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Research Article

The Effect of Formulation Variables on the Swelling Capacity of *Khaya senegalensis* Gum

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ABSTRACT

Khaya senegalensis gum (Family: Meliacae), is hereby subjected to some formulation variables; in order to elucidate the effects of such on its swelling capacity. A three factorial design experiment was utilized to find the effects of granule wetness (binder volume), drying temperature and compression pressure on the swelling index of sodium bicarbonate tablets formulated with the gum. The results revealed that binder volume and compression pressure do affect swelling index, while drying temperature had no direct effect on swelling index. Maximum swelling of gum is attained with binder volume of 20-30 % aqueous binder and compression pressure of 5-6 metric tonnes (MT) to produce hard tablets that can withstand handling and prompt release of active medicament. However slower release was obtained with 50 % aqueous binder and 6-7 MT compression pressure. This investigation has established the need to carefully design the formulation pathway, in order to achieve the desired release characteristics.

INTRODUCTION

Gums from various plant sources are now utilized as useful pharmaceutical excipients due to their inertness, hydrophilic and jelling properties. These include xanthan gum [1], locust bean [2] and guar gum [3].

Khaya senegalensis gum was reported to possess a swelling capacity, ten times its original weight [4]. Earlier on, high binding and suspending properties were reported with *Khaya grandifolia* gum [5, 6].

The release of drugs from matrix formulations have been linked to the nature of matrix material, complex processes such as swelling, diffusion and erosion [7]. It is pertinent to know that formulation variables which could directly or indirectly affect these phenomena in gum matrices will definitely affect drug release profiles.

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MATERIAL AND METHODS

Khaya senegalensis gum obtained from Samaru, Zaria. Sodium bicarbonate and lactose powders were from BDH, Poole-England.

Extraction and Purification of Gum

The crude gum was purified and dried by adopting the method reported earlier [4].

Determination of Swelling Capacity

A 5 g sample was placed in a 200 ml measuring cylinder and tapped 200 times. The volume (V_1) was noted. Water was added to the mass to reach the 100 ml mark and left to stand for 24 hours. The new volume of gum in measuring cylinder (V_2) was recorded [8, 9]. The swelling capacity Φ as the ratio of initial volume to final volume:

$$\Phi = V_2/V_1$$

Formulation of Sodium Bicarbonate Tablets

A multifactorial experimental design of three variables at three levels was adopted i.e. 3^3 giving 27 batches. The experimental variables were binder volume, granule drying temperature and compression pressure.

A physical mixture of active ingredient and excipients (Table 1) was divided into 3 portions.

Table 1: Quantities of ingredients used for the formulation of sodium bicarbonate tablets

Ingredients	Quantity/ tablet (mg)	Quantity/ 300 tablets (g)
Sodium bicarbonate	100	30
Khaya gum	200	60
Lactose	50	15
TOTAL	350	105

One portion was granulated with 20 % water; the second with 30 % while the third 50 %. The details of further treatments of wet granules up to compression into tablets are as summarized in Fig. 1.

The wet granules were force screened through 1.7 mm mesh and after drying through 1.2 mm mesh.

Granules were compressed using 8 mm punch and die set on the Erweka Single Punch tableting machine (Korsch, Type EKO, Western Germany), at 5, 6 and 7 MT. Tablets were allowed 24 hours for elastic recovery before subsequent evaluation.

Physical Tests on Tablets

Tablet assay

Five tablets were weighed and powdered. A quantity of powder containing an equivalent of 300mg of sodium bicarbonate was dissolved in water and analyzed titrimetrically using 0.5M hydrochloric acid (Martindale).

Crushing strength

This was carried out by subjecting a tablet to increasing pressure until it breaks. The Monsanto hardness tester and crushing strength in Kgf was recorded.

Swelling index

Two tablets from each batch were placed in a petri-dish with 2ml distilled water. The diameter of tablets was taken at intervals of five minutes until maximum diameter was attained with a Digital Vernier caliper (Z540-1, U.S.A). Thereafter the swelling indices (SI) were calculated from initial diameter of tablet (D_1) and maximum diameter on swelling in water (D_2) as expressed below:

$$SI\ (\%) = D_2/D_1 \times 100$$

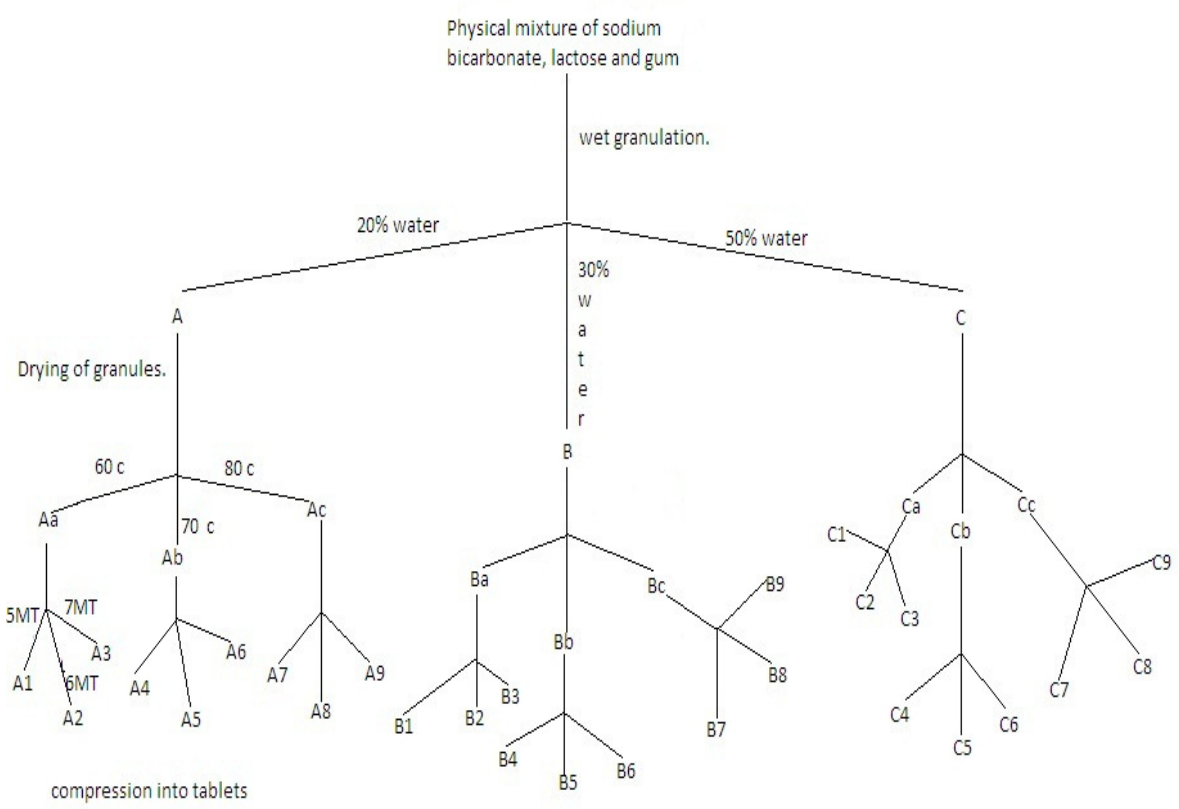

Figure 1: Processing pathway of tablets

Table 2: Results of physical tests on tablets

Batch code	Binder volume (%)	Granule drying temp(°C)	Comp. pressure (MT)	Crushing strength (Kgf)	Maximum diameter (cm)	Time taken (min.)	Swelling index (%)
A_1	20	60	5	0	3.2	20	400
A_2			6	0.5	2.7	35	338
A_3			7	1.0	2.4	45	300
A_4		70	5	0	5.2	45	650
A_5			6	1.0	3.8	25	475
A_6			7	1.5	2.1	30	263
A_7		80	5	0.2	4.1	40	513
A_8			6	0.8	3.8	40	475
A_9			7	3.8	3.7	35	463
B_1	30	60	5	0	3.5	25	438
B_2			6	1.6	2.4	25	300
B_3			7	4.2	2.8	30	350
B_4		70	5	0.2	3.3	25	413
B_5			6	1.8	1.8	30	225
B_6			7	4.8	1.3	25	163
B_7		80	5	0.2	1.9	25	238
B_8			6	1.9	1.7	15	225
B_9			7	4.9	1.3	15	163
C_1	50	60	5	2.9	1.4	35	175
C_2			6	6.8	1.3	20	163
C_3			7	11	1.1	15	138
C_4		70	5	3.0	1.4	25	175
C_5			6	10	1.1	15	138
C_6			7	12	1.2	15	150
C_7		80	5	3.8	1.3	15	163
C_8			6	7.0	1.2	15	150
C_9			7	13	1.1	15	138

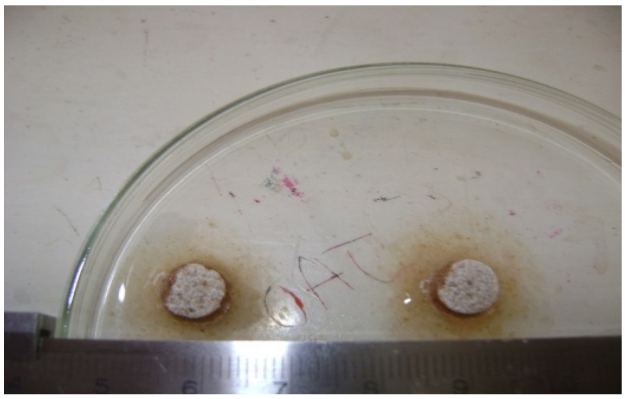

Plate 1: Swelling of A_4 in water

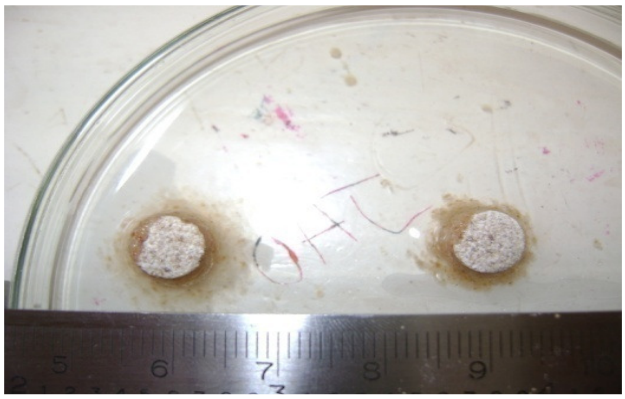

Plate 2: Swelling of A_6 in water

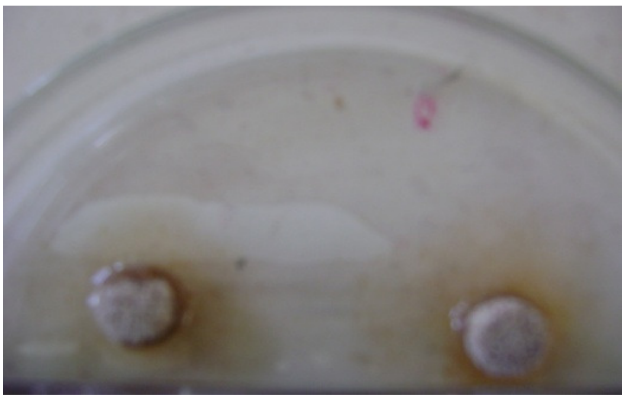

Plate 3: Swelling of B_3 in water

Plate 4: Swelling of B_6 in water

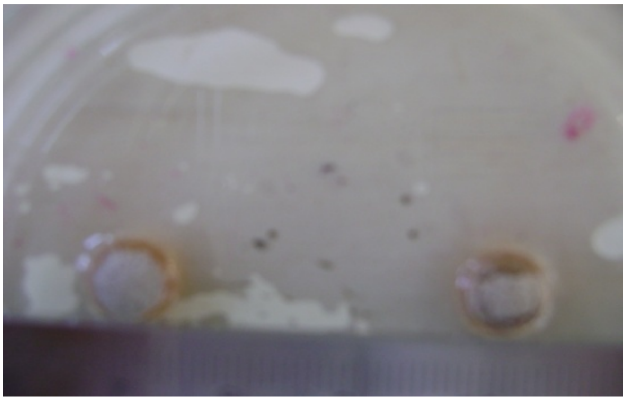

Plate 5: Swelling of C_3 in water

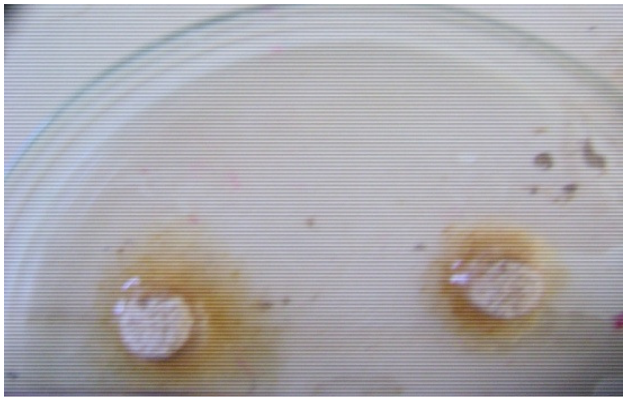

Plate 6: Swelling of C_4 in water

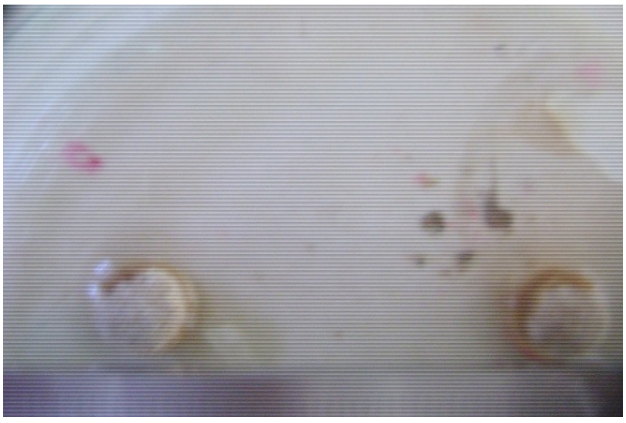

Plate 7: Swelling of C_9 in water

Table 3: Percentage drug dissolved after 30 and 60 minutes

Batch	Swelling index (%)	D_{30} (%)	D_{60}(%)
A_4	650	42	
A_6	263	21	53
B_6	163	21	42
C_3	138	21	40
C_4	175	21	49
C_7	163	21	42
C_9	138	18.5	32

Dissolution profile

The test was carried out using tablets from selected batches (Plates1-6) and Erweka dissolution rate apparatus (Type DT) with 500ml distilled water as dissolution medium. D_{30} and D_{60} values were later computed from the dissolution data.

RESULTS

Effect of Binder Volume on Swelling Capacity

The volume of binder used in wet granulation was found to affect the swelling index of tablets. It was observed that batches A_8, B_8, and C_8 processed with 20, 30 and 50 % binder volume but dried and compressed with same temperature and compression pressure had different swelling indices (Table 2). The swelling indices were in the order $A_8 > B_8 > C_8$. An increase in binder volume decreased swelling index of gum.

Effect of Drying Temperature

It was observed that granule drying temperature had no direct effect on swelling index of tablets. Batches C_1, C_4, and C_7 dried at different temperatures, granulated with 50 % water and compressed with 5 Kgf had swelling indices of 175, 175 and 150 % respectively, though with different hardness values. The other data on Table 2 indicates that granule drying temperature had minimal effect on swelling index of gum.

Effect of Compression Pressure

There was a general reduction of swelling with increasing compression pressure. For batches A_1 A_2 A_3, and B_1 B_2 B_3; this was the trend (Table 2).

Effect of Swelling Index on Drug Release

The results of dissolution studies indicated increase in drug release with increase SI (Table 3). The selected batches (Plates1-6) released the incorporated sodium bicarbonate at different rates. Those with higher swelling indices released faster than those with lower values.

DISCUSSION

The results of effect of binder volume on swelling capacity revealed swelling with low binder volume. This could be attributed to low bonding between the gum and other excipients of tablet as indicated from the low hardness of tablets from the crushing strength values. As the volume of binder increased, more bond formation occurred between particles resulting in harder tablets with lower porosities, giving rise to less space for penetration of water and swelling. Swelling indices were in the order 20 % > 30 % > 50% of binder volume. Tablets are generally required to have adequate mechanical strength to withstand handling and other hazards; hence 50 % binder volume could be used for granulation with compression pressure not exceeding 6 MT (Table 2).

The granule drying temperature did not directly affect swelling but directly affected hardness. Harder tablets were obtained when granules were dried at higher temperatures (Table 2). This may have been due to formation of more solid bridges as water is removed from the matrix.

With increasing compression pressure, a general reduction in swelling was obtained. This is attributable to the closer packing of particles into a compact mass with lower porosities. Reduced porosity limited the swelling of tablets as evidenced by the shorter times taken to attain maximum swelling (Table 2 and Plates 1-6). It then meant that incorporated drug will have to gradually diffuse out of the system.

Tablets from selected batches A_4, A_6, B_6, C_3, C_4, C_7 and C_9 were subjected to dissolution testing. Tablets from batches A_4 and A_6 completely released the incorporated sodium bicarbonate within one hour dissolution time (Table 3). The drug is water soluble and hence was easily dissolved from the loosely bound matrix. Batches with lower swelling indices had lower dissolution rates. This could be due lower penetration by water which was the dissolution medium.

CONCLUSION

This study has revealed that processing variables do affect the swelling capacity of khaya gum and subsequently drug release profile; so it is imperative that the pharmaceutical formulator should carefully select optimal formulation methodology in order to achieve desired release and therapeutic objective.

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