Formulation Development and Evaluation of Sodium Bicarbonate Tablets by Direct Compression Method

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Abstract: Acidity is a worldwide problem caused by an imbalance between the acid secreting mechanisms of stomach and proximal intestine. It creates great trouble in the life of many people. An antacid neutralizes excess acidity and provide relief. Sodium bicarbonate is prescribed as an antacid to treat heartburn and acid indigestion condition. The main objective of the current work was to prepare sodium bicarbonate antacid tablets by direct compression method and to evaluate trial formulation with those available in the local market by pharmacopeial and nonpharmacopeial methods. Besides sodium bicarbonate, the excipients used were lactose, microcrystalline cellulose (Avicel) and magnesium stearate. The tablet weight set for compression was 318mg (±5%). After sieving through a 20 mesh screen, the powder was blended for five minutes and evaluated for its flow properties before compression on a single punch machine. The results revealed that the blend possessed good flow property, compressed easily and the resulting tablets complied all the standards and showed a close resemblance with sodium bicarbonate tablets which are available in the local market.

Keywords: Direct compression, formulation, sodium bicarbonate, tablets.

INTRODUCTION

It is known that acid overload is the main cause which is associated with heart issues, allergies, obesity and digestive problems in more than thirty eight million people around the world [1]. It appears that acidity is now a worldwide problem creating restlessness and trouble in the life of the peoples [2]. A survey in 2003 showed that 40 percent of all Americans experience acidity symptoms like heart burn at least once in a month. The body requires a proper balance in acid production and its utilization but when the amount of acids increase in the body symptoms like weakness, illness, heartburn, chest pain, inflammation and pain appears apparently. It also flourishes the growth of many viruses and bacteria. Further, acidosis hinders the energy production in the cells and the capability to refurbish damaged cells. For a person suffering from acidity problems, the ideal diet should be one that comprises of 60% of alkaline foods and only 40% acidic foods. The best way to overcome acidity problem is to avoid junk foods or high acidic food or to consume these foods in limited amounts [3].

Antacids are the drugs that neutralize excess gastric acid [4]. Oral sodium bicarbonate has been given for the treatment of acute acidosis; where as parenteral sodium bicarbonate is indicated to correct severe acidosis [5]. It is a non-elastic material and causes hindrance during compression. In order to overcome poor compressibility and bad flow ability of sodium bicarbonate, spray-drying technique was used for the formulation. The directly compressible spray dried sodium bicarbonate possesses high-quality compressibility and stability due to the presence of accessible additives such as polyvinyl pyrollidone and silicon oil [6].

The major purpose of the study was to manufacture a new formulation of sodium bicarbonate tablet by direct compression technique and to compare this formulation with the commercially available brands in the local market of Karachi, Pakistan. Direct compression is economical over other methods of manufacturing tablets as it requires less number of unit operations, consequently lesser in expenditure and low time consuming, produces greatest bioavailability in human body [7] and have low microbial contamination level due to lack of moisture [8]. This process is chosen for tablet manufacturing particularly for those drugs which are moisture sensitive and thermo labile in nature [9].

MATERIALS AND METHODS

Sodium bicarbonate was kindly donated by Karachi Pharmaceutical Laboratory, lactose from FMC Corporation; USA, Avicel from FMC Corporation, Ireland, magnesium stearate from Magnesia, Germany, hydrochloric acid and methyl orange solution from Merck; Germany were purchased.

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Formulation of Sodium Bicarbonate Tablets

The quantity of active pharmaceutical ingredient (API) and the excipients were weighed accurately (Table **1**). Prior to blending in a poly bag, all ingredients were passed through a 20 mesh sieve. The purpose of this step was to break any lumps and to ensure a uniform particle size which is extremely necessary for the proper flow of powder and uniform filling of the dies. After sieving, the powder was blended in a poly bag with about half empty space by tumbling to provide enough space for the powder bed to tumble for five minutes and evaluated for flow properties by angle of repose and Carr's index. The blend of active and excipients were transferred directly into the hopper of a single punch machine (Erweka, GmbH, Germany) and compressed manually at room temperature to get a tablet of 318 mg (±5%) weight.

Evaluation of Sodium Bicarbonate Tablets

Trial formulations of sodium bicarbonate 300 mg tablets (T1 and T2) with its commercial brands (A1, A2 and A3) available in the local market in same strength were evaluated by pharmacopoeial and non pharmacopoeial tests [10][11] as described below. The deviation of the weight of individual tablet is an apparent sign of the consequent variation in the drug contents [12]. The weight variation test of trial formulations and commercial brands were carried out by individually weighing 20 tablets on a balance (Sartorious GmbH; type A 6801) and then mean weight and standard deviation were calculated. The quantity of the filling material allowed to enter to the die cavity and the amount of pressure applied during compression is the result of tablet thickness [4]. Random samples of 20 tablets of both commercial and trial batches were chosen and their diameter and thickness was measured in centimeters with the help of a vernier caliper. For crushing strength, hardness of randomly selected 20 tablets of each brand and trial formulation was determined in kgs using a Hardness Tester (Fujiwara, Seisukusho Corporation, Japan). Likewise, friability test was performed on 20 randomly selected tablets of trial formulation and available commercial brands that were cleared from any loose dust particles with the help of a soft brush and weighed accurately for their initial weight. Each set of tablets were placed separately in friabilator (H. Jurgens and Co-GmbH, D2800, Germany) and run for 4 minutes at 25 rpm. At the end of the test, tablets were removed, cleared from loose dusts, observed for capping and than their final weight was determined to calculate loss of weight in percent. After the physical tests, tablets were subjected to the assay test by titration method [11] and disintegration test [10]. For the assay, 20 tablets were accurately weighed, powdered in a mortar with a pestle. One gram of the powder was taken in a conical flask and 20 ml of water was added into it, the solution was than titrated with 0.5 M hydrochloric acid using 1-2 drops of methyl orange solution as an indicator. The disintegration test of the trial and commercial brands were done in simulated gastric fluid maintained at 37 ± 0.5^{o} [10].

RESULTS AND DISCUSSION

Although, sodium bicarbonate is available in the form of effervescent tablets / granules alone or in combination with other drugs to be added in a glass of water before use, yet at times it is not convenient for a patient to access water and this may reduce patient compliance. The objective of the current work was to prepare sodium bicarbonate tablets by direct compression technique using a simple formula and to evaluate the test formulations with those available in the local market in conventional form.

Direct compression is a process by which active ingredient and excipients are compressed without any need of prelude action [13]. A simple formulation is considered to be composed of an active ingredient, a diluent and a lubricant [14]. In the present work, the excipients used for the formulation of the two trial

Table 1: Composition of sodium bicarbonate 300 mg tablets manufactured by the direct compression method

S. No	Material Name	Quantity per tablet	For 100 tablets
1.	Sodium bicarbonate	300 mg	30.00 g
2.	Avicel	10 mg	1.00 g
3.	Lactose	5 mg	0.50 g
4.	Magnesium stearate	3 mg	0.30 g
	Total weight	318 mg	31.80 g

batches of sodium bicarbonate tablets were microcrystalline cellulose (Avicel), lactose and magnesium stearate, all are commonly use in tablet formulations. Briefly, Avicel is commonly used as a filler in tablet and capsule formulations where it is used in both direct compression and wet granulation methods [15, 16]. Avicel also has some disintegrant and lubricant qualities make it useful in tablet manufacturing [17]. Magnesium stearate was found to be the very efficient lubricant based on low punch ejection force (LPEF) concentration profile [18]. Magnesium stearate is widely used as a pharmaceutical excipient and is generally regarded as being non-toxic following oral administration [19]. Lactose is commonly used as a diluent or filler in tablet and capsules. In general the grades of lactose selected are depending upon the type of dosage form being developed. Direct compression grades are often used to hold small quantities of drug and this allow tablets to be made without granulating [20, 21].

Prior to compression, trials blends (T1 and T2) were evaluated for their flow properties such as angle of repose and Carr's index [22]. The values of angle of repose and Carr's index was found to be less than 20º and less than 11% respectively which indicate excellent flow properties (Tables **2** and **3**). Trial batches were easily compressed on a single punch machine and the resulting tablets were evaluated using pharmacopoeial and nonpharmacopoeial tests (Table **4**). It is clear from Table **4** that weight variation of trial batches are in line with the commercial brands, complying the pharmacopoeial standards and showing good flow property of the trial blends and their uniform filling in the dies. It appears that the composition of lactose, Avicel and magnesium stearate and blending time selected in the present formulation is appropriate. Likewise weight variation, a close resemblance was found in diameters (range: 0.76 to 0.83 cm) and thickness (range: 0.33 to 0.46 cm) of all formulations with a very small standard deviation. In case of hardness test, A1, T1 and T2 showed lower yet similar hardness (about 5kg) while A2 and A3 showed higher hardness (about 7 kg). For a satisfactory tablet, hardness of 5 kg is considered to be acceptable [10]. From these results, it is evident that the trial batches bear satisfactory hardness suitable to withstand manufacturing and packaging operations. The friability of all the batches has been found to be satisfactory (< 1%).

Table 2: Angle of repose as an indication of powder flow properties (From Aulton, 2002, Ref. [22])

Angle of Repose (°)	Type of Flow
<20	Excellent
20-30	Good
30-34	Passable
>40	Very Poor

Table 3: Carr's Index as an indication of powder flow (From Aulton, 2002, Ref. [22])

Carr's Index (%)	Flow Character
5-15	Excellent
12-16	Good
18-21	Fair to Passable
23-35	Poor
33-38	Very Poor
>40	Extremely Poor

After the physical tests, the tablets were analyzed for the content of active ingredient. The results of pharmaceutical assay showed that all the formulations under study meet up the standard requirement of the test (90-110%) (Table **4**). All the formulations were disintegrated within 30 minutes in simulated gastric fluid maintained at 37±0.5^{o}C as depicted from Table **4** and thus complying official requirements of disintegration which is 30 minutes for sodium bicarbonate tablets [10].

Terashita and Imamura in 2002 recommended that direct compression is capable to produce tablets cheaper than wet granulation method and tableting technique owing to fewer items of process validation [23]. Therefore direct compression was observed to be most effective in formulating tablets with exceptional physical qualities. Mattsson and Nyström in 2001 studied physical and mechanical properties of a variety of binders from binary mixtures made from sodium bicarbonate. They reported that addition of a binder such as polyethylene glycol 3000 and polyvinylpyrrolidone results in less porosity and good tensile strength tablets [24]. Gazikolovic *et al*., 1999 also point out the manufacturing of lithium carbonate tablets by the direct compression. They reported that lactose, microcrystalline cellulose and corn starch gave finest qualities to lithium carbonate tablets [25]. In another study conducted by Olsson *et al*., 1998, it was found that addition of polyethylene glycols to sodium chloride or sodium bicarbonate increased the tablet strength [26].

Table 4: Physico-chemical tests of sodium bicarbonate tablets (300 mg)

*Formulation Code	Weight(gm) Mean±SD	Diameter(cm) Mean±SD	Thickness(cm) Mean±SD	Hardness(Kg) Mean±SD	Friability (%)	Assay (%)	Disintegration (Min)
Pharmacopeial Limits	±5%	-	-	At least 5 kg	< 1%	90%-110%	Within 30 min.
A1	0.30±0.007	0.83±0.03	0.46±0.02	5.8± 2.0	0.41	106	8
A2	0.31±0.01	0.83±0.004	0.33±0.02	7.11±1.30	0.32	108	6
A3	0.32±0.009	0.81±0.004	0.44±0.01	6.81±1.30	0.30	107	5
T1	0.32±0.01	0.76±0.001	0.33±0.02	4.55±2.07	0.65	102	10
T2	0.31±0.01	0.76±0.001	0.35±0.02	4.57±2.09	0.63	105	13

*Formulation Code:
A1= Sodium bicarbonate brand 1.
A2 = Sodium bicarbonate brand 2.
A3 = Sodium bicarbonate brand 3.
T1 = Sodium bicarbonate trial 1.
T2 = Sodium bicarbonate trial 2.

CONCLUSION

In the present work, sodium bicarbonate tablets were successfully formulated by direct compression method using Avicel, corn starch and magnesium stearate. These tablets showed compliance with all the standards and were found promising with the available brands. It appears that the present formulation of sodium bicarbonate is simple in composition, easy to manufacture and cost effective as compare to its counterparts available in the market. Further work is required to optimize this formulation.

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