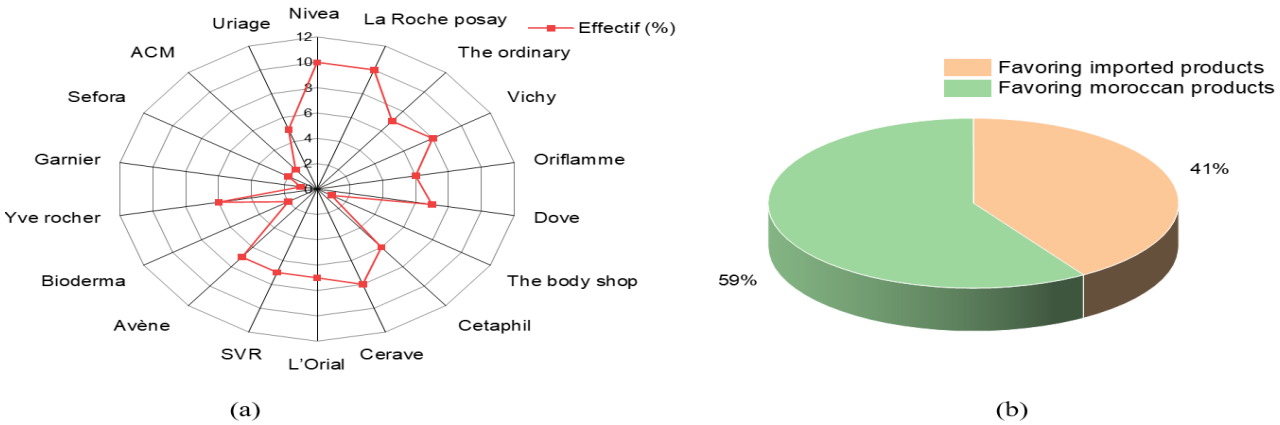


Figure 9: Consumer opinions: (a) Brand preferences, (b) Choice of domestic or imported cosmetics.

Samples S6, S10 and S13 show varying levels of bacteria, yeast, and fungi. S6 shows 296.7 CFU/g for bacteria, 320 CFU/g for fungi, and 103.3 CFU/g for yeast. S10 shows 1150.3 CFU/g for bacteria, 2200.3 CFU/g for fungi, and 2213.0 CFU/g for yeast. S13 shows 530.3 CFU/g for bacteria, 200.0 CFU/g for fungi, and 141.7 CFU/g for yeast. In contrast, samples S12 and S13 show acceptable microbiological levels, with no contamination or yeast levels within acceptable limits. Corrective measures are needed to maintain high microbiological quality standards in the production of the cosmetic creams within traditional cooperatives in the Fes-Meknes region.

Cosmetic products can induce alterations in the skin's pH, a critical factor influencing the natural microflora's skin environment. These pH alterations, particularly from acidic to alkaline levels, can be linked to the development of dermatological conditions such as atopic dermatitis and acne vulgaris.[39] Samples with pH levels exceeding 7, such as S6 and S12, may require reformulation to achieve appropriate pH levels, possibly by adding an acidic solution such as lactic or citric acid. Alkaline skin is conducive to the dispersion of the skin's resident bacterial flora away from the surface.[21] In contrast, to raise pH level in formulations, the use of alkaline salts such as sodium, calcium, magnesium or potassium hydroxide is possible.[40]

Water activity levels are pivotal in dictating both microbial growth and the overall stability of cosmetic formulations. The extensive spectrum of water activity levels detected in samples, ranging from 1% to 81.5%. This variance reflects the water and oil content in the products, which can impact their stability. Products with lower water content exhibit greater stability, exemplified by S7 and S13, while those with higher water content encounter stability issues. In prolonged use, preservatives play a crucial role in inhibiting microbial contamination. Synthetic preservatives such as parabens, formaldehyde donors and phenol derivatives are effective, but their potential health risks and controversial nature are problematic. Parabens, despite their efficacy, are under scrutiny because of their potential for endocrine disruption. Phenol derivatives such as phenoxyethanol, while effective, raise concerns about skin irritation.[40] Natural alternatives can be explored to address these issues. Such as rosemary and rose geranium essential oils.[41] These alternatives can be used with raw materials to inhibit germ growth while benefiting from their biological and protective activities (multi-functional ingredients).

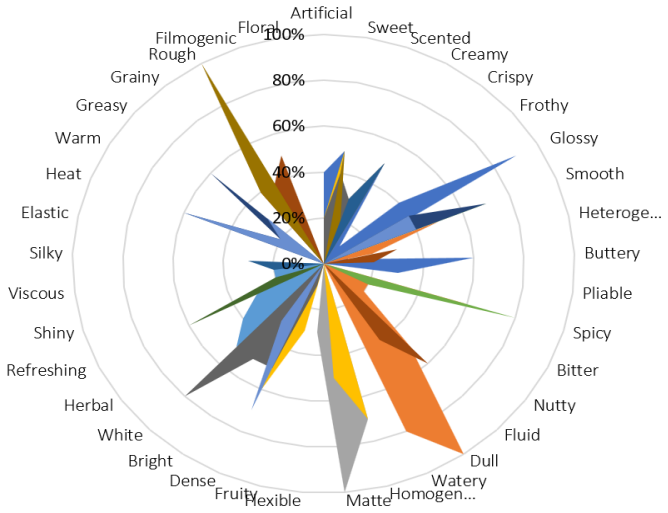


Figure 10: The triangle's corners define the descriptors for each sample, and the length from the middle is the score attributed according to the percentage of descriptors identified by the panelists.

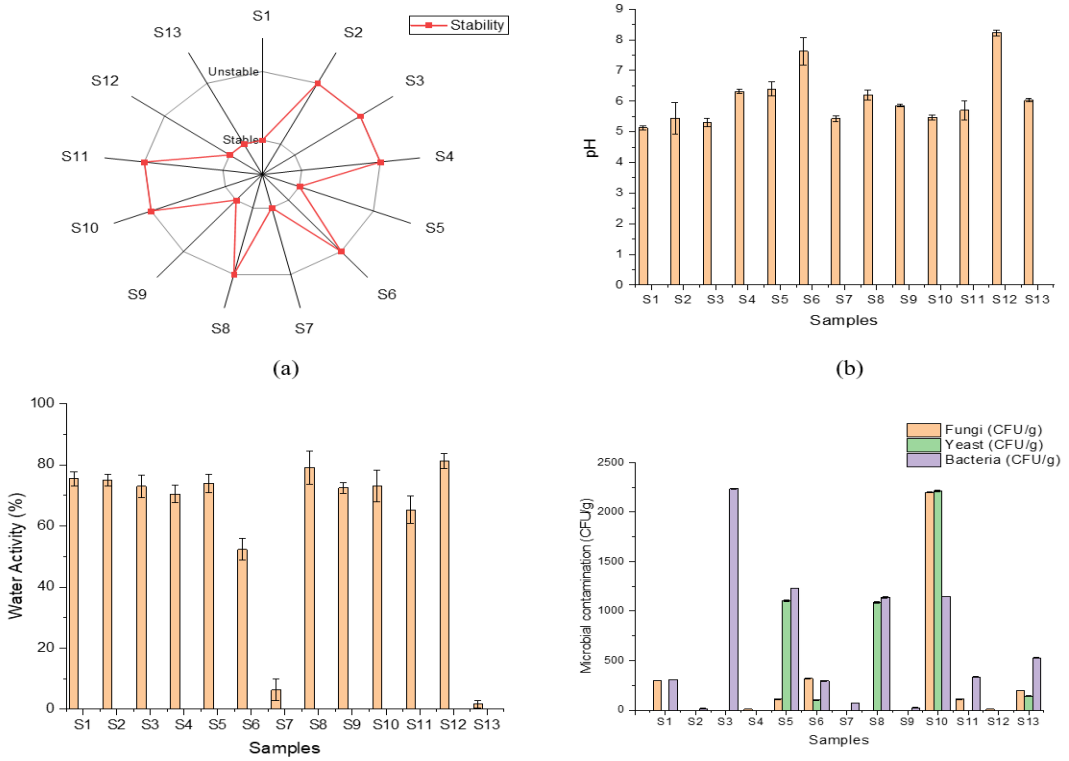


Figure 11: Creams quality: (a) Physical stability (b) pH values (c) Water activity (d) Microbial contamination.

Quality of bio-actives
Oils
Vegetable oils

By exploring the physicochemical properties of vegetable oils, their quality can be characterized, even for application in cosmetics. We have tested five vegetable oils extracted from seeds of *Cannabis sativa, Sesamum indicum, Juglans regia, Prunus amygdalus dulcis*, and *Prunus amygdalus var.* amara. Figure 12 shows the physicochemical parameters of these oils in comparison with Food and Agriculture Organization (FAO) standards. In terms of relative density, refrective index and acid value, all oil samples (S34, S31, S36, S37 and S17) satisfy the criteria for use in cosmetic preparations. Showing significant ($p < 0.05$) compliance with the (FAO) standards. In fact, the saponification value of S36 (168.33 mgKOH/g) and S37 (182.357 mgKOH/g) are relatively below FAO standards. indicating their suitability for cosmetic formulations. Their low saponification value, due to their higher molecular weight and high fatty acid content, can be ideal for soap and candle production.[42] In recent years, the significance of vegetable oils has grown due to their fatty acid contents, which are widely employed in pharmaceutical and cosmetic applications as carriers of active substances.[43,44] On the other hand, acid index reflects oxidative stability and overall lipid quality. In a comparison of the tested oil samples, S17 (0.28 mgKOH/g oil) suggesting low acidity, and S37 showing a significantly higher level (2.8 mgKOH/g oil). Mamadaliev and Kushiev characterized *Cannabis sativa* seed oil from the Syrdarya region,[45] reporting acid index values between 1.22 and 1.76 (mg KOH/g), its relative density was between 0.915 and 0.925 g cm^{-3}. These values are almost the same as ours which has an acid value of 1.29 mgKOH/g and a relative density at 25°C equal to 0.915 g cm^{-3}. Nevertheless, additional analyses are necessary to understand the impact of these differences on the physical and functional properties of the oils. Furthermore, this finding adds weight to the argument that the stringent adherence to standards is pivotal in determining the quality of vetable oils, a cornerstone in sustainable practices within the industry. Some products are not yet subject to quality standards, such as *cannabis sativa* seed oil.

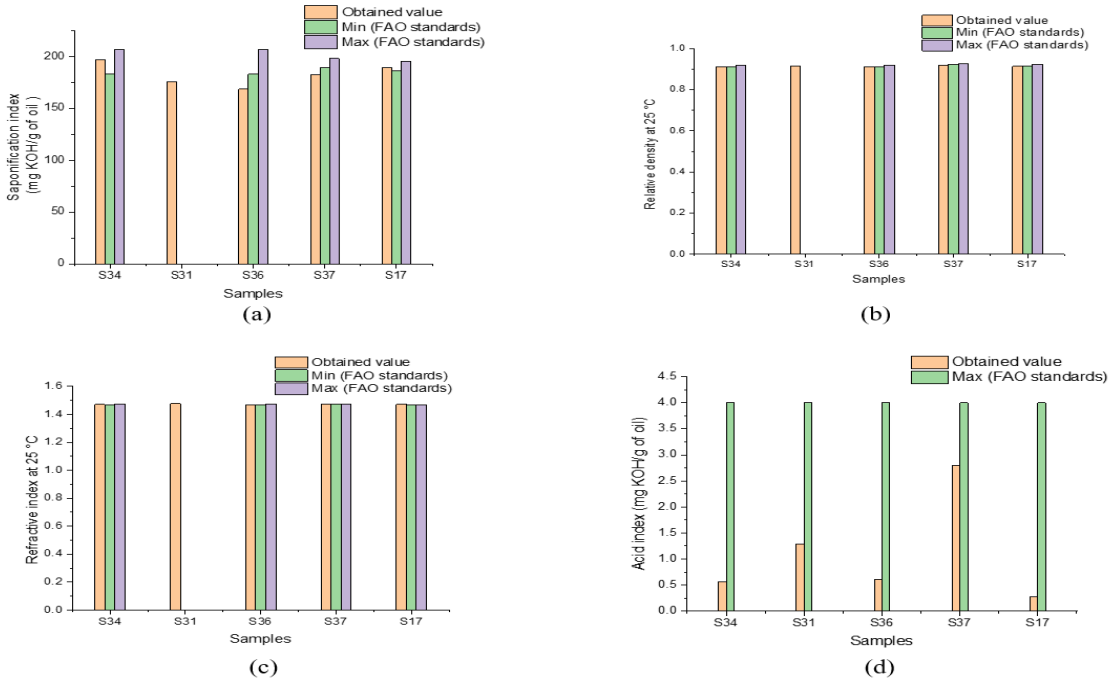


Figure 12: Quality of vegetable Oils: (a) Saponification Index (b) Relative density (c) Refractive index (d) Acid Index.

Essential oils

Essential oils quality depends on their compliance with the strictest quality standards.[24] The pivotal evaluation of essential oils quality involves the examination of refractive index and acidity. This index demonstrates a correlation with distillation parameters, including speed, temperature, and duration.[25] Overall, the essential oils studied - *Rosemarinus officinalis, Thymus vulgaris, Lavendula angustifolia* and *Mentha piperita* - were of moderate quality. Refractive index and acid number values are shown in Figure 13. S40 and S35 are perfectly within the AFNOR (Association Française de Normalisation) standard for refractive index.[26,27] While S38 and S32 are slightly below the upper limits. S39 is moderately above.[28,29] For cosmetic applications, the lowest possible acidity index is required; an acidity index below 2 mg KOH/g means effective oil preservation.[29] Among others, samples S39, S38 and S32 have acidity values of 1.96, 0.84 and 1.122 mg KOH/g of oil respectively, all less than 2 mg KOH/g. However, samples S40 (7.012 mg KOH/g) and S35 (2.168 mg KOH/g) are significantly higher. Food production can benefit from essential oils with superior acidity, as fatty acids become less oxidized, resulting in better preservation.[30] Effective preservation necessitates acidity levels below 2 mg KOH/g, a criterion met variably among samples. Notably, oils exhibiting higher acidity levels present intriguing possibilities for bolstering food preservation efforts, highlighting the nuanced interplay between quality standards and sustainable practices in the field. To obtain a high-purity essential oil, the distillation still should be made of stainless or copper steel. To prevent the risk of over-oxidation, low-pressure distillation, between 0.05 and 0.10 bar is recommended.[46] Distillation should be prolonged to ensure the complete capture of all volatile molecules, from the most volatile to the least volatile.[47] Water with a low calcium content is ideal.[48]

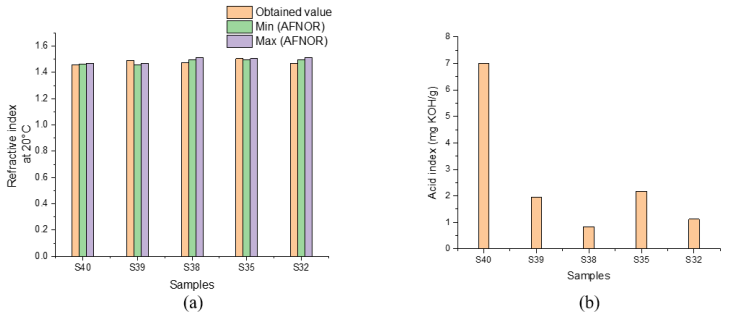


Figure 13: Quality of essential Oils: (a) Refractive index (b) Acidity index.

Hydrosols

The most produced hydrosols by cooperatives in Fes-Meknes region are *Citrus aurantium, Rosa damascena, Rosmarinus officinalis, Thymus vulgaris* and *Matricaria chamomilla*.

In Figure 14, the refractive index of the tested hydrolats exhibits statistically no significant differences (p <0.05).Values areranging from 1.3330 to 1.3307 for S22 and S26 , found to be inside the COSMOS standard lines (1.33 - 1.34).[31] The relative densities shown in (Figure 14b), exhibit a related similarity (p <0.05), ranging from 1.0634 g cm^{-3} for X26 to 1.0656 g cm^{-3} for X22. Values slightly above the COSMOS standard limit. This suggests a potential correlation between these physical parameters, as confirmed by.[32] Physical stability of the hydrolats does not prevent contamination at later stages. Consequently , in the absence of sterile storage and handling, chemical stabilization is necessary to keep all properties intact.[33] The tested hydrolats have a slightly acidic pH, ranging from 5 to 6, (Figure 14a) which creates favorable conditions for the growth of some bacteria.

Microbial analysis of the hydrolats (Figure 14d) showed no bacterial or fungal contamination in samples S22 and S24. These hydrolats are of acceptable microbiological quality, reflecting effective processing during hydrodistillation, as well as inclusion of certain molecules with antimicrobial potential. Such hydrolats are suitable to use in cosmetic preparations, as an alternative of the aqueous phase to increase the biological percentage of formulations. In all, three samples (S23, S25, S41) surpassed 100 CFU/mL, of which S23 showed an excessively high germ charge (260 CFU/mL). Remarkable levels of yeast (30 CFU/mL) and fungal (80 CFU/mL) contaminants were found in this sample. However, The presence of certain bacteria in hydrosols can influence their volatile profile and alter their organoleptic properties, leading to the formation of dark-brown bacterial clusters and slight turbidity.[33] This higher-than-standard result for all three samples suggests a possible source of contamination, associated probably with insufficient purification of the alombics during hydrodistylation and packaging. Hydrodistillation short durations at high temperatures can damage the volatile molecules responsible for the antimicrobial effect. conservators such as 2-phenoxyethanol (<10g/L), bronopol (<1g/L) and isothiazolinone (<0.015 g/L) are authorized by the European Parliament and Council Regulation (EC) No. 1223/2009, to ensure long shelf-life of hydrolats[33].

Heavy metals

Two heavy metals, Cadmium (Cd) and Lead (Pb), were assessed in the different samples of identified cosmetic products listed in Figure 15. Cadmium (Cd) was systematically found in considerable quantities in the samples tested. Levels ranged from 9.529 ppm to 0.0619 ppm. The lowest Cd level was detected in Aloe vera gel extract (S32), while the highest level was observed in body lotion (S2). The second highest level was found in sun cream (S4), and the third in blush cream (S1). The distribution of Cd in the creams followed the order S2 > S4 > S1 > S5 > S3 > S6 > S7, while in the hydrolats, the order of distribution was S19 > S31 > S23 > S30 > S33. Prolonged exposure to cadmium increases the risk of cancer, particularly lung cancer. Cadmium can cause fertility problems, hormonal disturbances, and complications during pregnancy. In contrast, lead (Pb) content was very low. Concentrations of Pb in creams and scrubs were as follows: S1 > S2 > S5 > S3 > S4, ranging from 0.3435 ppm to 0.1316 ppm. Lead was absent from all other samples. The analysis of Cd and Pb levels in cosmetic products unveils pertinent insights into their potential health implications and underscores the importance of stringent quality control measures. Such disparities highlight the diverse composition of these products and emphasize the need for vigilant monitoring to ensure consumer safety. Prolonged exposure to Cd, especially at elevated levels, poses significant health risks, including an increased risk of cancer and adverse effects on fertility, hormonal balance, and immune function.[49] These findings underscore the importance of implementing stringent regulations and quality assurance protocols to mitigate potential health hazards associated with heavy metal exposure in cosmetic formulations. In contrast, the Pb content in the analyzed products is relatively low (p < 0.05). Despite the lower levels, it's imperative to recognize the potential health consequences of Pb exposure, particularly through skin absorption. Even trace amounts of Pb can lead to serious neurological, cardiovascular, and renal issues.[49,50]

SWOT Analysis

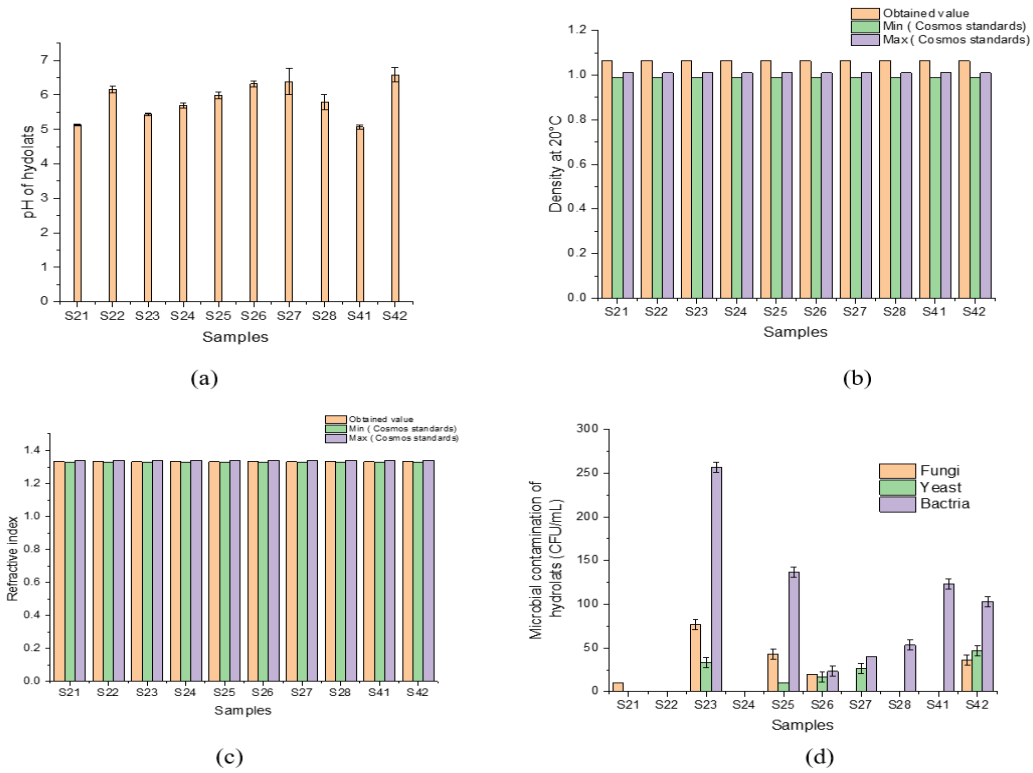


Figure 14: Quality of Hydrosols: (a) pH (b) Relative density (c) Refractive index (d) Microbial contamination.

The strengths, weaknesses, opportunities, and threats (SWOT) of natural cosmetic cooperatives in Fes-Meknes region are referenced in our study and presented in Table 3.

Strengths

The Fes-Meknes region offers a favorable environment to produce medicinal plants, which the cooperatives benefit from by developing their own vegetable ingredients, guaranteeing the authenticity of the substances used in their products. As such, they are significantly less dependent on external suppliers, reducing the risks associated with quality and the availability of supplies, which gives them a considerable competitive edge. The production of natural ingredients also has the advantage of reducing supplier costs, which in turn increases the economic viability of their products.

Further strengths of the cooperatives studied is family support, as 17% of them provide financial assistance for their activities through family connections. This may play a significant role in their stability and ability to overcome obstacles, strengthening their market position. Also, half of these cooperatives have university-trained managers. Education level contributes to operational knowledge and financial management competence.

Opportunities

These cooperatives are facing promising strategic opportunities. For one, the increased international demand for natural and organic products offers considerable potential for expansion on the international market. This global trend provides fertile territory for Moroccan cooperatives, giving them access to a global clientele in search of quality natural products. Responding to consumer preferences with natural ingredients represents a major opportunity. These cooperatives capitalize on Moroccans' preference for local over imported products, strengthening their position in the local market. Market expansion also offers growth prospects. Consumers' growing preference for local products opens new opportunities for cooperatives capable of meeting this need by supplying products of the highest quality. Building strategic partnerships with cosmetics brands could offer cooperatives access to more extensive markets and a more diversified customer base, boosting their presence on the international stage.

Another potential opportunity for cooperatives is to use the Forsa program as a source of additional funding for their projects.

Weaknesses

Several weaknesses of the cooperatives studied suggest the need for strategic reflection to improve their performance. Production capacity is limited in some cooperatives. This constraint can seriously hamper their ability to respond effectively to growing market demand. It can also potentially prevent them from capitalizing on growth opportunities. As regards consumer preferences, the products most offered by these cooperatives are not necessarily those they produce in large quantities. For example, cleansing gels account for 36% of consumer purchases, while extracts only constitute 13%. Even so, 45% of these cooperatives focus more on extract production, and less on gel cleansers (21%). This mismatch between demand and production can lead to imbalances in their product offering. Reliance on personal funding is also a key limitation. Most cooperatives rely primarily on personal funds for their activities, which means limited access to a wider range of financing options. This dependence can make them vulnerable to the personal financial fluctuations of their members and inhibit their ability to invest in their development. A significant number of cooperatives declare that they generate no annual income, while others have very low incomes.

Threats

International competition is increasing, decreasing cooperatives' market potential, and negatively influencing their profits in the natural cosmetics sector. Restrictive regulations governing cosmetic products represent a challenge in terms of conformity. To maintain compliance with these regulations, cooperatives will need to invest in manufacturing and quality control processes that meet current standards. This regulatory constraint may also require adjustments to their operations. In addition, people's improved lifestyle and growing concerns about the safety of cosmetic products, particularly regarding allergic reactions to medicinal plants, have led to increased demand for product quality, safety, and efficacy. Cooperatives must be vigilant to meet these stringent requirements while maintaining consumer confidence.

Suggestions on the development

A strategic approach focused on problem-solving is essential for bolstering the position and resilience of cooperatives, both those the specific cooperatives studied and Moroccan cooperatives., the implementation of targeted strategies designed to address inherent challenges becomes imperative. Such strategies facilitate the enhancement of operational efficiency, sustainability, and socioeconomic impact within these cooperative frameworks. This strategic paradigm involves a meticulous analysis of individual cooperative challenges, thereby enabling tailored solutions that harmonize with their specific contexts and objectives. By fostering a collaborative environment and employing innovative approaches, such as refining governance structures and streamlining resource accessibility, these cooperatives can adeptly surmount challenges, thereby fostering robustness within an evolving business landscape. The embracement of such a strategic problem-solving approach not only fortifies individual cooperatives but also catalyzes the overall growth and development of the cooperative sector in Morocco, thus fostering a resilient foundation for sustainable socioeconomic progress.

The implementation of stringent quality control measures stands as a linchpin for cooperatives endeavoring to ensure the eminence of their product line. Establishing stringent quality control protocols across all production phases—from plant harvesting to final product manufacturing—stands as a critical endeavor. This encompasses routine microbiological assessments aimed at assuring the absence of microbial contamination in both raw materials and finished products. Investing in cutting-edge production infrastructures becomes imperative to modernize operational frameworks. The acquisition of state-of-the-art equipment and technologies not only ensures optimal production environments but also facilitates the preservation of product integrity and quality. The confluence of these measures significantly contributes to upholding product quality standards. Concurrently, personnel training in good manufacturing practices assumes pivotal significance. Provision of comprehensive training encompassing manufacturing norms, personal hygiene, product traceability, and food safety equips employees to contribute to high-quality production. Long-term product stability must also be thoroughly assessed. This involves checking microbiological, chemical, and physical stability under various conditions, such as variations in temperature and humidity, to ensure consistent product quality throughout their shelf life.

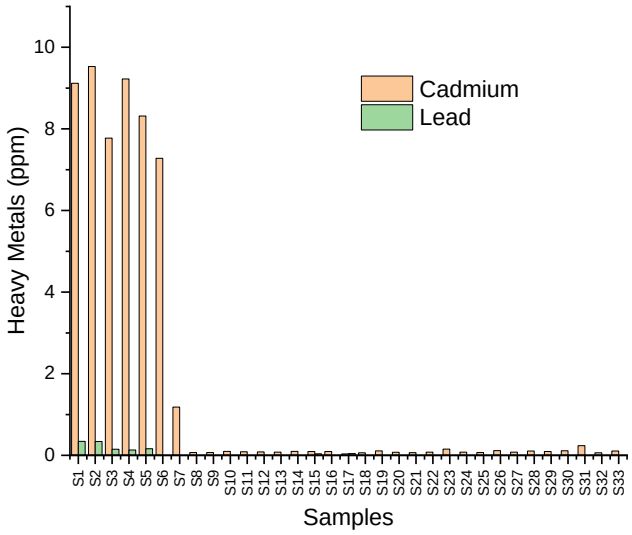


Figure 15: Heavy metals quantification in cosmetic cooperative from Fes-Meknes region, Morocco.

Table 3: SWOT Analysis: Natural Cosmetic coops in Fes-Meknes region

Strengths	**Weaknesses**
-Strong familial and community support. -Differentiation in the marketplace. -Using Local Ingredients can reduce costs. -Improving managers' skills is possible through their education level (university). - In-depth knowledge of local plants, their properties and traditional uses is acquired through the older members of these cooperatives...	- Small production capacity and mismatch between consumer demand and production. - Lack of expertise in formulation. - Dependence on personal financing. -Annual income insufficient for future improvement
Opportunities	**Threats**
- Natural products are becoming increasingly popular, 59% of consumers promote local Moroccan production. - Strategic partnerships: Establishing collaborations with international cosmetics companies. - Forsa program as a source of financial support.	-International competition; imported products reputed by consumers to be of good quality. - Regulatory constraints and standards impact on performance, these cooperatives encounter challenges in adhering to the regulatory standards necessary for obtaining a quality label. - Consumers have become aware and sensitive to the importance of the quality and safety in cosmetics products.

The following recommendations are essential steps to ensure sustainability in cooperatives involved in natural cosmetics:

Collaboration with external laboratories
Strengthening ties with external laboratories significantly boosts credibility. Developing partnerships with these labs for independent product testing validates microbiological quality and stability. It reinforces the credibility of cooperatives, and boosts consumer confidence in product quality. By implementing these measures, cooperatives can ensure high-quality production, heightened stability, and adherence to stringent market microbiological standards. Alignment with consumer demands further solidifies their market stance. Tailoring products to suit consumer preferences enables cooperatives to innovate, mitigate risks, and sustainably expand market share, ultimately driving increased profitability and continual product enhancement.

Artificial intelligence (AI)
AI is becoming a key technology for traditional cooperatives that are seeking to revolutionize their operational landscape. AI technology can facilitate radical transformations in research methodologies, plant selection and cosmetics formulation. Precise identification of plant properties and customized formulations aligned with specific consumer needs are hallmarks of such an AI-powered paradigm. Additionally, accentuating the development of products sourced from rare and endemic plants serves as a unique market differentiator. By accentuating the intrinsic value of the region's rare medicinal plants, cooperatives can attract a specialized clientele seeking exclusive ingredients, thereby augmenting their market positioning.

Partnerships with local farmers
Medicinal plant partnerships with local farmers are of particular importance in ensuring a steady supply of top-quality raw materials. Besides guaranteeing top-quality raw materials, such alliances maintain ties with the community while simultaneously reducing costs. Organizing immersive sensory experiences for consumers—such as workshops and events highlighting the benefits of medicinal plants and cosmetic products—facilitates deeper consumer engagement. These events, inclusive of product-making demonstrations, massage sessions, or guided botanical garden tours, serve to enhance consumer experiences and augment product awareness.

Eco-friendly packaging
The trend to invest in environmentally friendly packaging is in line with growing consumer preferences for sustainable products. The adoption of recyclable or biodegradable materials underlines the cooperative's commitment to environmental responsibility, enhancing its brand image. Continuous investment in research and development further amplifies the authenticity and quality of ingredients utilized, thereby reducing reliance on external suppliers while reinforcing a competitive edge. Leveraging familial connections for financial support, coupled with effective utilization of university-trained managerial expertise, further fortifies cooperatives' operational and financial management.

Financial expansion
Diversifying funding sources beyond personal financing through collaborations with financial institutions and potential investors stands as a critical facet in securing sustainable financial support for cooperative activities. Analyzing market trends, aligning product offerings with consumer preferences, and accentuating unique selling points serve to differentiate cooperatives from international competition. Accentuating strengths such as authentic ingredients and local production further consolidates their market position.

Skills building
Training non-academic staff through the provision of educational resources on formulation of natural cosmetics facilitates skills enhancement. Setting out manufacturing guidelines and standards ensures compliance with industrial practices, enabling better product quality. Furthermore, traceability systems create transparency in the supply chain, enhancing product credibility and consumer confidence.

Conclusion

The study offers a comprehensive exploration of the entrepreneurial landscape within the cosmetics industry, focusing on the valorization of botanical resources by Moroccan cooperatives in the Fes-Meknes region. Through meticulous analysis, various aspects of cooperative operations were scrutinized, shedding light on their financial strategies, marketing approaches, product quality, and adherence to regulatory standards. Findings reveal the diverse financial avenues pursued by cooperatives, underscoring their adaptability in securing funding. However, challenges related to financial constraints and production capacity persist, warranting urgent measures to enhance financial performance and stimulate market demand. Despite these hurdles, cooperatives demonstrate resilience, benefiting from strong familial

support networks and managerial expertise. As consumer demand for natural products surges globally, these cooperatives are poised to capitalize on emerging opportunities, particularly through strategic collaborations and international market expansion. Nonetheless, aligning product offerings with evolving consumer preferences and ensuring compliance with regulatory standards remain imperative. Addressing these challenges requires concerted efforts, including diversification of funding streams, investment in manufacturing processes, and stringent quality control measures. These findings provide a foundation for future research endeavors aimed at investigating and enhancing manufacturing practices within complex environments(e.g., cooperatives and micro-entrepreneurs), with a specific focus on offering streamlined guidelines tailored to small businesses with older and non-academic members. By navigating these obstacles, cooperatives can unlock their full potential and contribute to sustainable growth in the cosmetics industry.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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