White Paper – Flavor and Fragrance Industry

Technology Cluster Manager

Technology Centre System Program (TCSP)

Office of DC MSME, Ministry of MSME

06 June 2019

Disclaimer

This Report has been prepared on the basis set out in our engagement contract reference 21/DCMSME/TCSP/CON/TCM/2016/TR with The Development Commissioner, MSME, Ministry of MSME dated 03rd December 2018 (the "Contract for Supplier Services")

Nothing in this report constitutes a valuation or legal advice.

We have not verified the reliability or accuracy of any information obtained in the course of our work, other than in the limited circumstances set out in the Services Contract.

This Report is for the benefit of The Development Commissioner, MSME, Ministry of MSME and the other parties that we have agreed in writing to treat as parties to the Services Contract (together "the Beneficiaries").

This Report has not been designed to be of benefit to anyone except The Development Commissioner, MSME, Ministry of MSME / Beneficiaries. In preparing this Report we have not taken into account the interests, needs or circumstances of anyone apart from The Development Commissioner, MSME, Ministry of MSME / Beneficiaries, even though we may have been aware that others might read this Report. We have prepared this report for the benefit of The Development Commissioner, MSME, Ministry of MSME / Beneficiaries alone.

This Report is not suitable to be relied on by any party wishing to acquire rights against KPMG Advisory Services Pvt. Ltd. (other than The Development Commissioner, MSME, Ministry of MSME / the Beneficiaries) for any purpose or in any context. Any party other than The Development Commissioner, MSME, Ministry of MSME / the Beneficiaries that obtains access to this Report or a copy and chooses to rely on this Report (or any part of it) does so at its own risk. To the fullest extent permitted by law, KPMG Advisory Services Pvt. Ltd does not assume any responsibility and will not accept any liability in respect of this Report to any party other than The Development Commissioner, MSME, Ministry of MSME / the Beneficiaries.

In particular, and without limiting the general statement above, since we have prepared this Report for the benefit of The Development Commissioner, MSME, Ministry of MSME / Beneficiaries alone, this Report has not been prepared for the benefit of any other local authority / Trust / etc. nor for any other person or organization who might have an interest in the matters discussed in this Report, including for example General Practitioners / those who work in the respective sector or those who provide goods or services to those who operate in the respective sector.

Please note that the Services Contract makes this Report confidential between The Development Commissioner, MSME, Ministry of MSME/the Beneficiaries and us. It has been released to The Development Commissioner, MSME, Ministry of MSME/the Beneficiaries on the basis that it shall not be copied, referred to or disclosed, in whole or in part, without our prior written consent. Any disclosure of this Report beyond what is permitted under the Services Contract will prejudice substantially this firm's commercial interests. A request for our consent to any such wider disclosure may result in our agreement to these disclosure restrictions being lifted in part. If The Development Commissioner, MSME, Ministry of MSME / the Beneficiaries receive[s] a request for disclosure of the product of our work or this Report under relevant laws and regulations, having regard to these actionable disclosure restrictions The Development Commissioner, MSME, Ministry of MSME / the Beneficiaries should let us know and should not make a disclosure in response to any such request without first consulting KPMG Advisory Services Pvt. Ltd and taking into account any representations that KPMG Advisory Services Pvt. Ltd might make

Acknowledgement

We would like to express our sincere gratitude to MoMSME, o/o DCMSME and its officials for their involvement and valuable inputs during the preparation of this White Paper. We would like to express special thanks to Shri Ram Mohan Mishra, IAS, (Additional Secretary and DC-MSME) for his proactive support and guidance to the team during the entire process.

We would also like to express our gratitude to Shri Piyush Srivastava (ADC), Shri Virinder Sharma (Director), Shri Sanjeev Chawla (Director), Shri R K Rai (Director), Dr. Sunil Kumar Newar (Deputy Director, TCSP), Shri B.M Saxena (Assistant Director, TCSP) and TCSP PMU Team for extending their support during the entire process.

We would also like to thank Shri S.V. Shukla, General Manager, FFDC, Kannauj and his team of TC officials for their guidance and valuable inputs during the preparation of white paper

Revision History

Version	Issue Date	Prepared by	Reviewed by
1.0	22nd March 2019	Mr. R.S Ragavan	Mr. Rituraj Sharma Mr. Anshul Katyal
1.1	18th April 2019	Mr. R.S Ragavan Mr. Anshul Katyal	Mr. V Ganesh Mr. Dharmesh Goswami
2.0	26th April 2019	Mr. R.S Ragavan Mr. Anshul Katyal	Mr. S.V. Shukla
2.1	06th June 2019	Mr. Anshul Katyal	

Table of Contents

List of Figures

1. Introduction

Flavors and Fragrances (F&F) are significant constituents in food and cosmetics industry. They consist of varied ingredients including absolutes, oleoresins, isolates, attar, essential oils, aroma chemicals and special aroma ingredients. The developed countries have a mature flavor and fragrance market that forms an integral part of the home & personal care and food & beverages industries. Though India is at a nascent stage when it comes to penetration of flavor and fragrance finished products, the F&F ingredient manufacturing market in India is quite mature. However, increasing disposable income of the Indian masses and rural penetration of FMCG and F&B power houses, two consumption driven sectors, are providing the much needed boost to flavor and fragrance industry as a whole.

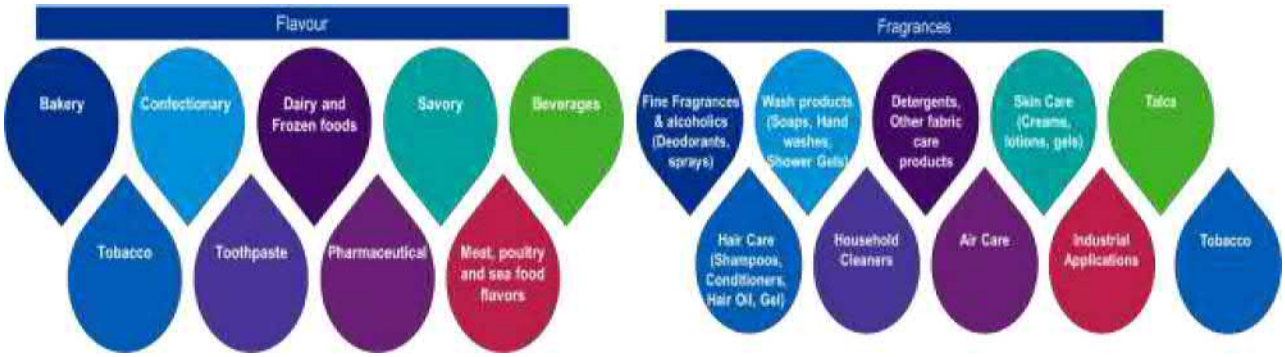

Figure 1: List of Products- Flavor and Fragrance Industry

2. Global Industry

As of 2017 the global market for flavor and fragrance was estimated to stand at USD 28.2 bn[1] with the flavor and fragrance ingredient market standing at USD 9 bn[2]. The increasing demand of essentials oils, natural extracts and aroma chemicals due to transitioning of flavor and fragrance industry from nascent to a mature stage in a number of developing countries has contributed in overall growth of the industry that is expected to reach USD 36 bn by 2022. The key factors that are contributing to the growth of this industry are

- **Growth in the Asian markets and other developing countries**: The Asian market and other developing countries have witnessed high growth of 13% as compared to 4% growth of their developed counterparts in the period 2014-2019 This can also be attributed to the increasing presence and investments of the global F&F power houses in the developing countries especially in the greater Asian Countries[3]

Firm	Increasing Presence in Asia *(Source: Company Websites)*
IFF	IFF has committed an investment of more than USD 100 Mn in the Asian countries and have also opened one of their largest manufacturing facility in China

[1] Global markets for Flavors & Fragrances 2018, IAL Consultants,
[2] Specialty Chemicals in India Report, 2017, Avendus Capital
[3] Orbis Research, Fragrance Ingredients Market, 2017

Givaudan	Givaudan has committed as investment in Pune, India by opening it largest manufacturing facility in Feb 2019
Wild Flavors	Started Indian production facility in 2011

- **Increasing use of fragrance in personal health care**: Unlike developed countries, fragrance was considered more of a luxury product in the developing nations such as India & China. Though fragrance was used for nutraceutical[4] purposes, but the daily usage was very limited. However, the changing perception of fragrance being an integral part of the personal health care has led to increase in the overall demand.[5]

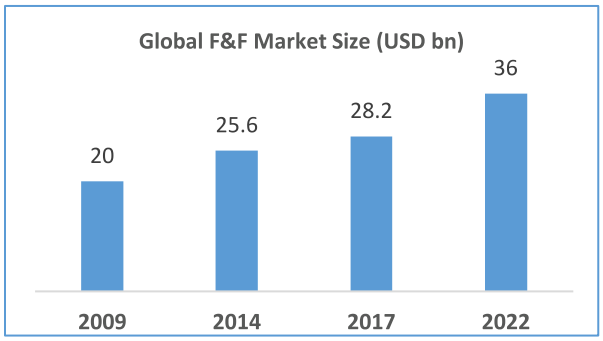

Figure 2: Global F&F Market

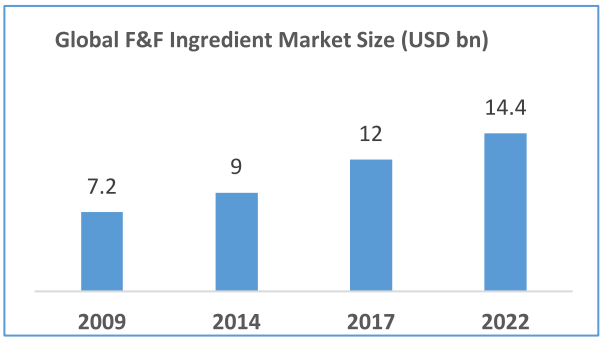

Figure 3: Global F&F Ingredient Market

- **Increase in processed food market:** The increasing penetration of processed food market in the developing countries has increased the overall demand in the flavor industry. The demand has further increased with increased focus on low calorie food in the developed countries. In order to produce high variants of low calorie food that have rich taste, the demand in flavor industry has increased

3. Indian Industry Overview

The F&F market in India is dominated by global F&F players that contribute 60% of the total flavor and fragrance blend production in the country. The strong presence of all leading global players in the country can be attributed to the fact that India is one of the leading suppliers of the F&F ingredients in the global market exporting around 85% of the total produce and accounting to 30-35% of the total supply of F&F ingredients. As per market reports, it has been identified that total domestic F&F consumption in the country stood at USD 0.81 billion in the year 2015 and the F&F ingredient market stood at around USD 3.4 bn.[6]

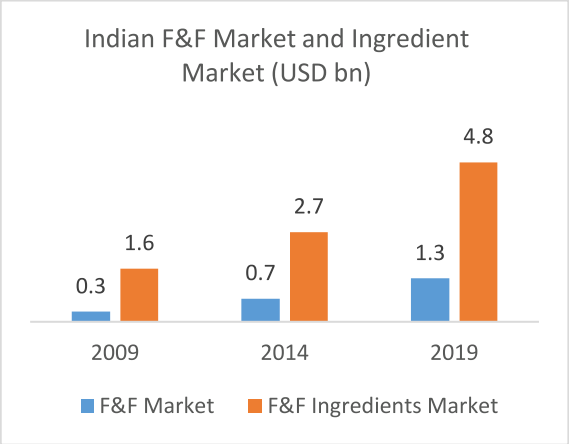

Figure 4: Indian F&F and Ingredient Market

The F&F market in India is dominated by 4 global players that control more than 2/3rd market with remaining being occupied by around 1000 local Indian players. It is estimated that F&F ingredient

[4] Nutraceutical: A food containing health-giving additives.
[5] Industry Reports
[6] Specialty Chemicals in India Report, 2017, Avendus Capital and KPMG Analysis

export market in India stands at USD 3.8 billion as which is expected to increase to approximately USD 4.8 bn by 2021[6]. This growing demand in the Indian market and increasing acceptance of Indian F&F ingredients has further helped in making India a gateway to the South East Asian F&F market.

There are 4 key stakeholders that make up the flavor and fragrance value chain; raw material suppliers, base ingredient manufacturers, blenders and end consumer industries.

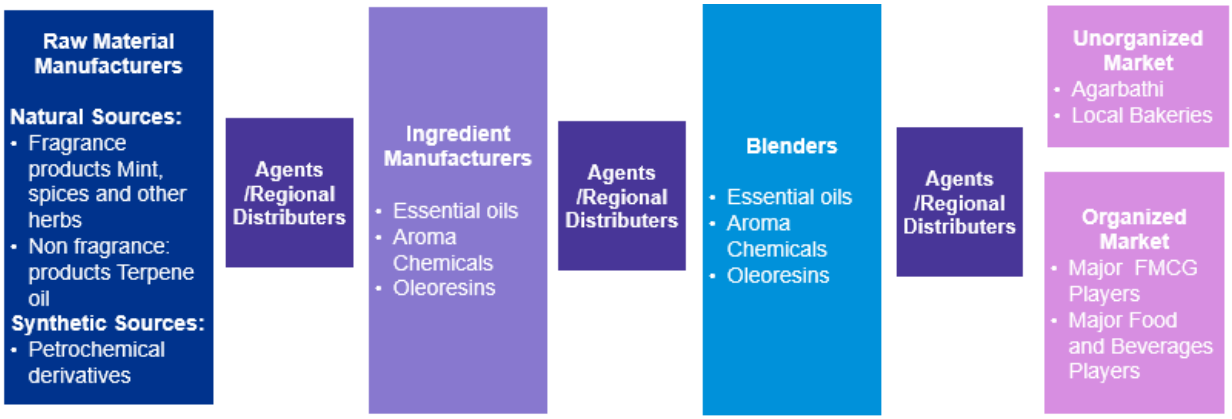

Figure 5: Flavor and Fragrance Industry Supply Chain: Key Stakeholders

Being one of the largest producers for some of the key natural resources like mint, ginger, chilly and pepper, spices, anise, fennel and coriander, lemongrass oil, nutmeg, mace and cardamom, eucalyptus oil, India has a strong presence in the raw material and base ingredient export market. Flavors and Fragrances are derived from these raw materials, both from natural as well as synthetic sources. Essential oils are extracted from the process of distillation while aroma chemicals are derived from petrochemical compounds or from different natural sources. Due to the low bargaining power of natural resource suppliers in the country, ingredient manufacturers relying on natural resources have an advantage of securing a consistent supply of raw materials with seasonality and variation in yield being one of the major challenges. The situation is not same for players relying on synthetic sources, with the market being occupied by only a few synthetic suppliers.

Ingredient	Global Ranking – India (production)	Production MT	Geographical Presence
Mint	1	32,000	Uttar Pradesh, Haryana, Punjab
Ginger	1	703,000	Karnataka, Gujarat, North East
Chilly & Pepper	1	1,299,000	All over the country
Spices	1	1496,990	All over the country
Anise, Fennel and Coriander	1	537,330	Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh
Lemon Grass Oil	1	1000	Western India
Nutmeg, Mace and Cardamom	3	18,070	Karnataka, Kerala, Tamil Nadu
Eucalyptus Oil	3	1000	Kerala, Tamil Nadu

Figure 6: Natural Raw Material Production – Indian Ranking (United Nations Data, 2017)

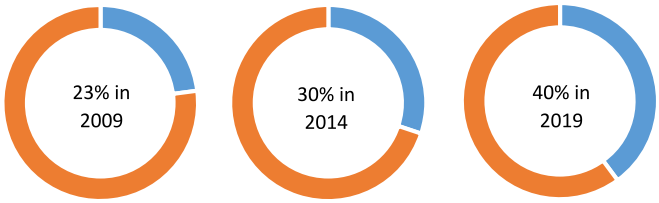

Figure 8: Share of Indian Ingredient market in the Global Market

The finished and blended flavors and fragrances space in India is dominated by global F&F players with limited participation from Indian players. The large global and Indian players use aroma ingredients to create their own distinct blends. Apart from major Indian players like S.H Kelkar, Sami Labs, Arjuna etc. most of the Indian small time blenders and finished blend manufacturers do not have integrated in-house manufacturing facilities. Limited investment in research and

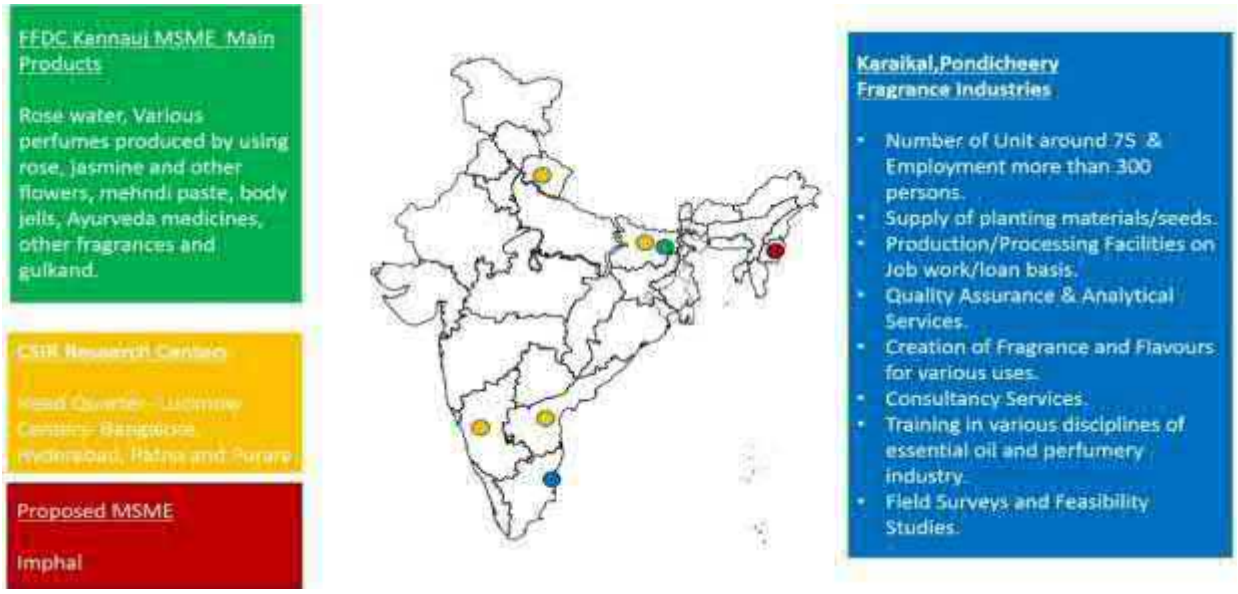

Figure 7: Fragrance Industry India

development by majority Indian payers have ceded the Indian space to foreign players. The large payers like Givaudan, IFF, SH Kelkar, Sami Labs, Arjuna Natural Extracts etc. in turn have made tie ups with FMCG players for supply of the blends and other finished flavors and fragrances. The large blenders have also aligned their operations with a number of smaller ingredient manufacturers to develop and produce new flavors and fragrances. This association with lager power houses has helped smaller Indian players in attaining required R&D exposure and maintaining international standards of production

Apart from the organized blending market in the country, which is dominated by global players, the unorganized blending marked is estimated to be larger than the organized market but is difficult to quantify. The unorganized market is dominated by Tobacco, Agarbatti, Pan Masala and other end products.

The F&F market in current state is not driven by domestic consumption and is dependent on foreign consumption. However, the domestic consumption market in the country is growing with increasing consumption of F&F products in home, personal care and FMCG industry. India like other developing countries is on the same maturity curve when it comes to increasing consumption in the F&F market. The key factors such as increasing demand of processed food, increasing penetration of FMCGs in rural markets and transition of fragrance from luxury to basic need, that are increasing the global consumption are also responsible for consumption growth in the domestic market.

3.1.1. Key Challenges faced by Indian Firms

Though there are a large number of Indian players in the F&F market, majority of the players are involved in the ingredient manufacturing space and are not able leave a mark in the blending market. Increasing pressure from FMCG players to reduce the prices has contributed in limiting the investment in research and development activities and is among one of the major challenges faced by the Indian firms.

1) **Progression in Value Chain**: Most of the Indian players are suppliers to Global and Indian F&F Houses. Majority of the players are involved in production of synthetic aroma chemicals and due to limited research and development facilities, they are not able to create product differentiation and hence end up facing stiff price competition. Apart from this, the increasing competition from the Chinese players has further increased the price competition which has forced the Indian players to operate on low profit margins (roughly around 10-15%). This has limited their capability to invest in product development activities which in turn hampers their growth and progression in the value chain
2) **Barriers to Entry**: Though the F&F blending space is not restricted by significant technological entry barriers, client relationships and social capital is one area where the smaller players are not able to compete with the established F&F power houses. Market study shows that F&F houses derive their majority revenue from FMCG players, the market which is far from the reach of smaller players due to stiff price completion. Apart from this, limited capabilities of Indian players in terms of product differentiation further reduces their ability to position themselves in front of big FMCG players.
3) **Adherence to International Standards**: With increased focus on carbon neutral and environment friendly techniques, markets in Europe and North America are focusing on implementing mandatory standards. It has been observed that the implementation of such standards has impacted a number of players in the Indian market which is largely export driven. Adherence to these standards bring in high costs which makes the playing field difficult for players already operating at low margins.
4) **Availability of Raw Material**: Herbal raw materials in the F&F industry are largely dependent on farm produce thus is marred with challenges like poor yield and seasonality as a number of fragrances and flavors are made using natural ingredients. This has considerable impact on the cost and the availability of raw materials. This impacts their overall cost structure and in turn further reduces their margins
5) **Limited R&D Investment**: Due to low operating margins, there are only a few companies that are able to invest in R&D to make substitutes of important aroma chemicals

3.1.2. Changing trends in the F&F Market

1) Growth of natural ingredients based products: The global F&F market is largely based upon synthetic market with synthetic ingredients accounting close to 60-65% of the total market. The changing trend in the global market can be observed from the fact that the market for natural ingredients is growing at a CAGR of close to 6-7% as compared to synthetic ingredient market i.e. growing at a slower rate of <1%[7]. The shift towards natural ingredients can be attributed to increasing consumer awareness towards healthy foods and government regulations prohibiting use of certain synthetic flavors in food production. The global F&F houses have also been taking steps to strengthen their natural products portfolio. For example, in 2014, Firmenich entered into a joint venture with Jasmine

[7] Orbis Research, Fragrance Ingredients Market, 2017

Concrete in India, a leader in Indian floral extracts specializing in the extraction of Indian flowers, such as jasmine and tuberose. Similarly in 2014, Mane acquired Kancor, a Kerala based manufacturer of spice oleoresins. This increase in demand in the natural ingredients based F&F products provides a special advantage to Indian players of sourcing these raw materials at lower cost. The manufacturing of natural ingredients is close to 10-100 times expensive as compared to synthetic products. There is a need to adopt new technologies that would help the Indian MSMEs make this shift from synthetic to natural resources with marginal increase in overall cost.

2) **Scaling of Operations:** Increasing presence of global F&F power houses in the country requires the small Indian firms to scale their operations to match the bargaining power of the bigger players. Medium size firms are moving towards scaling of operations that would help improve raw material sourcing efficiency and pricing, as well as improve cost structures by means of manufacturing efficiencies.
3) **Enhanced R&D Spending:** The ability to create unique and creative fragrances, often involve significant research and perfumery skills which is one of the main differentiating factor between the Indian players and the top F&F houses. Even though small Indian players have made limited investment in such skills, it has been observed that medium size to large Indian players are working towards development of proprietary blends, often using proprietary constituent ingredients. Large players like S.H. Kelkar, Arjuna, Sami Labs, etc. have demonstrated the capability to create unique blends and other smaller players have made collaborative tie ups with global F&F houses for development of propriety blends and constituents. Some of the activities being taken up by other global players are
    a. Improving fragrance delivery systems using techniques like encapsulation, sustained release
    b. Developing captive aroma chemical ingredients through R&D (eg. Bigaryl™ developed by Givaudan)
    c. Long term purchase arrangements with global FMCG player

4. Technology Interventions

Creation of Flavor and fragrances is broadly a four step process that involves collections of raw material, either from synthetic and/or natural resources, which is followed by extraction of concretes and absolutes that are blended with different ingredients and then kept for aging for creation of unique fragrances. The following figure gives an idea of different steps involved in the

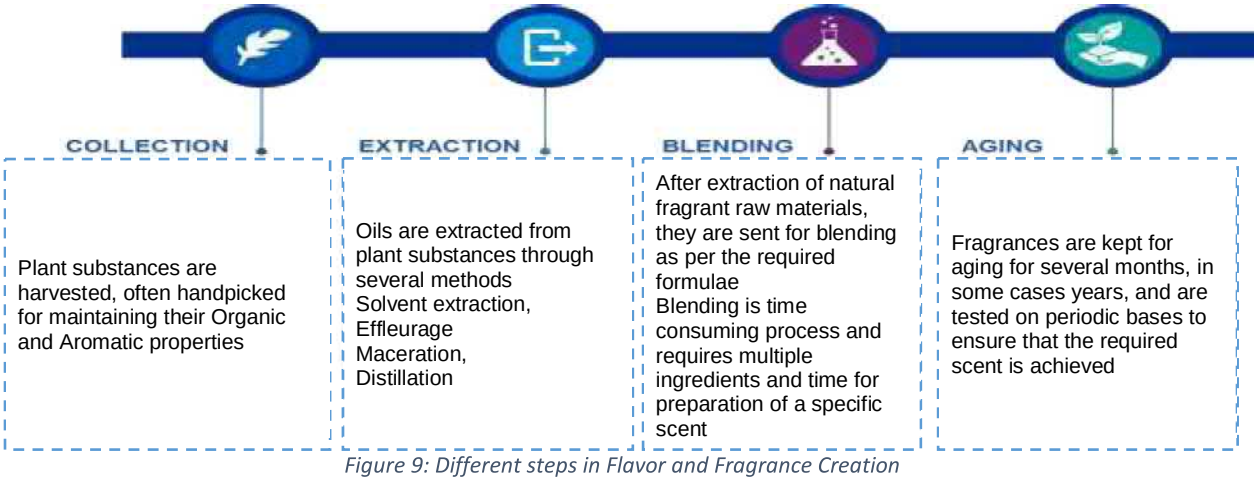

Figure 9: Different steps in Flavor and Fragrance Creation

process of creation of new fragrances

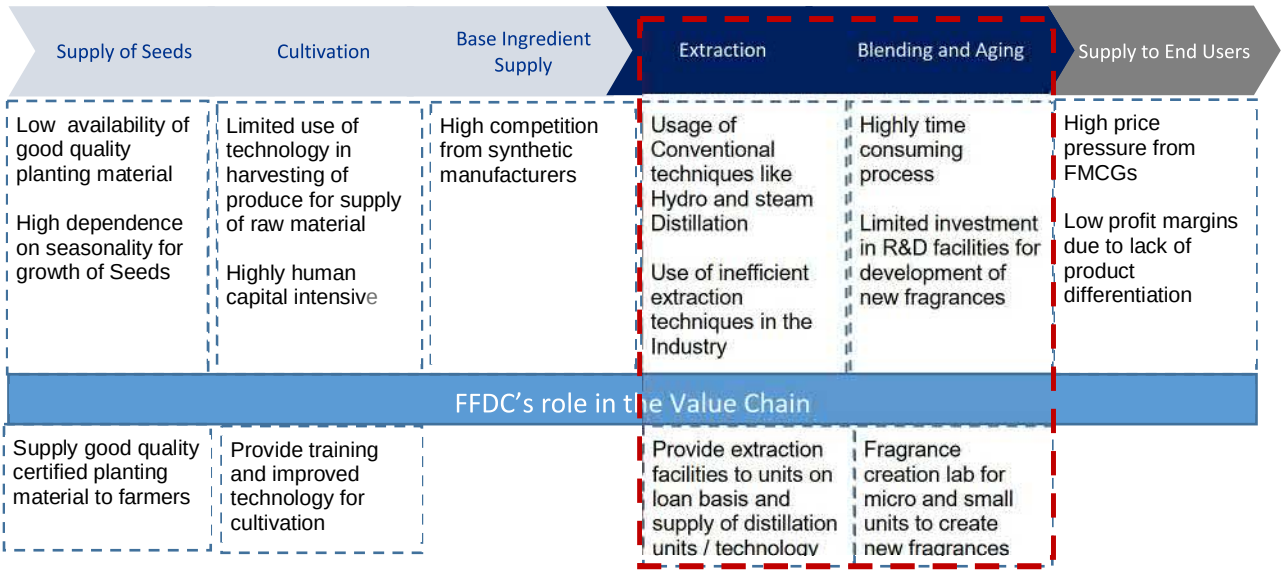

Figure 10: Challenges across Flavor and Fragrance Value Chain

In order to improve the situation of industrial units by either reducing their pricing pressure or by enabling them to increase their margins by lowering production costs, there is a need to invest into new technologies that would help in increasing yield or help them in reducing the overall cycle time in creation of new fragrances and further enable them to identify and create new fragrances

4.1. Extraction of Base Ingredients

Essential Oils include a large class of volatile odoriferous oils of vegetable origin that give plants their characteristic odour and often other properties. These are obtained from various parts of the plants (as flowers, leaves, bark, seeds, fruits etc.) by steam distillation, expression, or extraction and are usually mixtures of compounds (as aldehydes, esters, Alcohols, ketones etc.), and are used often in fragrances, flavors, and pharmaceutical preparations. Essential oils often vary in specifications of their content and odour profile as they are influenced by geo-climatic conditions and variety of planting materials.

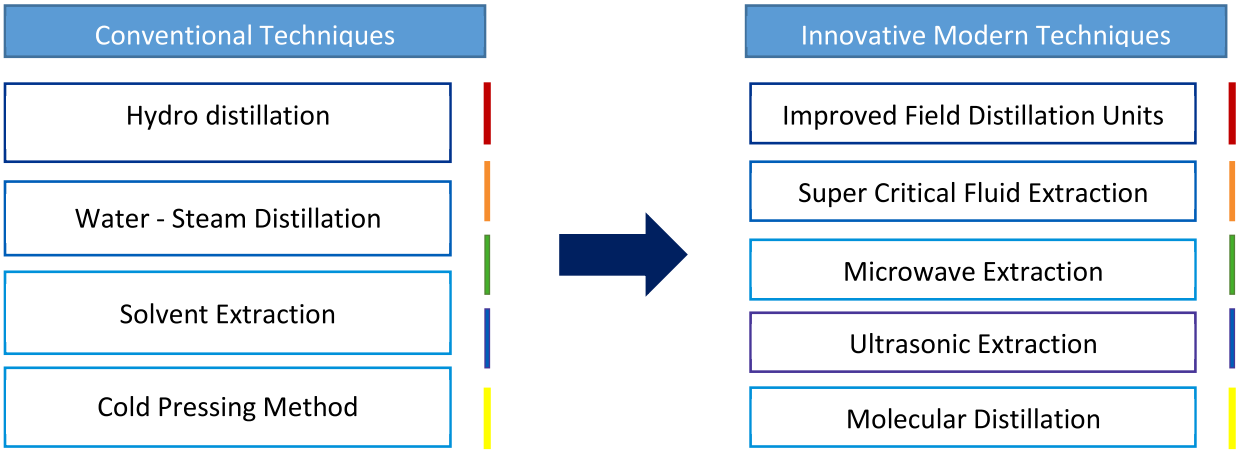

Figure 11: Techniques for Extraction of Base Ingredients

As different plants have different percentage of oxidized impurities and color, it is practically impossible to follow a one size fit all techniques for their extraction. As a result different techniques are used which adopt different methods such as selective elimination or enrichment. Since world-wide consumption of essential oils is increasing in a variety of consumer goods, it is imperative to come up with modern techniques of extraction that are focused on yield improvement together with environmental preservation.

Though innovative techniques have been adopted by a number of big industrial players, small units are still dependent on conventional techniques. The conventional techniques not just produce a lower yield but also use a greater amount of energy, solvent and raw materials for obtaining the required quantity.

4.1.1. Improved Field Distillation Units

Field distillation units are widely used across the industry for production of essential oils and form a vital part in the production cycle of fragrances. Though field distillation units are widely used across the country and different regions, it has been observed that the yield produced by these units is 20-30% lower than what is prescribed theoretically. It is primarily due to the inefficient distillation method that is currently used in the field units. In order to improve the yield of these units by 15-20%, it is important to ensure that that the existing units are modified to replace the conventional “batti” system, used in water distillation, by direct steam sparging method as used in steam distillation

In order to develop an improved solution, the existing facility should be modified to add a steam generator next to the distillation column. The marginal cost of adding a steam generator is not very high and is compensated by the improved yield of the overall facility. The installation of steam generators require minimum power and a boiler fuel that is required to be sourced at the site.

Figure 13: Sample Field Distillation Unit

The steam generators that are to be used can be simple steam generators which do not require IBR registration. These boilers can use any agro waste and can even operate on fire briquettes. The pumps can also be used for both cooling tower water circulation and boiler feed. Unlike the conventional boilers, these distillation units don’t need water softener plant. This further helps in keeping the increase in marginal cost minimal.

There is an increased need to ensure widespread adoption of these improved FDUs as FDUs help in distillation of Essential Oils immediately after the harvest that helps in preserving the aroma compounds by preventing their decay that happens due to a longer lead time in reaching the processing plant. It further helps in reducing the overall production cost of essential oil by eliminating the transportation cost.

Relevance for FFDC, Kannuj:

Though this technology is currently widely adopted it is recommended that FFDC designs & supplies their own FDUs with steam generator and oil trap receiver and offer it as a service to the individual farmers. Alternatively, FFDC can also assist/consult individual large faming neighbor

hoods such as farmer's co-operatives to collectively install these units and assist them in designing FDUs with steam generators as per their needs and capacity requirement.

4.1.2. Super Critical Fluid Extraction (SCFE)

Another extraction technique that is slowly gaining attraction in the extraction/isolation industry is Super Critical Fluid Extraction (SCFE). SCFE is a relatively new technique in which high pressure carbon dioxide gas is used as a solvent. Like any solvent extraction, the CO_2 extraction takes place at a low temperature, extracts a wide range of compounds, and leaves the aromatics unaltered by heat, resulting in an essence that closely resembles the original odour of the raw material. The main advantage of SCFE, using CO_2, lies in the fact that the cycle time in this case is at least $1/4^{th}$ as compared to conventional techniques of solvent based extraction. Apart from this, super critical fluid extraction also helps in increasing the efficiency of the system to 90% as compared to conventional techniques where efficiency is still 70%. The improved efficiency can also be attributed to the fact that CO_2 leaves no trace of itself in the final product, allowing one to get the absolute directly without having to deal with a concrete.

Though Super Critical Fluid Extraction helps in achieving improved results, it is still far away from being used for mass production. This is primary due to two main reasons. Firstly, SCFE isolates only non-polar compounds, which are oil-soluble and secondly due to very high installation costs of these units. It is estimated that an industrial unit would require a capital outlay of around 10 Cr. for installing a unit of commercially viable capacity i.e. 3 cylinders of 50 ltrs capacity each. Due to this very high marginal cost of investment, this technique is currently being used only by large industrial units and still require more modification for making in available for general production.

Relevance for FFDC, Kannuj:

Due to large initial cost of installation, setting up a Super Critical Fluid Extraction unit might not seem a lucrative option for FFDC at this stage, but in its quest to become a center of excellence, it is important to ensure that FFDC has all the upcoming technologies and process improvement techniques. Installation of Super Critical Fluid Extraction unit would bring FFDC in the list of few players who have access to this technology in India. Moreover as it would be one of its kind facility in the region, FFDC can attract regional units to use the facility on use per charge basis and obtain a product with improved yield and reduced cost.

4.1.3. Rotary Extractors

Solvent extraction is one of the processes that is used for the extraction of concrete and absolutes for products like

a) Floral fragrance – concretes and absolutes: Jasmine, Rose, Tuberose, Lotus
b) Medicinal plant extracts & phytochemicals. E Polyphenols of cinnamon, Neem ext.
c) Spice oleo resins: Red chili, Pepper, Ginger
d) Phytochemicals: Curcumin (turmeric), Piperine (Pepper), Capsaicin (Chilli)

The process of production of concretes and absolutes involves use of volatile organic solvents like Ethanol, Methanol, n-Hexane, Acetone, Ethyl Acetate, IPA, etc. and various natural materials. These ingredients are too delicate to undergo the high heat of the distillation process and require a procedure where the raw material is submerged and agitated in a solvent that can dissolve the desired aromatic ingredient. The resulting extract, called the concrete, is a mixture of essential oil, waxes and resins and is used for further processing. To remove the non-fragrant waxes and resins from the concrete, another solvent is used to extract only the

fragrant oil from the concrete. The solvent is then removed by evaporation leaving behind the absolute. Absolutes are essentially highly concentrated essential oils.

In most of the units a vertical extractor is used for the process in which the bulk of the raw material is stationary and the solvent is circulated gently to obtain the required product. However in order to increase the efficiency in this entire process, there is need to use modern equipment like Rotary Extractors. Unlike conventional system where the bulk of raw material is kept stationary, mechanical agitation is provided within the bulk of raw material through horizontal rotation of the main shell. At the end of operation, maximum solvent retained in the spent cake is recovered by external heating and efficient condensation of solvent vapors. This equipment has the following advantages over the conventional extraction vessels

- Higher yields of ingredient due to agitated extraction
- Reduced process cycle time
- Better recovery of solvent and better operation costing
- Cleaner shop-floor, since the spent cake is almost dry

Based on practical experience of Industrial units where Vertical Extractors have been replaced by Rotary Extractors, it has been observed that the overall efficiency increases by 15-20%. Though the installation cost of Rotary Extractors is about 25-30% more than vertical extractors, it has been noted that overall cost of production reduces by 20% due to reduced cycle time of extraction and increased percentage of solvent recovery

Relevance for FFDC, Kannuj:

FFDC currently doesn't have Rotary Extractors and rely on vertical extractors for solvent extraction techniques. Due to increased yield and reduced cost of production, Rotary Extractors are slowly replacing Vertical Extractors across the industry. It is important for FFDC to have an increased focus on installing Rotary Extractors. Availability of more efficient Rotary Extractors will help in increasing the customer base of FFDC

Figure 16: Rotary Extractors used in extraction of Herbal Plants

4.1.4. Ultrasonic Extraction

One of the most common techniques for distillation is hydro distillation. This is a process in which the plant material is soaked in water and is then heated for some time after which the volatile material is carried in steam and is condensed in a separate container. It is a common technique that is used in order to isolate essential oils from the plant material. Though this method is time consuming and has a lower yield as compared to other modern techniques, it is the most widely used process across the units. There is a need to replace this existing process by more efficient process that is less time consuming and offers better yield and superior extract quality. [8]

Figure 19: Sample Ultrasonic Extractors

Figure 23: Sample Ultrasonic Extractors

One such technique that can be used instead of prevalent steam distillation technique is Ultrasonic extraction. This technique is based on the principle of bubble implosion that is generated by an ultrasonic cavitation. In the process, the bubble implosion generates micro-jets which destroy the lipid glands in the plant cell tissue thereby triggering an improved mass transfer between cell and solvent and eventually leading to release of essential oil. This technique gives a major advantage of having precise control over the operating parameters thereby giving the manufacturers an opportunity to control the decomposition of organic compounds that tends to happen at high sustained temperature during steam distillation. Ultrasonic Extraction is currently at a very nascent stage and only a few countries around the world have started using this technology in mass production with China being one of them. In India ultrasonic extractors are used only by a few companies that too at prototyping stage. Basis on the output received from various prototyping units, it has been observed that ultrasonic extractors have following advantages that would push this technology for adoption in mass production

Figure 22: Sample Ultrasonic Extractors

- Fast & efficient extraction with process time reduced by around 50%
- Non-thermal, mild process
- High quality extracts
- High yield
- Full aroma spectrum

[8] Hielscher – Ultrasound Technology, 2018

- Less raw material
- Green Extraction

Relevance for FFDC, Kannuaj:
Ultrasonic Extractors despite being in nascent stage are being adopted at a fast pace by the Industry. FFDC can set up an initial level ultrasonic extractors on prototype basis and based on inputs received from the local units can plan to upgrade the facility. Since Ultrasonic Extractors are devices that would be placed in the existing process flow, by this FFDC would have an opportunity to design the entire process flow, customize it as per the local requirements and offer it as service to local units or neighboring farmer's co-operatives.

4.1.5. Microwave Extraction Technologies

In order to control the usage of solvent in the extraction process, increase the overall yield and make it more energy efficient, a number of techniques have come up that involves treatment of bulk raw material in a microwave oven rather than treating it with steam or some other solvent. These processes are increasingly becoming more popular with more and more research happening towards their adoption for mass production. Though these new techniques are at a very nascent stage, it is expected that these will replace the conventional methods of extraction, hence making the process more yield and cost efficient. Currently microwave based extraction is only deployed in prototype basis and still require sufficient research for making it available for local units.

Microwave Assisted Hydro-Distillation

One of the innovative extraction techniques that is used these days is microwave assisted hydro distillation in which extraction process is carried out in a microwave oven. The principle of heating used in Microwave-assisted hydro distillation is based upon its direct impact with polar materials/solvents and is governed by two phenomenon: ionic conduction and dipole rotation, which in most cases occurs simultaneously[9]

Figure 24: Microwave Extraction-Prototype

As per research it has been identified that unlike conventional methods of extraction that are time & solvent consuming and are also thermally unsafe this method offers high and fast extraction with improved yield and less solvent consumption. Apart from this, it has also been observed that this process minimizes environmental impact by emitting less CO_2 in atmosphere (Lucchesi et al., 2004; Ferhat et al., 2006) and consuming only a fraction of the energy used in conventional extraction methods (Farhat et al., 2009).

Solvent Free Microwave Extraction (SFME)

Solvent free microwave extraction is another extraction process that is based on the principle of integrating dry integration and microwave heating energy. It works on the principle of microwave dry-distillation at atmospheric pressure of plant without adding water or any organic solvent (Filly et al., 2014). In a model SFME procedure, the plant

[9] Techniques For Extraction of Essential Oils From Plants: A Review, Hesham H. A. Rassem, Abdurahman H. Nour, Rosli M. Yunus 2016

material is moistened before to extraction by soaking in a certain amount of water for 1 to 2 hrs and then draining off the excess water. After that, the moistened materials are subjected to the microwave oven cavity and a condenser is used to collect the extracted essential oils in a presetting procedure.

Though these techniques have been developed recently, they is a potential of them being preferred over conventional methods of extraction because of the following advantages

- Reduction of extraction time
- Reduction in solvent usage and selectivity
- Improved treatment volatile material
- Controlled heating process

Relevance for FFDC, Kannauj:
Being at a very nascent stage there is no urgency for FFDC to invest in this technology. In order to keep the courses updated with the new technologies, FFDC can set up a prototype of microwave based extractors. It should be noted that usage of these new methods of extraction would require specialized skill set, therefore it would be essential for FFDC to even invest in training of its staff for becoming adept and demonstrating them.

4.2. Blending of Essential Oils/Creation of Flavor/Fragrances

Fragrance creation has traditionally been a time consuming process and generally takes 6 months to 4 years for creation of required fragrances. Over the years major Flavor and Fragrance power houses have started exploring usage of new technologies for reducing the total lead time for faster creation of fragrance and identification of new molecules for creation of new and unique fragrances. However this is not the case with smaller fragrance creation units that are still dependent on conventional blending techniques and minimal expenditure on R&D.

4.2.1. Artificial Intelligence Powered Fragrance Creation

Usage of big data and artificial intelligence for creation of new fragrances and perfumes is a key development happening in the blending space. Major power houses such as Givaudan and Symrise have partnered with different organizations like IBM to create AI and Big Data powered tools that intelligently use different ingredients as per the prepared organogram and create new fragrances as per the customized requirements and experience of customers.

These AI powered tools are currently not available for mass production and are being used as prototypes in experience centers. These tools invites perfumers to develop and test new accords through a playful visual approach, with a wide touch screen, where they can create their formulas differently from the traditional organograms. The experience of using these tools also includes an instant-sampling robot that allows a seamless production of fragrance trials at a speed that cannot be matched by traditional sampling methods.

Relevance for FFDC, Kannauj:
Usage of big data and artificial intelligence for creation of fragrances is at a very nascent stage and requires a lot of development for industry wide adoption. Successful implementation of such technologies would require a complete digital transformation of an industrial unit to complement such upcoming innovative technologies. Since the future for creation of flavor and fragrances would require creation of customized experiences for different customers, at one stage it would become imperative for institutes like FFDC to develop courses and facilities offering such

developments. FFDC should consider such developments as long term targets and should keep it as a part of their plan in overall development of F&F ecosystem

4.2.2. Automation of Blending Process

Considering the criticality in the process of blending where even a slight variance of 0.001% in the final formulation can impact the creation of the final fragrance, most of the top flavor and fragrance power houses are shifting to automated processes to achieve highest degree of accuracy and precision

The usage of robotics in final formulation of fragrances is currently limited to big players with smaller units in India still being dependent on manual mixing and blending. There is a need for smaller Indian players to adapt to such changes in the technology to ensure that the required levels of precision are maintained and they can match the quality of their larger counterparts.

Relevance for FFDC, Kannauj:
In order to ensure that these new systems are brought into the flavor and fragrance ecosystem and the smaller industrial units start using them, there is a need for FFDC to develop such automated systems that can help their customers achieve the required quality by achieving the highest degree of precision. FFDC can also develop experience centers where benefits of such modern techniques are demonstrated to the nearby units.

4.3. Technology Adoption

There are a number of technological and process improvement developments that are happening in the flavor and Fragrance industry. Considering the fact that most of the units in India are still dependent on conventional techniques of extraction and blending, the new interventions should be introduced in a phased manner that can help the units embrace the changes happening in the Industry. Centers like FFDC play one of the most crucial roles in assisting these units to adapt to these new conditions and should be given an additional responsibility of being capacity development centers for the local industry to achieve the required results. Following are some of the important things that should be focused upon while adopting new technologies.

Extraction/Isolation

- Assist smaller units in achieving the required improvements in process improvement for increasing overall yield
- Reduction in overall cost of production through by adopting new technologies and reducing the wastage of solvents
- Development of the good testing labs to assist smaller units in getting the required certification for concrete and absolute

Creation of Fragrances

- Assist smaller units in instrumentation analysis of leading brands by extracting the fragrance to understand broad ingredient structure, which will require experience and seasoned Analytical person perfumery ingredients and sensorial knowledge.
- Develop facilities for sensorial match of most preferred fragrance profile by using step wise sensory evaluation and aroma base molecules.
- Create combinations of accord to come up with unique fragrance profile to create the impact in market.

For further information, please connect with:

Vivek Agarwal

Partner– Infrastructure, Government and Healthcare (IGH)
KPMG in India
T: +91 98117 05760
E: vivekagarwal1@kpmg.com

Amit Kumar

Technical Director – Infrastructure, Government and Healthcare (IGH)
KPMG in India
T: +91 9910903175
E: amitk3@kpmg.com