Startab®
Directly Compressible Starch

Colorcon®

Compression Profiles of a Directly Compressible Starch using Compaction Simulation and High-Speed Tablet Press

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Introduction

Starch-based excipients are frequently used in solid oral formulations for their effective binder, filler and disintegrant properties. Inert and stable, with low water activity, maize starches are often the preferred choice for moisture management in solid oral dosage forms. A variety of starch-based excipients are available to formulators, some of which have been modified to enhance properties such as improved binder capability and moisture management. StarTab®, Directly Compressible Starch, has been developed to simplify formulation and processing.

StarTab exhibits superior powder flow and compressibility compared to native starch or other modified starches, while having all the properties of a typical starch-based excipient. The purpose of this study was to evaluate the powder flow properties of StarTab as well as its compressibility compared to native corn starch using flow measurement methods, compaction simulation and high-speed rotary tablet press, respectively.

Methods

StarTab and native corn starch were evaluated for their powder flow characteristics using bulk and tapped density (Tap Density Tester, Varian), minimum orifice diameter and powder flow (Flodex, Hansen), surface morphology via scanning electron microscopy (SEM) (Phenom XL, Phenom World) and particle size distribution (Mastersizer 2000 Particle Size Analyzer, Malvern Instruments). Both materials were lubricated with 0.25% magnesium stearate and subjected to compaction evaluation using STYLCAM 100R rotary press simulator (Medelpharm); the equipment was fitted with 7 mm flat-faced tooling with an individual target tablet weight of 150 mg. The compression cycle followed a generic rotary press profile that corresponded to 7.5-30 mS dwell time. Measurements of punch displacement, compaction force (from which compaction pressure was calculated) and ejection force were determined using the ANALIS software. True powder density was determined using Helium pycnometer (AccuPyc, Micromeritics). Tensile strength, solid fraction and strain rate sensitivity were calculated using equations 1-3, respectively (**Table 1**).[1] The calculated values were used to generate compressibility, compactibility and tabletability profiles (**Figure 1**). Placebo tablets (400 mg target weight) of lubricated StarTab were compressed on a lab scale single-rotary tablet press (4-station, Piccola B/D 370 press, SMI) and a production scale single-rotary tablet press (25-station, Manesty TPR 200, Bosch). Powder paddle feeder was used on both rotary tablet presses. Tablet press parameters are listed in **Table 2**. Tablets were evaluated for their physical properties and disintegration time.

Table 1. Equations

1	$$Tensile\ Strength\ (\sigma) = \frac{2F}{\pi D H}$$
2	$$Solid\ Fraction\ (SF) = \frac{W}{\rho . V}$$
3	$$Strain\ Rate\ Sensitivity\ (\%) = \frac{Py1 - Py2}{Py2}\ x\ 100$$

F, D, H, W and V are tablet hardness, diameter, thickness, weight and volume respectively; ρ is true density; Py1 is yield pressure at low dwell time and Py2 is yield pressure at high dwell time, which were calculated from slope of Heckel plot [2]

Figure 1. Compaction Terminology Based on Tye et al. 2005[1]

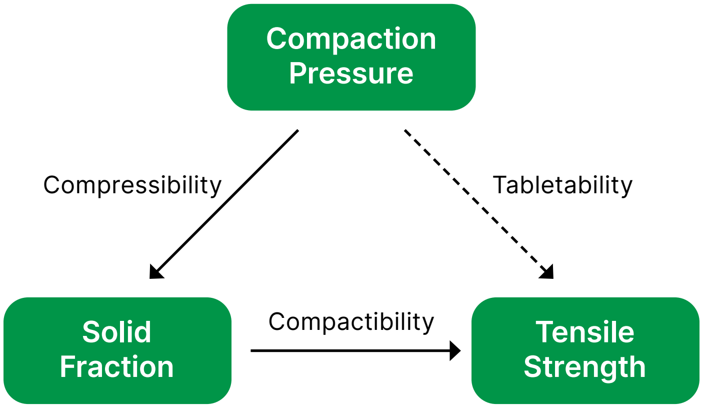


Figure 2. SEM Images at 900X Magnification of (A) Native Corn Starch and (B) StarTab

(A) **(B)**

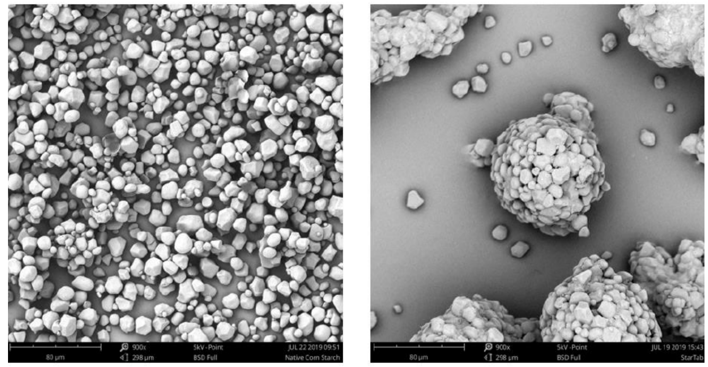


Table 2. Rotary Tablet Press Parameters

	Piccola	Manesty TPR 200	
Dwell time (mS)	24	18	7**
Tooling type/ size	B-tooling 10 mm round FF*	B-tooling 10.5 mm round SC^	B-tooling 10.5 mm round SC^
Press speed (rpm)	50	40	92
Tablet per minute (TPM)	200	1000	2300
Tablet per hour (TPH)	12,000	60,000	138,000

* FF = flat-faced; ^ SC = standard concave; **without or with 2 kN pre-compression force

Table 3. Powder Flow Properties

Powder Flow Testing	StarTab	Native Corn Starch
Bulk Density (g/mL)	0.57	0.51
Tapped Density (g/mL)	0.70	0.84
Hausner Ratio	1.22	1.64
Compressibility Index (%)	18.00	40.00
Flodex minimum orifice diameter (mm)	4	30
Flow rate from 4mm (g/min)	37.58	Did not flow
Particle size, d10 (µm)	36.90	9.49
Particle size, d50 (µm)	89.77	14.01
Particle size, d90 (µm)	171.37	20.59
Particle size, d4,3 (µm)	97.74	14.62

Results

Figure 2 compares the particle morphology of StarTab to native corn starch. StarTab particles have an optimized morphology, almost spherical in shape, which attributes to the excellent flow properties of the material. When compared to native corn starch, StarTab exhibited exceptional powder flow, demonstrated by compressibility index and Hausner ratio (**Table 3**).[3] Flodex minimum orifice diameter testing, exhibited StarTab powder flow through the 4mm diameter (smallest orifice available), indicating good flow and a uniform tablet die fill during the tableting process.[4] StarTab also has a mean particle size (d50) of approximately 90 µm, similar to most directly compressible excipients.

When subjected to compaction simulation at different dwell times, StarTab formed compacts with greater than 0.8 (80%) solid fraction. It also had superior tabletability and compactability in comparison to native corn starch. StarTab compacts were robust, with tensile strengths above 2 MPa (Figure 3). At all compaction pressures, high compactability was demonstrated with increasing compaction pressure. The Heckel plot[2] shows that StarTab primarily undergoes plastic deformation (Figure 4). Strain rate sensitivity was low for StarTab, with a calculated value of 3.4% (Table 4).

Figure 3. (A) Compressibility, (B) Compactability and (C) Tabletability Plots for StarTab

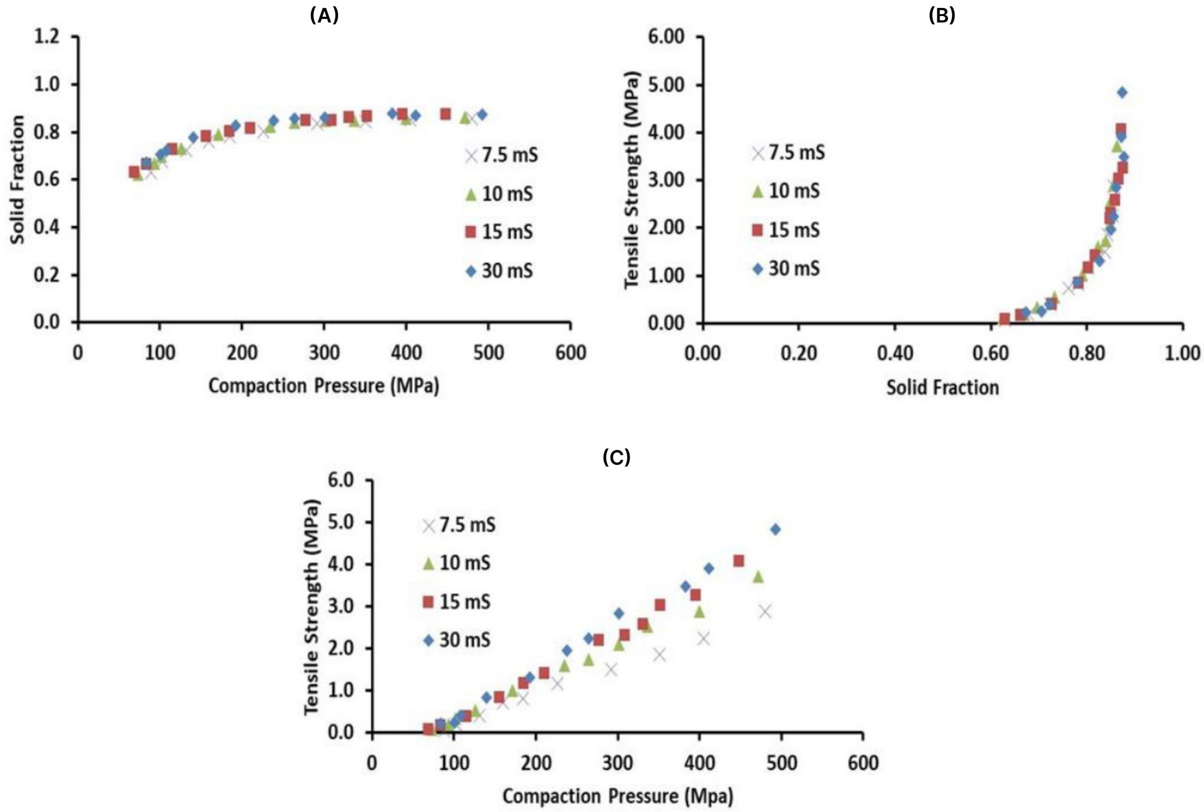
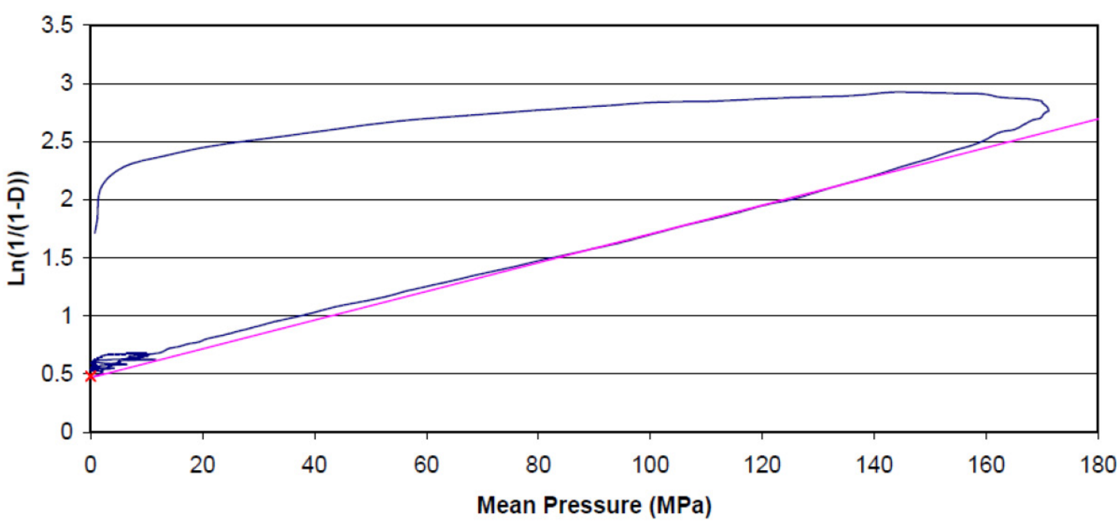


Figure 4. Heckel Plot of StarTab Compacts Compressed at Increasing Compaction Pressure, at a Dwell Time of 10 mS



Key: D = relative density

Table 4. Strain Rate Sensitivity (SRS) of StarTab and Native Corn Starch Blends

Material	Py1*	Py2**	%SRS
Startab	81.3	84.2	3.4
Native Corn Starch	58.7	61.2	4.1

** Py1 = yield pressure at 10 mS dwell time*
***Py2 = yield pressure at 30 mS dwell time*

StarTab or native corn starch, lubricated with 0.25% magnesium stearate, were subjected to rotary tablet compression using powder paddle feeder. Native corn starch could not be compressed due to its poor flow and severe rat-holing. Thus, no data could be generated for this material. Conversely, StarTab demonstrated excellent flow and compressibility on rotary tablet press at different dwell times, with uniform die fill, characterized by low variation in thickness (data not shown), weight and tensile strength of tablets (Figures 5A and 5B). StarTab tablets had low ejection force (between 200 - 400N), low friability of <1 % (Figure 5C) and fast disintegration time in water of < 3 minutes (Figure 5D) at all compression forces. To avoid issues such as tablet capping and lamination, during high speed tableting, formulators often use pre-compression station set at up to 2kN to allow powder deaeration in the die cavity prior to main compression. StarTab placebo tablets were compressed at a very low dwell time (7 mS) with pre-compression force of 0-2 kN followed by main compression force of 10-30 kN on Manesty TPR-200 single-rotary tablet press. Similar tablet compression profiles were obtained, indicating versatility of StarTab and confirming high air permeability and low cohesivity of this excipient. StarTab tablets were free of any tablet defects such as picking, sticking, capping or lamination and showed pH-independent disintegration in various buffer media (**Figure 6**).

Figure 5. Effect of Dwell Time and Compression Force on (A) Weight, (B) Hardness, (C) Friability and (D) Disintegration Time of StarTab Placebo Tablets

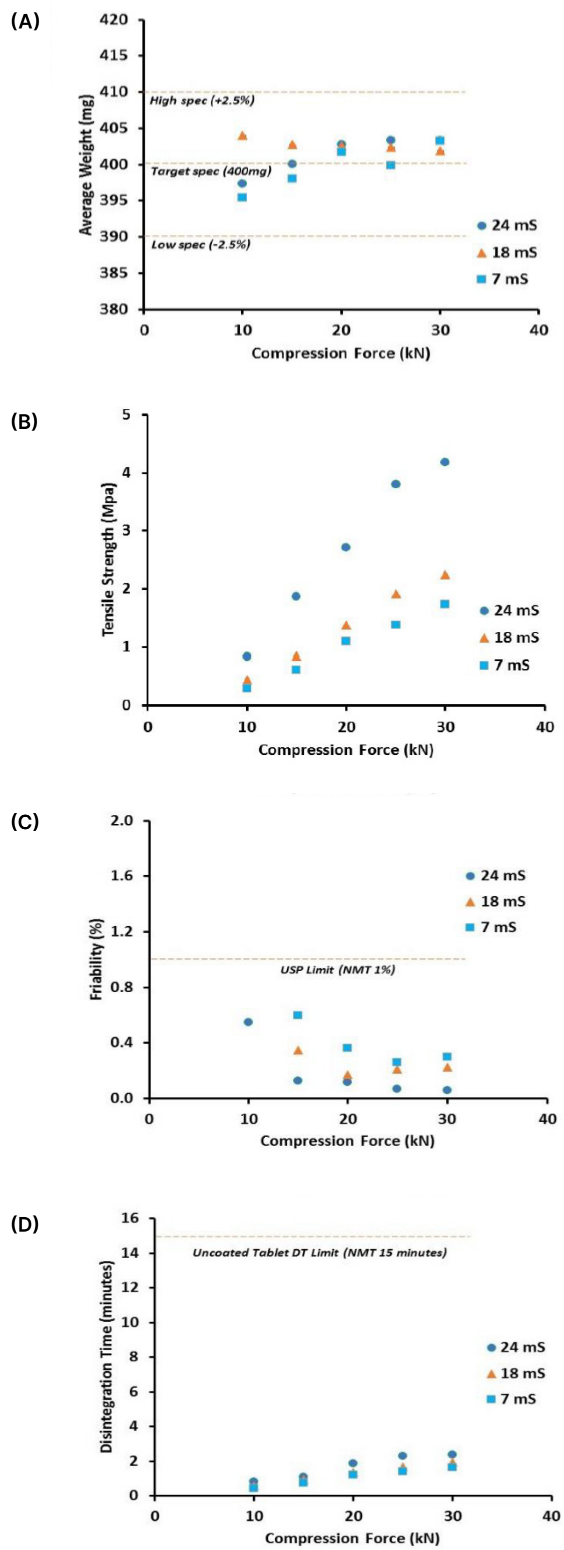
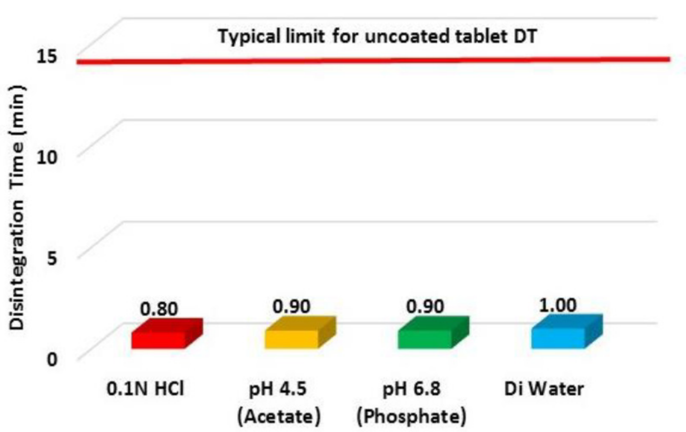


Figure 6. pH Independent Disintegration of StarTab Placebo Tablets Compressed at 15kN Compression Force



Conclusions

StarTab, Directly Compressible Starch, demonstrated excellent powder flow and compression properties on both the compaction simulator and high-speed tablet press compared to native corn starch. This product provides tablets with robust tablet strength and fast pH-independent disintegration times. This new excipient, designed through particle optimization, is particularly applicable for high-speed tablet compression.

References

1. Tye, C., Sun, C. and Amidon, G. 2005. Evaluation of the effects of tableting speed on the relationships between compaction pressure, tablet tensile strength, and tablet solid fraction. JPS, 94(3), pg. 465-474.
2. Heckel, R. 1961. Density-pressure relationships in powder compaction. Transactions of the Metallurgical Society of AIME, vol 224, pg. 671-675.
3. USP 42 General chapter <1174> Powder flow.
4. Gioia, A. 1980. Intrinsic flowability: a new technology for powder-flowability classification. Pharmaceutical Tech.

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