Available online on 15.06.2021 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

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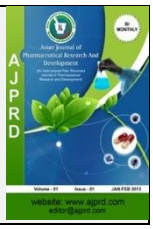

Open Access Research Article

Preparation and Characterization of Different Types of Extruders and Its Techniques

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A B S T R A C T

The study on characterization of different types of extruder such as single screw cone type, axial type extruder, radial type extruder, die roller type extruder from excipient, enzyme and silica has been performed. The primary goal of the project focuses on making pellets from MCC+LACTOSE, MCC+STARCH, Enzyme and Silica. The process is extremely encouraged in several pharmaceutical industries. The below article will help us understand various aspects of techniques used in the extrusion of pellets. The extruder process of pellets are mainly mixing and extrusion. We will also discuss about the several factors that might influence the pellet quality which includes formulation - granulating liquid, excipients; Equipment (Rapid mixer granulator, various type of extruder, and size of extrusion screen) and process (Extrusion speed, extrusion time). The characterization of the pellets includes estimation of various parameters such as moisture content ,appearance, shape , bulk density, disintegration of the pellets are explained.

Keywords: Excipients, Enzyme, silica, Extruder Techniques, Extrusion, Rapid mixer granulator, Quality Parameters, Physical Characterization

A R T I C L E I N F O: Received 12 Feb. 2021; Review Complete; 20 April 2021 Accepted; 05 June 2021 Available online 15 June. 2021

Cite this article as:

Ogale N, Kamble K, Preparation and Characterization of Different Types of Extruders and Its Techniques, Asian Journal of Pharmaceutical Research and Development. 2021; 9(3):48-51. **DOI:** http://dx.doi.org/10.22270/ajprd.v9i3.929

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1. INTRODUCTION

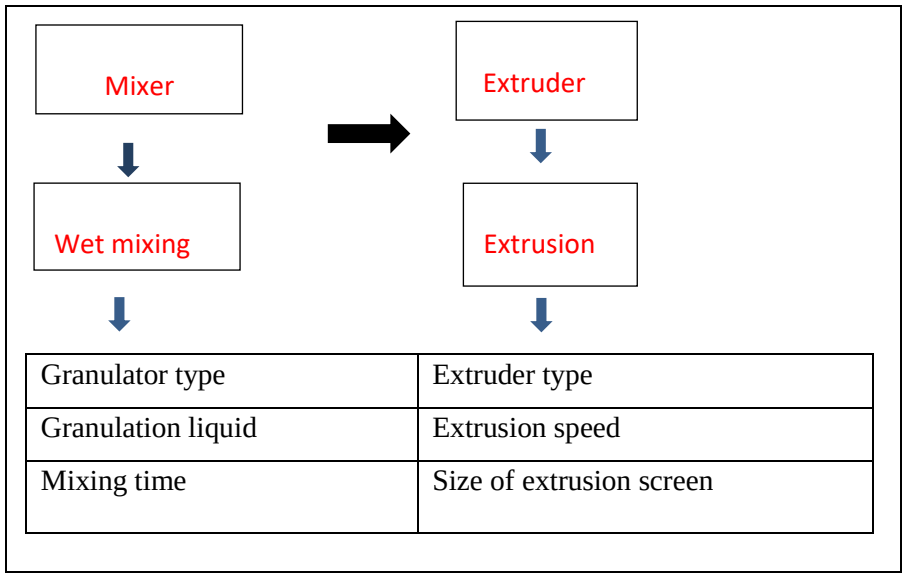
Extrusion is currently one of the techniques used to produce pharmaceutical pellets. Every production technique results in pellets having specific characteristics. The preparation of pellets by extrusion is now a more established method because of its advantages over the other methods such as include ease of operation, High throughput with low wastage, particle size distribution, Production of pellets with low friability , sustained and controlled drug-release profile, pellets suited for file coating.[1]

2. PROCESS AND EQUIPMENT

The extrusion process involves below two steps:

- Granulation – This involves preparation of the wet mass;
- Extrusion – This involves shaping the wet mass into cylinders;

Same steps, same process parameters, same extrusion screen size but different type of extruderare summarized in Fig. 1.[1]



Granulator type	Extruder type
Granulation liquid	Extrusion speed
Mixing time	Size of extrusion screen

Figure 1: Flow diagram showing process steps, process parameters and different type of extrusion screen size equipment involved in extrusion to produce pellets

2.1Equipment parameters

2.1.1 Mixer:

The intial step of the extrusion is preparation of the wet mass. There are various types of granulators like rapid mixer granulator which are used to perform the mxixing of the powder blend alongwith the granulation liquid. However, it is worth noting that high shear mixers will introduce a large amount of heat in the mass while performing the granulation process which could result in evaporation of the granulation liquid caused due to the rise in temperature, eventually impacting the extrusion behaviour of the wet mass. By cooling the granulation bowl we can avoid this situation.[2]

2.1.2 Extrusion:

The next step is the Extrusion which consists of shaping the wet mass into long rods. These are more commonly termed as 'extrudate'. The usage of this process is not limited to the pharmaceutical industry, but widely used in food, polymer and ceramic industries also. As of current date, this process is used as an alternative method for the manufacture of tablets which are completely water-soluble. Extrusion devices type can be grouped into four main classes viz. Single screw cone type extruder, radial type extruder, arial type extruder, die roller extruder. [2]

2.1.3Extruder :

As the name implies, it utilizes a screw to develop the necessary pressure to force the material to flow through the uniform openings, producing uniform extrudates.[3]

2.1.3.1 Single screw Cone Extruder :

Figure 2: Single Screw Cone Extruder Machine

Single screw cone extruder is widely used for making pellets of different sizes ranging from 500 microns to maximum 1500 microns. Extrusion chamber consist of twin screws used to transfer the material towards the pressing cam and then out from the perforation of the screen of desired diameter.[3]

2.1.3.2 Axial Extruder :

Figure 3: Axial Type Extruder machine

Axial Extruder has the screen placed at the end of the screw which lies perpendicular with the axis of the screw. This extruder is widely used for making pellets ranging from minimum 300 microns to maximum 1500 microns.[3]

2.1.3.3 Radial Type Extruder :

Figure 4: Radial Type Extruder machine

In this type, die is placed around the screw, discharging the extrudate perpendicularly to the axis of the screw. The range lies between 400-1500 microns.[3]

2.1.3.4 Die Roller Type Extruder:

Figure 5: Die Roller Type Extruder machine

This extruder is equipped with two contra rotating wheels. Either one or both the wheels are perforated.

In this type, the mass is fed between the two wheels and the extrudate is collected inside the extrusion wheels.

3. MATERIALS AND METHODS FOR MCC + LACTOSE:

MCC +LACTOSE and Granulation liquid were used for the preparation of binary mixture.The mixture of required concentrations were prepared by suitable dilution of the stock solutions. After desired mixture was prepared, the mixture were taken and was tested in batch process in different type of extruder.

Figure 6: MCC Excipient

Figure 7: LACTOSE Excipient

3.1 PREPARATION OF MIXTURE FOR MCC + LACTOSE:

MCC is the principle excipient in the pellets prepared by extrusionprocess . Water is an appropriate liquidfor preparation of binary mixtures of MCC+ lactoseTake 60 % MCC: 40 % lactose mixture, Add 200ml water in Rapid mixer granulator for 10 min . After proper mixing in rapid mixer granulator desired mixture was found, then transfer this into different type of extruder andset all parameter like extruder speed ,Extruder Time and Size of extrusion screen in different type of extruder.

Figure 8 : Single Screw Cone Extruder product

Figure 9: Axial Type Extruder product

Figure 10 : Radial Type Extruder product

Figure 11: Die Roller Type Extruder product

4. MATERIALS AND METHODS FOR MCC + STARCH :

MCC + STARCH and Granulation liquid were used for the preparation of binary mixture .The mixture of required concentrations were prepared by suitable dilution of the stock solutions. After desired mixture was prepared, the mixture was taken and tested in batch process in different type of extruder.

Figure 12: MCC Excipient

Figure 13: Starch Excipient

4.1 PREPARATION OF MIXTURE FOR MCC+STARCH :

MCC is the most important excipient in the pellets prepared by extrusion . Water is an appropriate liquid for preparation of binary mixtures of MCC+ STARCH Take 60 % MCC : 40 % starch mixture, Add 200ml water in Rapid mixer granulator for 10 min . After proper mixing in rapid mixer granulator desired mixture was found, then transfer this into different type of extruder and set all parameter like extruder speed ,Extruder Time and Size of extrusion screen in different type of extruder.

Figure 14: Single Screw Cone Extruder product

Figure 15: Axial Type Extruder product

Figure 16: Radial Type Extruderproduct

Figure 17: Die Roller Type Extruder product

5.MATERIALS AND METHODS FOR ENZYME :

Enzyme mixture and Granulation liquid were used for the preparation of binary mixture .The mixture of required concentrations were prepared by suitable dilution of the stock solutions. After desired mixture was prepared, the mixture was taken and tested in batch process in different type of extruder.

Figure 18: Enzyme Mixture

5.1 PREPARATION OF MIXTURE FOR ENZYME :

Figure 19: Single Screw Cone type product

112.5 gm enzyme are mixed in a laboratory mixer with 3 g magnesium stearate and wetted with approximately 32.5 ml isopropanol in Rapid mixer granulator for 10 min . After proper mixing in rapid mixer granulator the desired mixture was found, we then transfer it into different type of extruderand set all parameter like extruder speed ,Extruder Time and Size of extrusion screen in different type of extruder.

Figure 20: Die Roller Type Extruder product

6. MATERIALS AND METHODS FOR SILICA:

Figure 21 : silica

Silica and Granulation liquid were used for the preparation of binary mixture .The mixture of required concentrations were prepared by suitable dilution of the stock solutions. After desired mixture was obtained,the mixture was taken and tested in batch process in different type of extruders.

6.1 PREPARATION OF MIXTURE FOR SILICA:

Take silica 250 gm and 200ml mixture of water and isopropanolin Rapid mixer granulator for 10 min . After proper mixing in rapid mixer granulator the desired mixture was found and then transfer it into different type of extruder, set all parameter like extruder speed ,Extruder Time and Size of were extrusion screen in different type of extruder.

Figure 22: Die roller extruder product

7. CHARACTERIZATION

The instruments used for Physicalanalysis were for Moisture balance, Bulk density apparatus,

7.1 FINAL EXTRUDED PRODUCT:MCC+LACTOSE

Figure 23: Single Screw Cone Extruder

Figure 24: Axial Type Extruder

Figure 25: Radial Type Extruder

Figure 26: Die RollerType Extruder

7.2 FINAL EXTRUDED PRODUCT: MCC+STARCH

Figure 27: Single Screw Cone Extruder

Figure 28: Axial Type Extruder

Figure 29: Radial Type Extruder

Figure 30: Die RollerType Extruder

7.3 FINAL EXTRUDED PRODUCT ENZYME :

Figure 31: Single Screw Cone Type

Figure 32: Die Roller Type Extruder

7.4 FINAL EXTRUDED PRODUCT SILICA :

Figure 33: Die roller extruder

8. RESULTS AND DISCUSSION:

8.1Table No 1: The Physical Characterization of the extruded product of MCC+LACTOSE

Type of extruder	**Single screw cone type extruder**	**Axial extruder**	**Radial extruder**	**Die Roller extruder**
Extruder speed	80 rpm	80 rpm	80 rpm	30 rpm
Extrusion time	3 min	2 min 50 sec	3 min 5 sec	2 min
Size of extrusion screen	1 mm	1 mm	1 mm	1 mm
Moisture content	32.47%	41.43 %	37.53 %	43.88 %
Bulk density	0.437 gm/cc	0.530 gm/cc	0.480 gm/cc	0.417 gm/cc
Appearance	Good	Excellent	Good	Good
Shape	Vermicelli	Vermicelli	Vermicelli	Vermicelli
Disintegration	5.30 min	4.20 min	2.01 min	1.10 min

As per the above result of MCC+ LACTOSE, the bulk density and the appearance of axial extruder is greater as compared to other three extruder.

8.2 Table No 2: The Physical Characterization of the extruded productofMCC+STARCH

Type of extruder	Single screw cone type extruder	Axial extruder	Radial extruder	Die Roller extruder
Extruder speed	80 rpm	80 rpm	80 rpm	30 rpm
Extrusion time	2 min	2 min	3 min	4 min
Size of extrusion screen	1 mm	1 mm	1 mm	1 mm
Moisture content	43.13%	44.72%	43.21%	46.0%
Bulk density	0.491 gm/cc	0.545 gm/cc	0.540 gm/cc	0.582 gm/cc
Appearance	Good	Good	Excellent	Good
Shape	Vermicelli	Vermicelli	Vermicelli	Vermicelli
Disintegration	1.47 min	3 min	1.27 min	50 sec

As per the above result of MCC+STARCH, the bulk density of die roller extruder is greater as compared to the other three extruder. However, the appearance of radial extruder is excellent in comparison with the other three extruder .

8.3 Table No 3: The Physical Characterization of the extruded product of Enzyme

Type of extruder	Single screw cone type extruder	Die Roller extruder	Axial extruder	Radial extruder
Extruder speed	80 rpm	30 rpm	Extruder choked	Extruder choked
Extrusion time	1 min 30 sec	2 min		
Size of extrusion screen	1 mm	1 mm		
Moisture content	15.60 %	12.87 %		
Bulk density	0.418 gm/cc	0.530 gm/cc		
Appearance	Good	Good		
Shape	Vermicelli	Vermicelli		

As per the above result of enzyme the bulk density of die roller extruder is greater as compared to the single screw cone type extruder. Though, the material was not able to pass through the axial extruder and the die roller extruder, the appearance of both the extruder was same.

8.5 Table No 4 :The Physical Characterization of the extruded product of Silica

Type of extruder	Die Roller extruder	Single screw cone type extruder	Axial extruder	Radial extruder
Extruder speed	30 rpm	Extruder choked	Extruder choked	Extruder choked
Extrusion time	2 min 30 sec			
Size of extrusion screen	1 mm			
Moisture content	72.9%			
Bulk density	0.222 gm/cc			
Appearance	Excellent			
Shape	Vermicelli			

As per the above result of silica,the material passed only through die roller extruder while the single screw cone type extruder ,axial extruder and radial extruder choked the material inside the extruder and the appearance of the die roller extruder with silica was found to be excellent.

9. CONCLUSION:

The extrusion is a very effective technique for the production of pellets. The success of this method largely depends on its advantages over other techniques. To produce pellets with uniformity in size and density, this method is highly proved.

When MCC+LACTOSE was tested across all extruders, we found that the bulk density of axial extruder was 0.530 gm/cc which is more as compared to other three extruder and also in terms of appearance axial extruder was the best.

When MCC+STARCH was tested across all extruders, we found that the bulk density of die roller extruder was 0.582 gm/cc and its as compared to the other three extruder. While radial extruder performed excellent in terms of appearance.

When Enzyme was tested across all extruders, we found that the bulk density of die roller extruder was 0.530 gm/cc which was greater than the single screw cone extruder, on the other hand the material was not able to pass through the axial extruder and die roller extruder while the appearance on both the extruder was same.

When Silica was tested across all extruders, we found that the material passed only through die roller extruder, while all three extruders got choked. The bulk density with die roller was 0.222 gm/cc and appearance with the die roller extruder was excellent.

To summarize, this process is capable of high throughput, minimum wastage and easy-to-perform operations. As this process is being encouraged widely it will be popular in no time. Our literature shows that different type of materials can be passed through different type of extruders with a good physical characterization to make pellets. Therefore, depending on the material that is used and the bulk density that needs to be achieved, commercialization of the above extruders is highly recommended.

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