International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 05 Issue: 01 | Jan – 2026 DOI: 10.55041/ISJEM05331
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Processing Of Spices in the Food Industry: A Review of Roasting, Grinding, and Temperature Control System

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1. ABSTRACT:

Spices being an integral part of food industry contributes to food flavour,aroma,color,and health promoting properties.Spices are majorly used in culinary tradition word wide.The quality of spice products depends on roasting and grinding,post harvest processing.Roasting enhances the flavour and alters the chemical structure according to the temperature and time,which influences the antioxidant property and sensory characteristics in spices.Lack of control leads to loss of volatile compound,degradation of bio-active compounds,non uniform practical size and decreased shelf life.Grinding reduces the particle size for even consistency, which is further more enhanced by sieving. The traditional spice processing is commonly practice in small scale industry and household operations,that are performed manually resulting in reduced quality,inconsistent product,high labour requirement.As consumer demand increases the need for standardized and high quality product becomes necessary,thus adopting automated system.Cryogenic and low temperature grinding are the advanced method which reduces the heat damage,preserves essential oil,maintains the overall property.

This review emphasis on spice roasting and operations including time and temperature control in roasting,grinding operation.It also highlights the need for automation to enable precise processing parameters,thereby improving the efficiency and consistency.

It also helps understanding traditional and modern spice processing technologies ensuring efficiency.

Keywords: Spice Processing, Roasting, Grinding, Tempertaure Control , Automation, Traditional, Modern Methods.

2. INTRODUCTION:

For centuries spice have been used across different cultures for their sensory quality of food and to provide benefits in medicinal and preservation techniques.Spices contains bio- active compounds such as essential oils,alkaloids,phenolics and antioxidants which provide flavour, aroma (Srinivasan,2019). In modern food industry spices are also used as functional components which makes consumer acceptance and product differentiation.The global consumption of ready to eat foods and processed foods will increase the demand for high quality and standardized spices(Singh and Verma,2019).

Spice processing involves a operation of cleaning,drying,roasting,grinding and sieving.In this roasting and grinding are considered the most important step which directly determine the sensory attributes and final spice powder(Brennan et al., 2018)

Roasting process will improves the flavour development through controlled thermal reaction and release of volatile aromatic compounds. Degradation essential oil and thermal decomposition of sensitive compounds

which results by the excessive heat or prolonged roasting time,this can be reduced the flavour and nutritional value(Farah and Donangelo ,2018).

Grinding enable uniform mixing in food by roasting spices into powder form.Partical size distribution determine the texture, shelf life and flavour release into the food(Aguilera and Stanley,2019).

Fine grinding increases the surface area of powder accelerating the rate of oxidization and moisture

absorption resulting in shorter shelf life and reduce aroma(Gupta and Sharma,2019). Grinding generate heat due to friction,that degrades heat sensitive compounds(Zhou et al.,2020)

In traditional methods spices roasting and grinding it have been carried manually such as pan roasting over open flame and stone grinding these methods are still in practice in household and small scale processing units due to low cost (Patil and Joshi, 2018)
Traditional technique relay on skilled operators making it difficult to achieve consistent quality.

Difference in heat distribution, roasting and grinding operation result in non uniform product with inconsistent texture(Singh and Verma,2019).Manual roasting and grinding increase the risk of contamination.
The modern food processing technique include automation that helps overcome limitation of traditional methods.Automated system provide control over temperature time and motor speed producing consistent product thereby reducing labour(Kumar et al,2019).
Industrial equipment uses electrical heater for roasting and high speed motors for grinding producing large quantities.Precise control throughout the process for expense in and large quantity products are essential(Fellows,2017).

Temperature sensor like thermistor provides aqqurate heating during roasting (Gupta and Jain,2019).Controlled motor operation minimizes heat generation(Ahmed and Khan 2020).In automated spice roasting time and temperature control are crucial.Maintaining optimal temperature and controlled time that prevents thermal degradation(Rao and Kulkarni,2020).This review paper provides detail on spice processing method that includes Spice roasting,grinding,temperature control and the traditional & modern methods.

3. LITERATURE REVIEW:

Spice processing determines the final quality of product that includes flavour,aroma,color, and nutritive value.Controlled heat applied during roasting induces physio chemical reaction that releases aromatic compounds required for sensory profile for spices(Martins et al.,2019).Even heat distribution during roasting ensures the preservation of bio active compounds(Fikry et al.,2019).Conventional roasting methods real on manual operation results in inconsistent quality among batches(Srinivasan ,2019).

Presence of high moisture content and these spice composition complicates the roasting process.Retention of volatile oil require for aroma and flavour is affected by temperature and time variation.(Srinivasan,2019).Manual roasting affects the parameters required for roasting,thus the need for technology to monitor comes in role.Embedded system in food industries address the real time monitoring system(Ahmed and Khan,2020).

Traditional roasting methods depends on manual stirring and visual inspection which leads to non uniform and inconsistent heating.(Patal and Joshi,2018).

Grinding in spice processing determines the quality of powder and the partical size distribution.Traditional grinding method used stone grinding or mechanical grinding that produce high heat due to friction leading to loss of volatile oil and essential compounds that degrades the nutritive value and flavour.Conventional grinding increases the product temperature by 90 ℃ causing the loss of quality.(Kumar et al.,2019).

Zhou et al.,(2020)reported frictional heat reduced during high sped grinding affects the properties of spices.

Advance techniques such as cryogenic grinding uses low temperature liquid nitrogen that reduces the heat generated during grinding.This method preserves the physio chemical properties of spice powders. It also reduces the clumping of particals and improves the flow property of spice powders.But the major disadvantage is that it is of high cost.(Mujumdar,2019).

Non uniform partical size affects the packaging properties and flow ability of powder.The blade design and speed of rotation influences the performance of grinding.So it requires careful operational design two get optimum results.(Aguilera and Stanley,2019)

The integration of sensors and displace system improves the monitoring system that includes LCD and alert system to indicate the end of each processes.(Ramesh and patel,2020).

Kumar and Das (2020) reported the need of control in roasting and grinding to ensure affordability of the product.The automated food processing reduces labour requirement improves quality by enhancing hygiene and make it suitable for small scale industries.(Lee et al.,2021)

Research by Kulkarne et al.,(2020) Demonstrates that segregation of fine and coarse particles occurs due to improper sieving resulting in inconsistent appearances.In small scale industries reprocessing is reduced by integrating automatic sieving

(Deshpande,2021).Proper processing reduces the agglomeration of particle and microbial growth during storage and distribution.

Longer the exposure of spice powder to light, air leads to lipid oxidation and moisture absorption altering the composition,texture and properties of powder reducing the shelf life (Farah and Donangelo,2018).

4. ROLE OF SPICES IN FOOD INDUSTRY:

Spices play a muti functional role in food industry enhancing the stability,quality,nutritional value of food products.Spices are widely used in cooking and industrial food manufacturing that adds characteristic flavour aroma,color to the products(Srinivasan,2009).They also posses good anti microbial,anti oxidant properties that contributes to preservation of foods and ensure human health(Sarah and Bonangelo, 2018).

Spices are used as whole or powder depending on the use.Spice powder are prefer in processed food such as RTE meals,snacks and seasoning due to their ease of uniform mixing and consistence flavour dispersion(Selows,2017).Even a slight variation in taste affects the overall acceptance of the product(Brennan et al.,2018).

The major challenge in spice processing is to maintain uniformity among batches.Raw materials combine with processing containing defects results in undesired spice product(Singh and Varma,2019).Food manufactures aims in controlled processing through ensure the spice quality,particularly during roasting and grinding(Gupta and Sharma,2019).

Roasting of spices enhances flavour and reduces the bitterness in certain spices.By using temperature sensor such as thermistor helps controlling roasting temperature that improves the sensory characteristic of spice in industries(Martins et al.,2019).Over roasting deteriorate leads to quality deterioration.Optimal roasting is ensure by maintaining precise time and temperature.

Grinding converts rotated spices into fine powders.Uniform particle size is essential to ensure even mixing and consistent flavour.Controlled grinding prevents oxidation and minimizes heat generation. The needs of standardized spice powder requires adaptation of advanced technologies.

As the concern among consumers have increase the needs for natural flavour and quality must meet the safety standards,reducing the use of preservatives (Lee et al.,2021).

5. SPICE PROCESSING METHODS:

Conversion of raw materials spice into finished product(spice powder includes the followings stages;cleaning, drying, roasting, grinding and sieving.The process varies based on scale of production and technology,they are broadly classified into traditional and modern methods.

5.1 TRADITIONAL METHODS OF SPICE PROCESSING :

Traditional spice processing are practice in household and small scale units that involves manual or semi manual operations.They include sun drying, pan roasting, stone art mechanical grinding(Patal and Joshy,2018).Pan roasting uses metal pans that are heated over flames which are stirred manually to prevent burning.Roasting temperature and time are determined by visual inspection and aroma using through experienced operator.(McGee,2018).

Grinding was performed using stone grinder,motor and pastel for small scale production.These methods are simple and cost saving.But the major limitation of traditional method is non uniform practical size,inconsistent product and reduced quality(Singh and Varma,2019).Other includes the increase risk of contamination due to manual handling.The heat generated during grinding cannot be controlled thus leading to loss of volatile compounds.Traditional methods are still prefer due to low initial cost.But they are applicable only for small scale industry,non suitable for large scale production as they do not meet the quality requirements (Fellows,2019).

Fig1. Traditional spice processing method

5.2 MODERN METHODS OF SPICE PROCESSING:

Modern spice processing addresses and overcomes the limitation of traditional method by involving automation.Industrial spice processing uses the continuous roasting combined with stirrer,pulverizer to grind large quantities efficiently(Kumar et al.,2019).They all precise control over varries parameters such as temperature,time,speed,resulting in uniform product.

Even heating distribution is achieved through mechanical agitator that prevents over heating (Rao and Kulkarni,2020).Grinding machines such as hammer

mills,pin mills are design to produce uniform partical size and minimizing the heat generated(Zhou et al.,2021).Sieving ensures uniformity by separating particles based on size.

Modern methods are highly reliable and effective reducing the requirement of labour but consider expensive,occupying more space(Fellows,2020).

5.3 PROCESSING TECHNIQUES:

There are several other methods used to improve spice processing efficiency.Cryogenic grinding uses low temperature liquid nitrogen to reduce heat generated during grinding thus preserving the volatile oils and quality (Mujumdar,2019).Micro controller based system controls roasting temperature and grinding time(Ahmed and Khan,2020).These are suitable for small scale industries with less capital invested.The evaluation of spice processing through automation improves the quality and efficiency.Combination of traditional and modern methods are used in food industry.

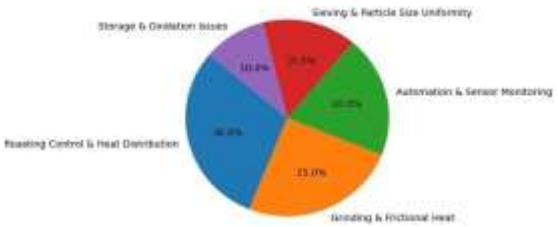

Fig2.Factors affecting spice processing quality

6. SPICE ROASTING AND TEMPERATURE CONTROL:

Roasting is the important processing step in spice processing which majorly influence the sensory and functional properties of the spice.The objective of roasting is to improve the flavour,aroma and color by controlling the temperature,which minimizing the degradation of essential oils and bio active compounds(Srinivasan,2019).Maillard reactions, caramelization, and volatilization of aromatic compound will occur during the roasting process,which contributes the characteristics flavourprofile of roasted spieces(Martins et al.,2019).

6.1 TEMPERATURE AND TIME CONTROL:

In spice processing roasting is an important thermal process which is influences the functional and sensory properties of spice.Roasting enhances flavor, aroma, color by controlled thermal processing that reduced the degradation rate of essential oils(Srinivasan,2019). Roasting involves chemical reactions such as maillard reaction,volatilization,caramelization which contributes to flavor of spice (Martins et al.,2019).

The important parameters of roasting are time and temperature.Roasting condition varies for each spices depending on chemical composition, moisture content,intended use. Medium roasting temperature for short period are preferred as it prevents the loss of volatile oils(McGee,2018). Uncontrolled roasting at high temperatures leads to lipid oxidation, aromatic compounds breakdown, undesired flavor,reduced product quality(Farah and Donangelo,2018)

Traditional roasting does not rely on temperature and time control sensors rather they are detected visually by appearance and aroma.This method is suitable for small scale units but may show variation among batches(Patil and Joshi,2018). Improper stirring and uneven heat distribution overheats affecting the spice quality(Singh and Verma,2019).

Modern roasting methods uses temperature sensor and controlled heating element to ensure uniform thermal distribution inside the roasting chamber.Sensors such as thermistors, thermocouples are used for temperature control(Gupta and Jain,2019). Automatic ON/OFF systems are used to prevent overheating or burning of spices to ensure stability in temperature and efficiency (Rao and Kulkarni,2020)

Mechanical or vibrational agitators are used to prevent burning of spices in contact with heating element and pan thereby ensuring even roasting (Patel and Shah,2019). Stirring also minimizes the energy consumption (Chen et al.,2021). Gentle mixing preserves the structure of spices.

Cumin(Cuminum Cyminum) is roasted at 125°C for about 10 minutes in conventional method says a study by CFTRI. A study by FAO notes the roasting condition of black pepper(Piper nigrum) to be 100-150°C for 15- 30minutes. Coriander(Coriandrum Sativum) is dry roasted in medium heat for 3-4minutes until the colour turns slightly darker and produces aroma.

Time controls play a vital role in roasting along with temperature by reducing labor requirement and error caused by human(Ahmed and Khan, 2020). These are used in both small scale and large scale industries (Lee et al.,2021).

7. GRINDING OF SPICES:

Grinding reduces the dried spices into powder form that are used in culinary and industrial uses. The particle size distribution influences the flavor, texture, appearance and shelf life of product, it also indicates

the quality of spices (Aguilera and Stanley,2019). Uniform grinding ensures consistency and consumer acceptance.

Traditional grinding method uses stones or mechanical grinders that are considered ineffective as they produce uneven particle size due to lack of speed control(Patil and Joshi,2018). Friction during grinding generates heat that causes oxidation and loss of volatile compound (Gupta and Sharma,2019). They do not produce standardized spice powder.

Modern grinding method uses high speed motors operating at 4,000 to 6,000 RPM to produce uniform particle size (Zhou et al.,2020) . To improve the efficiency and powder quality blade design, rotating speed,fees rate are varied. Proper maintenance and selection helps prevent heat generation.

Sieving separates particles based on size to ensure uniformity. It enhances consistency and removes oversized particles that are reground to improve the yield (Fellows,2017). Vibratory or rotary sieves are the most used machines in industries. For small scale mesh screens are used. Sieving improve the flow ability, packaging efficiency and mixing characteristics of spice powders(Brennan et al.,2018)

Automatic has improved the efficiency by controlling the motor operation thereby, reducing overheating (Ahmed et al.,2022). They also extend the life of equipment by monitoring the operations(Nair and Menon,2021).

Advanced techniques are cryogenic grinding that preserves the heat sensitive compounds by maintaining low temperature. They are expensive and used for large scaled industries (Mujumdar,2019). Performance, cost, and quality are balanced by integrating automation.

High quality spice powder are produced by controlled grinding along with sieving as post grinding operation. Uniform product extends shelf life of spices powder.

8. CONCLUSION

The sensory quality,safety and self life of spice product are determined by spice processing.Roasting and grinding play a important role in spice processing that influences the aroma,flavour,particle size,distribution and bio active compounds.From this review,it is evident that control of processing parameter such as time and temperature determines the quality,texture and storage properties(Srinivasan,2019).The need for controlled processing is essential for reducing good quality spice powder.The processing techniques and the operations involved traditional and modern methods are highlighted.Precise temperature and time control during roasting enhances flavour and prevents burning of spices(Martins et al.,2019).Grinding ensures uniform particle size and flavour release,but the major disadvantage is that it generates heat that affects the antioxidant properties(Zhou et al.,2020).Controlled thermal and mechanical processing preserves the quality of spice.

Advances in spice processing through automation enables accurate monitoring and processing operation that results in improve consistency,energy efficiency(Lee et al.,2021).

It reduces labour dependent minimizes human error there by meeting food safety standards and consumer requirements.

This review highlights the merits and demerits of conventional and modern factors.It defines the requirements of small scale and large scale industries.Traditional methods lack control in process and produces ineffective results.Therefore,the need to address automation in spice processing integrated with micro control is needed.

9. FUTURE SCOPE:

In conclusion, the development of compact and energy efficient system and spice processing is needed in the modern industries.The propose system overcomes the limitation of conventional method by integrating roasting and grinding in a single frame by controlling the heating temperature and rate of speed.It also ensures consistent roasting by use of agitator that prevents over heating or burning of spices.The use of temperature sensor (thermistor) controls temperature by automatic on or off,if the temperature exceed the limit.The whole process to make a spice powder takes less time when compared to existing methods.The roasting is perform to a preset temperature and time and then cool to proceed for grinding.High speed ensures uniform particle size and reduces the heat generated due to friction.Automatic agitator distributes heat uniformly,that cannot be achieved in manual roasting.

Precise control in roasting and grinding are monitored through micro controller and the end process is identified easily,but in conventional methods they are visually and aromatically determined that may lead to human error.This method can be applied in household,small restaurants,catering units for spice preparation.It has the benefit of producing fresh spice powder,with uniform particle size,with less investment.The compact size makes the user with easy handling practice.It ensures hygienic processing by minimizing manual contact ensuring food safety.Additional features includes automatic sieving and integration of cooling.

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