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OPTIMIZATION OF THE COMBINATION OF CANNA TUBERS (*Canna indica* L.) – AVICEL PH 101 AS A DILUENT FOR DIRECT COMPRESSION IBUPROFEN TABLETS

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ABSTRACT

Background: Canna tuber *(Canna Indica L.)* is a plant that contains large amounts of carbohydrates, so it can be used as a starch producer. Canna starch is starch extracted from canna tubers can be used to diluent. **Objective:** to determine the effect of the combination of green canna tuber starch with Avicel Ph 101 as a filler for ibuprofen tablets on the physical form of tablets and to determine the optimum formulation of the combination of canna tuber starch. with avicel PH 101. **Method:** This study is an experimental research using a descriptive method. The samples in this study were formulations combining canna tuber starch and Avicel PH 101 as fillers in directly compressed ibuprofen tablets, using the Simplex Lattice Design (SLD) method. **Results:** The physical quality test of the tablets from the 5 formulas met the requirements for the uniformity test of tablet weight, tablet size uniformity test formulas, tablet hardness test, friability test, and the dissolution test of the 5 formulas meets the requirements within 60 minutes of dissolving not less than 85% of the amount indicated on the label. **Conclusions**: The formulation of Ibuprofen tablets with Avicel PH 101 as a filler combined with canna tuber starch can affect the physical quality. The optimum formula for ibuprofen tablets combined with canna tuber starch and Avicel PH 101 is the proportion of canna tuber starch as much as 50,000 mg and Avicel PH 101 as much as 50,000 mg, with a desirabilty value of 1,000

ABSTRAK

Latar belakang: Umbi ganyong *(Canna Indica L.)* merupakan salah satu tanaman yang mengandung karbohidrat dalam jumlah banyak, sehingga dapat digunakan sebagai penghasil pati. Pati ganyong merupakan pati yang diekstrak dari umbi ganyong yang dapat digunakan sebagai pengisi. **Tujuan penelitian :** untuk mengetahui pengaruh kombinasi pati umbi ganyong hijau dengan avicel Ph 101 sebagai bahan pengisi tablet ibuprofen terhadap bentuk fisik tablet dan mengetahui formulasi optimum dari kombinasi pati umbi ganyong dengan avicel PH 101. **Metode Penelitian :** Penelitian ini merupakan penelitian eksperimental dengan menggunakan metode deskriptif. Sampel pada penelitian ini adalah formula kombinasi pati

umbi ganyong Avicel PH 101 sebgai bahan pengisi tablet Ibuprofen cetak langsung dengan menggunakan metode *Simplex Lattice Design* (SLD). **Hasil Penelitian :** Uji mutu fisik tablet dari ke 5 formula Complies persyaratan uji keseragaman bobot, uji keseragaman ukuran, uji kekerasan tablet, uji kerapuhan, uji waktu hancur tablet, dan uji disolusi dari ke 5 formula Complies persyaratan dalam waktu 60 menit larut tidak kurang dari 85% dari jumlah yang tertera pada etiket. **Kesimpulan** : Berdasarkan hasil penelitian menunjukkan formulasi tablet Ibuprofen dengan bahan pengisi kombinasi Avicel PH 101 dengan pati umbi ganyong dapat mempengaruhi mutu fisik. Serta diperoleh formula optimum untuk tablet ibuprofen kombinasi pati umbi ganyong dengan avicel PH 101 yaitu proporsi pati umbi ganyong sebanyak 50,000mg dan avicel PH 101 sebanyak 50,000mg, dengan nilai desirabilty 1,000.

INTRODUCTION

Indonesia is an agrarian country, where the majority of the population earns their livelihood from farming. The country has great potential for developing tropical fruits, horticultural crops, vegetables, and food crops as components of medicinal raw materials with strong potential for commercial development (Astutik et al., 2023). In pharmaceutical technology, the manufacture of tablet dosage forms requires not only active pharmaceutical ingredients but also excipients such as fillers, binders, disintegrants, lubricants, and other substances depending on the formulation used (Hadisoewignyo and Fudholi, 2013).

Fillers are required to provide bulk (increase weight so that it is suitable for compression), improve the compressibility and flow properties of poorly compressible active ingredients, and enhance cohesion so that direct compression can be achieved. Fillers can be classified into categories: organic materials (carbohydrates and modified carbohydrates), inorganic materials (calcium phosphates and others), and co-processed diluents. The amount of filler required varies, typically ranging from 5–80% of the tablet weight (depending on the amount of active ingredient and the desired tablet weight). Fillers that can be used for direct compression are known as filler-binders. Filler-binders are excipients that not only act as fillers but also improve flowability and compatibility of the tablet mass. Therefore, filler-binders are commonly used in direct compression formulations (Hadisoewignyo and Fudholi, 2013).

Canna tubers (*Canna indica L.*) are plants that contain a high amount of carbohydrates, making them a potential source of starch. Canna starch is obtained from the extraction of canna tubers. It contains 18.9% amylose and 81.1% amylopectin (Richana and Sunarti, 2004). In its native form, canna tuber starch has limitations such as low heat stability, limited solubility, and high viscosity, which restrict its applications (Gabriel et al., 2021).

The Simplex Lattice Design (SLD) method is used to determine the most optimal formulation from two or more mixtures. The purpose of the SLD method is to

identify the appropriate concentration of components, minimize trial-and-error in formulation, and produce a practical and efficient formulation with optimal physical properties and acceptable responses for consumers (Primadana et al., 2018).

METHOD

This study was conducted at the Laboratory of the Institut Ilmu KesehatanBhakti Wiyata, Kediri, East Java. It is an experimental study using a descriptive method. The samples in this study were formulations combining canna tuber starch and Avicel PH 101 as fillers in directly compressed ibuprofen tablets, using the Simplex Lattice Design (SLD) method.

Equipment

The equipment used in this practical work included a digital balance "Mettler Toledo", parchment paper, oven (Yenaco), mortar and pestle, porcelain dish, beaker glass, measuring cylinder, spatula, horn spoon, stirring rod, funnel, caliper, hardness tester (Biostellar), friabilator (CS-II), disintegration tester (Guoming), and dissolution tester (Biobase).

Materials

The materials used were canna tuber starch (*Canna indica L.*), Avicel PH 101, Primojel®, ibuprofen, and magnesium stearate.

Determination of Canna Tuber (*Canna indica* L.)

The canna tuber (*Canna indica* L.) used in this study was first subjected to determination. The purpose of this determination was to ensure the correct identification of the plant as the research object.

Preparation of Canna Tuber Starch (*Canna indica L.*)

Canna tuber samples (*Canna indica L.*) were randomly obtained from farmers in Pacitan Regency. A total of 5 kg of canna tubers were peeled, washed thoroughly under running water, and then dried under sunlight. After drying, the tubers were grated until a slurry-like consistency was obtained. The grated material was then squeezed using muslin cloth until no more liquid could be extracted. The remaining residue in the cloth was washed again with water and re-squeezed. This process was repeated until the extracted liquid became clear. The filtrate obtained was allowed to settle in a container for 24 hours. After complete sedimentation, the clear supernatant was decanted to obtain canna starch sediment. The starch sediment was then washed again with water until a clean, white starch precipitate was obtained. The starch was subsequently dried in a drying cabinet at 50°C for 24 hours. After drying, the starch was sieved using a No. 20 mesh sieve with three repetitions (Fuertes et al., 2024).

Formulation

Table 1 Formulation Ibuprofen Tablet

Ingredients	Function	F1 (mg)	F2 (mg)	F3 (mg)	F4 (mg)	F5 (mg)
Ibuprofen	Active Ingredients	400	400	400	400	400
Primojel®	Disintegrant	30	30	30	30	30
Magnesium strearat 2 %	Lubricant	12	12	12	12	12
Combination Avicel PH 101 & canna tuber starch	Diluent	ad 600	ad 600	ad 600	ad 600	ad 600

Table 2 Compotition of Combination Avicel PH 101 & canna tuber starch

Ingredients	Compotition				
	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)
Avicel PH 101	100	0	75	25	50
Canna tuber starch	0	100	25	75	50
Total	100	100	100	100	100

Preparation of the Combination

The formulation was determined using the Simplex Lattice Design method by varying the concentrations of canna tuber starch and Avicel PH 101. The combinations were prepared by weighing Avicel according to the predetermined ratios based on the Simplex Lattice Design using Design Expert software (Table 2). The components were then placed in a mortar, ground, and homogenized. A paste of canna tuber starch at 8% concentration, previously weighed, was added gradually until a compressible mass was formed. The resulting mass was sieved through a No. 45 sieve and then dried in an oven at 60°C for 3 hours. The dried canna tuber starch–Avicel PH 101 combination was sieved again using a No. 40 sieve.

Preparation of Ibuprofen Tablets

The canna tuber starch–Avicel PH 101 combination, used as a direct compression filler, was prepared in specific ratios (Table 1). All ingredients were accurately weighed using an analytical balance according to the formula. Ibuprofen, Primojel, and the Avicel PH 101–canna tuber starch combination were mixed in a mortar until homogeneous. Magnesium stearate was then added and mixed thoroughly. The final blend was compressed into tablets using a tablet compression machine.

Evaluation of Direct Compression Ibuprofen Tablets

The evaluation of ibuprofen tablets prepared by direct compression included tests for weight uniformity, hardness, friability, disintegration time, and dissolution.

RESULT

Determination of Turmeric Plant

The plant determination was conducted at the Institut Ilmu KesehatanBhakti Wiyata Kediri. The results of the determination showed that the canna tuber plant could be used in this study. The determination results, as presented in the appendix, confirm that the plant used in this research is canna tuber (*Canna indica* L.).

Results of the Evaluation of Canna Tuber Starch (*Canna indica* L.)

a. Flow Property Test

The flow property test result was 5.30 seconds. This result indicates that canna tuber starch exhibits good flow properties, as starch with a high amylose content has stronger hydrogen bonding due to the large number of linear chains in its granules (Feng et al., 2026).

b. Compressibility Test

The compressibility test result was 10%. Based on this result, canna tuber starch meets the required standard, as a good powder should have a compressibility index of ≤ 20%. A compressibility value that meets the requirement indicates that the powder has good packing ability, as higher tapping index values correspond to greater powder densification (U.S. Pharmacopeia, 2021).

Organoleptic Results of Canna Tuber Starch (*Canna indica* L.)

Table 3 Results of Canna Tuber Starch (*Canna indica* L.)

Characteristic	Starch
Form	Fine powder
Color	Grayish white
Odor	Characteristic odor

Results of Tablet Weight Uniformity Test

Table 4 Results of Weight Uniformity Test for Formula 1

No	Weight (mg)	A	B	Remarks
1.	635	√	√	Complies
2.	612	√	√	Complies
3.	604	√	√	Complies
4.	607	√	√	Complies
5.	625	√	√	Complies
6.	608	√	√	Complies
7.	625	√	√	Complies
8.	634	√	√	Complies
9.	624	√	√	Complies
10.	632	√	√	Complies
11.	600	√	√	Complies
12.	611	√	√	Complies
13.	618	√	√	Complies
14.	617	√	√	Complies
15.	601	√	√	Complies

No	Weight (mg)	A	B	Remarks
16.	618	√	√	Complies
17.	626	√	√	Complies
18.	606	√	√	Complies
19.	618	√	√	Complies
20.	618	√	√	Complies

Table 5 Results of Weight Uniformity Test for Formula 2

No	Weight (mg)	A	B	Remarks
1.	611	√	√	Complies
2.	620	√	√	Complies
3.	610	√	√	Complies
4.	624	√	√	Complies
5.	617	√	√	Complies
6.	607	√	√	Complies
7.	622	√	√	Complies
8.	625	√	√	Complies
9.	627	√	√	Complies
10.	627	√	√	Complies
11.	625	√	√	Complies
12.	624	√	√	Complies
13.	600	√	√	Complies
14.	601	√	√	Complies
15.	606	√	√	Complies
16.	604	√	√	Complies
17.	615	√	√	Complies
18.	603	√	√	Complies
19.	603	√	√	Complies
20.	623	√	√	Complies

Table 6 Results of Weight Uniformity Test for Formula 3

No	Weight (mg)	A	B	Remarks
1.	621	√	√	Complies
2.	604	√	√	Complies
3.	604	√	√	Complies
4.	633	√	√	Complies
5.	637	√	√	Complies
6.	607	√	√	Complies
7.	630	√	√	Complies
8.	603	√	√	Complies
9.	609	√	√	Complies
10.	627	√	√	Complies
11.	625	√	√	Complies
12.	628	√	√	Complies
13.	605	√	√	Complies
14.	623	√	√	Complies
15.	619	√	√	Complies
16.	621	√	√	Complies
17.	622	√	√	Complies
18.	632	√	√	Complies

No	Weight (mg)	A	B	Remarks
19.	612	√	√	Complies
20.	615	√	√	Complies

Table 7 Results of Weight Uniformity Test for Formula 4

No	Weight (mg)	A	B	Remarks
1.	605	√	√	Complies
2.	608	√	√	Complies
3.	623	√	√	Complies
4.	618	√	√	Complies
5.	628	√	√	Complies
6.	620	√	√	Complies
7.	618	√	√	Complies
8.	620	√	√	Complies
9.	617	√	√	Complies
10.	619	√	√	Complies
11.	620	√	√	Complies
12.	631	√	√	Complies
13.	624	√	√	Complies
14.	619	√	√	Complies
15.	605	√	√	Complies
16.	605	√	√	Complies
17.	638	√	√	Complies
18.	619	√	√	Complies
19.	623	√	√	Complies
20.	626	√	√	Complies

Table 8 Results of Weight Uniformity Test for Formula 5

No	Weight (mg)	A	B	Remarks
1.	615	√	√	Complies
2.	624	√	√	Complies
3.	622	√	√	Complies
4.	613	√	√	Complies
5.	605	√	√	Complies
6.	627	√	√	Complies
7.	604	√	√	Complies
8.	609	√	√	Complies
9.	616	√	√	Complies
10.	627	√	√	Complies
11.	615	√	√	Complies
12.	622	√	√	Complies
13.	622	√	√	Complies
14.	603	√	√	Complies
15.	620	√	√	Complies
16.	621	√	√	Complies
17.	616	√	√	Complies
18.	622	√	√	Complies
19.	611	√	√	Complies
20.	619	√	√	Complies

Results of Tablet Size Uniformity Test

Table 9 Results of Size Uniformity Test for Formula 1

No	Thickness (cm)	Diameter (cm)	Average Thickness (cm)	1⅓ × Average Thickness (cm)	3 × Average Thickness (cm)	Remarks
1.	0,6	1,212	0,399	0,838	1,611	Complies
2.	0,6	1,212	0,399	0,838	1,611	Complies
3.	0,6	1,212	0,399	0,838	1,611	Complies
4.	0,6	1,212	0,399	0,838	1,611	Complies
5.	0,6	1,212	0,399	0,838	1,611	Complies
6.	0,6	1,212	0,399	0,838	1,611	Complies
7.	0,6	1,212	0,399	0,838	1,611	Complies
8.	0,6	1,212	0,399	0,838	1,611	Complies
9.	0,6	1,212	0,399	0,838	1,611	Complies
10.	0,6	1,212	0,399	0,838	1,611	Complies

Table 10 Results of Size Uniformity Test for Formula 2

No	Thickness (cm)	Diameter (cm)	Average Thickness (cm)	1⅓ × Average Thickness (cm)	3 × Average Thickness (cm)	Remarks
1.	0,6	1,212	0,399	0,838	1,611	Complies
2.	0,6	1,212	0,399	0,838	1,611	Complies
3.	0,6	1,212	0,399	0,838	1,611	Complies
4.	0,6	1,212	0,399	0,838	1,611	Complies
5.	0,6	1,212	0,399	0,838	1,611	Complies
6.	0,6	1,212	0,399	0,838	1,611	Complies
7.	0,6	1,212	0,399	0,838	1,611	Complies
8.	0,6	1,212	0,399	0,838	1,611	Complies
9.	0,6	1,212	0,399	0,838	1,611	Complies
10.	0,6	1,212	0,399	0,838	1,611	Complies

Table 11 Results of Size Uniformity Test for Formula 3

No	Thickness (cm)	Diameter (cm)	Average Thickness (cm)	1⅓ × Average Thickness (cm)	3 × Average Thickness (cm)	Remarks
1.	0,6	1,212	0,399	0,838	1,611	Complies
2.	0,6	1,212	0,399	0,838	1,611	Complies
3.	0,6	1,212	0,399	0,838	1,611	Complies
4.	0,6	1,212	0,399	0,838	1,611	Complies
5.	0,6	1,212	0,399	0,838	1,611	Complies
6.	0,6	1,212	0,399	0,838	1,611	Complies
7.	0,6	1,212	0,399	0,838	1,611	Complies
8.	0,6	1,212	0,399	0,838	1,611	Complies
9.	0,6	1,212	0,399	0,838	1,611	Complies
10.	0,6	1,212	0,399	0,838	1,611	Complies

Table 12 Results of Size Uniformity Test for Formula 4

No	Thickness (cm)	Diameter (cm)	Average Thickness (cm)	1⅓ × Average Thickness (cm)	3 × Average Thickness (cm)	Remarks
1.	0,5	1,249	2,472	0,594	3,721	Complies
2.	0,5	1,249	2,472	0,594	3,721	Complies
3.	0,5	1,249	2,472	0,594	3,721	Complies
4.	0,5	1,249	2,472	0,594	3,721	Complies
5.	0,5	1,249	2,472	0,594	3,721	Complies
6.	0,5	1,249	2,472	0,594	3,721	Complies
7.	0,6	1,249	2,472	0,594	3,721	Complies
8.	0,6	1,249	2,472	0,594	3,721	Complies
9.	0,6	1,249	2,472	0,594	3,721	Complies
10.	0,6	1,249	2,472	0,594	3,721	Complies

Table 13 Results of Size Uniformity Test for Formula 5

No	Thickness (cm)	Diameter (cm)	Average Thickness (cm)	1⅓ × Average Thickness (cm)	3 × Average Thickness (cm)	Remarks
1.	0,6	1,212	0,399	0,838	1,611	Complies
2.	0,6	1,212	0,399	0,838	1,611	Complies
3.	0,6	1,212	0,399	0,838	1,611	Complies
4.	0,6	1,212	0,399	0,838	1,611	Complies
5.	0,6	1,212	0,399	0,838	1,611	Complies
6.	0,6	1,212	0,399	0,838	1,611	Complies
7.	0,6	1,212	0,399	0,838	1,611	Complies
8.	0,6	1,212	0,399	0,838	1,611	Complies
9.	0,6	1,212	0,399	0,838	1,611	Complies
10.	0,6	1,212	0,399	0,838	1,611	Complies

Results of Tablet Hardness Test

Table 14 Results of Tablet Hardness Test

Formula	Average Result (kg)	Remarks
1	7,78 ± 1,250312	Complies
2	6,63 ± 2,566314	Complies
3	4,94 ± 0,230911	Complies
4	4,72 ± 0,12341	Complies
5	7,10 ± 3,873362	Complies

Results of Tablet Friability Test

Table 15 Results of Tablet Friability Test

Formula	Average weight before testing (g)	Average weight before testing (g)	% Friability Test (<1%)	Remarks
1	12,387	12,288	0,799 ± 6,6619	Complies
2	12,521	12,421	0,798± 6,7395	Complies
3	12,522	12,418	0,830± 6,7205	Complies
4	12,364	12,262	0,824± 6,6333	Complies
5	12,546	12,428	0,940± 6,6669	Complies

Results of Tablet Disintegration Test

Table 16 Results of Tablet Disintegration Test

Formula	Average Tablet Disintegration Test (minute) (< 15 minutes)	Remarks
1	2,5 ± 0	Complies
2	2,9 ± 0	Complies
3	6,1 ± 0	Complies
4	4,2 ± 0	Complies
5	2,6 ± 0	Complies

Results of Tablet Dissolution Test

Table 17 Results of Tablet Dissolution Test Formula 1

	%					
Time (minute)	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
5	50,36	34,76	60,54	52,51	46,74	59,52
10	51,66	35,06	72,27	58,51	54,69	69,34
15	62,68	49,16	72,67	64,99	64,72	81,26
30	87,45	75,10	89,38	81,20	87,91	84,47
45	91,10	90,44	94,28	92,26	95,06	90,44
60	95,33	93,95	94,23	93,44	96,15	91,55

Table 18 Results of Tablet Dissolution Test Formula 2

	%					
Time (minute)	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
5	84,96	87,90	81,79	77,38	80,32	87,56
10	96,96	99,13	94,00	91,38	90,83	94,04
15	97,50	94,02	93,96	92,68	94,61	95,80
30	99,96	102,90	99,79	98,61	101,80	102,88
45	98,92	100,64	95,70	98,47	98,85	102,88
60	99,34	101,21	95,09	97,09	99,84	101,18

Table 19 Results of Tablet Dissolution Test Formula 3

	%					
Time (minute)	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
5	37,13	43,01	47,53	58,50	57,93	57,26
10	70,24	79,54	64,30	79,40	73,07	76,00
15	79,67	82,70	72,91	86,40	79,46	81,29
30	87,12	91,86	85,03	94,90	96,63	90,21
45	95,06	96,55	89,38	98,59	99,54	94,44
60	96,49	98,96	96,66	97,54	95,56	93,26

Table 20 Results of Tablet Dissolution Test Formula 4

%						
Time (minute)	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**
5	94,91	59,06	80,29	36,00	57,93	77,38
10	95,43	88,34	94,23	83,60	69,79	86,97
15	96,30	99,34	98,48	92,05	85,44	91,63
30	96,94	99,32	96,31	94,37	88,51	94,96
45	96,34	98,85	97,40	95,56	90,90	94,24
60	96,30	106,76	97,25	96,54	91,64	93,74

Table 21 Results of Tablet Dissolution Test Formula 5

%						
Time (minute)	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**
5	49,19	75,57	39,12	33,74	69,35	76,82
10	73,24	79,84	62,09	78,25	73,30	77,23
15	74,11	80,96	74,60	77,60	78,68	73,23
30	76,66	81,85	78,58	78,88	72,97	78,16
45	78,78	82,43	66,69	79,43	80,92	81,64
60	83,15	86,48	80,63	82,74	83,29	85,70

Results of Tablet Hardness Test Using Simplex Lattice Design

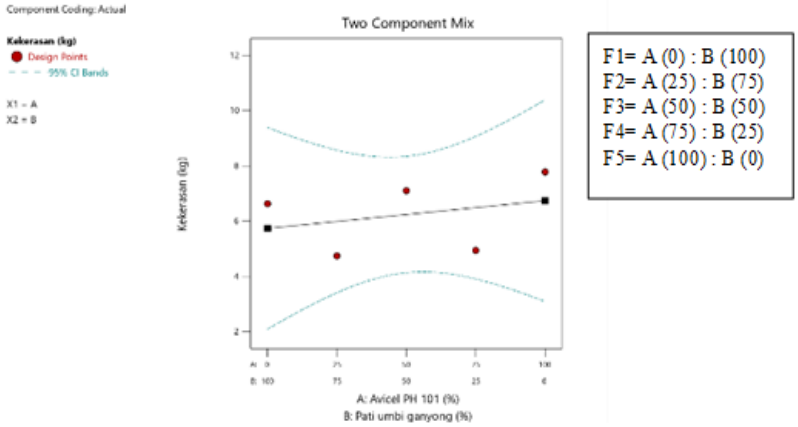

Figure 1 Optimization Results of the Tablet Hardness Test

Results of Tablet Friability Test Using Simplex Lattice Design

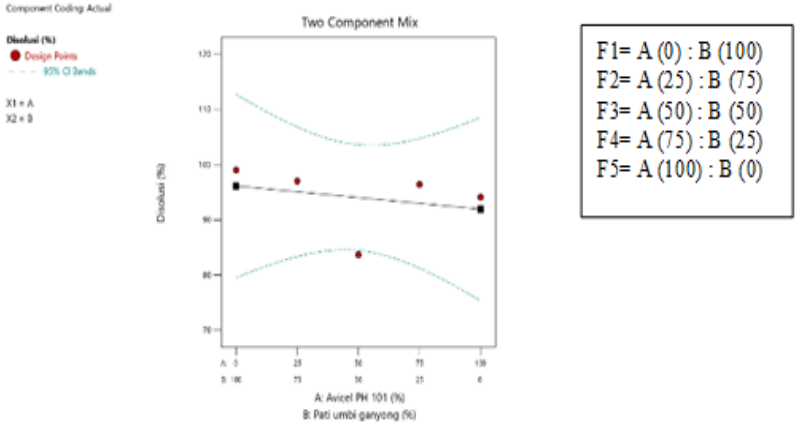

Figure 2 Optimization Results of the Tablet Friability Test

Results of Tablet Disintegration Test Using Simplex Lattice Design

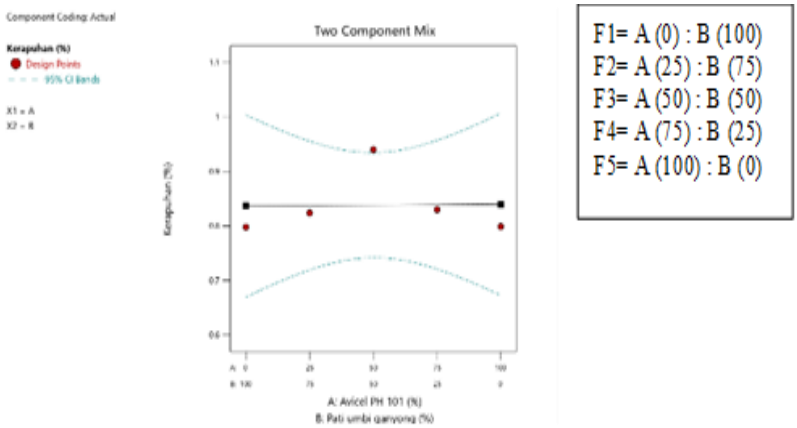

Figure 3 Optimization Results of the Tablet Disintegration Test

Results of Tablet Disolution Test Using Simplex Lattice Design

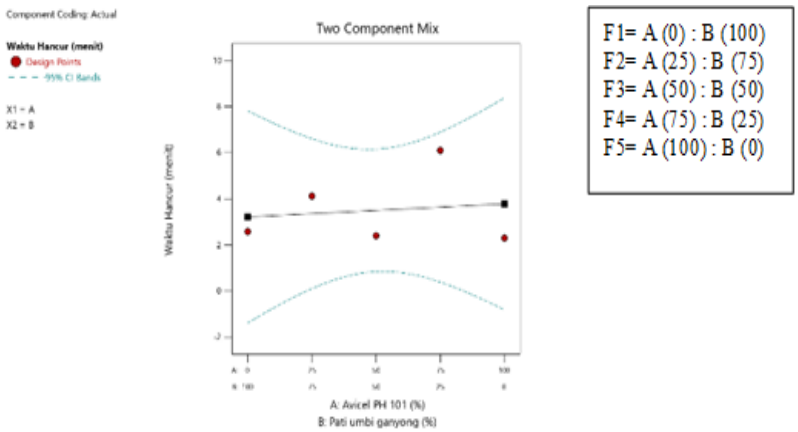

Figure 4 Optimization Results of the Tablet Disolutiontion Test

Results of Linear Equation Test Using Simplex Lattice Design

Table 22 Composition and Predicted Physical Properties of the Optimum Formula

Test Type	Linear Equation
Hardness	Y =7,78 (A) + 6,63 (B) -0,4(AB)
Friability	Y =0,799 (A) + 0,798 (B) + 0,604 (AB)
Disintegration	Y= 2,30 (A) + 2,58 (B) -0,16(AB)
Disolution	Y =94,10 (A) + 99,02 (B) -5,16(AB)

Optimum Formula Results Based on Simplex Lattice Design

Table 23 Composition and Predicted Physical Properties of the Optimum Formula

Avicel PH 101	Canna Starch	Hardness	Fragility	Disintegration Time	Dissolution	Desirability	
50,000	50,000	6,238	0,838	3,500	94,044	1,000	**Selected**

DISCUSSION

In the weight uniformity test, Formula 1 tablets (Table 4) had an average weight of 618 mg. Formula 2 tablets (Table 5) showed an average weight of 627 mg. Formula 3 tablets (Table 6) had an average weight of 625 mg. Formula 4 tablets (Table 7) had an average weight of 620 mg, while Formula 5 tablets (Table 8) showed an average weight of 622 mg. The results indicate that there were no deviations from the required specifications. Therefore, all five tablet formulations passed the weight uniformity test. The test results showed deviations of less than 5% for Table A and less than 10% for Table B, indicating that the tablets produced have good weight uniformity (DepKes RI, 2014).

The size uniformity test showed that Formula 1 tablets (Table 9) had an average diameter of 1.212 cm and an average thickness of 0.399 cm. Based on the calculation, Formula 1 met the size uniformity requirements, with the result $0.838 \leq 1.212 \geq 1.611$. Formula 2 tablets (Table 10) had an average diameter of 1.212 cm and an average thickness of 0.399 cm. The calculation results indicated that Formula 2 met the size uniformity requirements, with the result $0.838 \leq 1.212 \geq 1.611$. Formula 3 tablets (Table 11) had an average diameter of 1.212 cm and an average thickness of 0.399 cm. Based on the calculation, Formula 3 met the size uniformity requirements, with the result $0.838 \leq 1.212 \geq 1.611$. Formula 4 tablets (Table 12) had an average diameter of 1.249 cm and an average thickness of 2.472 cm. The calculation results showed that Formula 4 met the size uniformity requirements, with the result $0.594 \leq 1.249 \geq 3.721$. Formula 5 tablets (Table 13) had an average diameter of 1.212 cm and an average thickness of 0.399 cm. Based on the calculation, Formula 5 met the size uniformity requirements,

with the result 0.838 ≤ 1.212 ≥ 1.611. Overall, all tablet formulations met the requirements for size uniformity. According to the standard, tablets are considered to have good size uniformity if the diameter is not more than three times and not less than 1⅓ times the tablet thickness (DepKes RI, 1979).

The hardness test (Table 14) is a parameter that describes the tablet's resistance to mechanical shock and its tendency to crack during packaging, transportation, and distribution to consumers. Theoretically, the higher the concentration of the binder, the harder the resulting tablet. Formula 1 tablets had an average hardness of 7.78 kg. Formula 2 tablets showed an average hardness of 6.63 kg. Formula 3 tablets had an average hardness of 4.94 kg, while Formula 4 tablets had a hardness of 4.72 kg. Meanwhile, Formula 5 tablets exhibited an average hardness of 7.10 kg.

In Figure 1, the equation Y = 7.78 (A) + 6.63 (B) − 0.4 (AB) represents a linear equation generated using the simplex lattice design method recommended by Design-Expert 13 software. This equation indicates that the hardness response is influenced by Avicel PH 101 (A), canna tuber(B), and their interaction (AB). The negative coefficient of the interaction term suggests that the combination of Avicel PH 101 and canna tuberreduces tablet hardness. The physical quality test results of all five formulations met the tablet hardness requirement, which ranges from 4–8 kg (Lachman, 2008). One factor affecting tablet hardness is the presence of fines. A high amount of fines can make tablets more fragile because they consist of very fine particles, resulting in lower hardness (Hadisoewignyo & Fudholi, 2016). The ANOVA analysis of the hardness test showed no significant differences among the five formulations, with a p-value of 0.6305 (> 0.05). This indicates that the concentration of the combination of Avicel PH 101 and canna tuberdid not significantly affect tablet hardness (Wikantyasning & Indianie, 2021). The hardness test results were further evaluated using the Simplex Lattice Design approach to determine the effect of the component combination on the physical characteristics of the tablets, as shown in Figure V.1. The y-axis of the graph represents the hardness scale of the tablet formulations, while the x-axis represents the composition of the tablet formulation components.

The friability test (Table 15) was conducted to determine the tablet's resistance to abrasion and mechanical shock. Friability reflects a tablet's tendency to break into smaller particles when subjected to impact or friction during packaging and distribution. The average percentage of friability for Formula 1 tablets was 0.799%. Formula 2 tablets showed a friability of 0.798%. Formula 3 tablets had an average friability of 0.830%, while Formula 4 tablets had an average of 0.824%. Meanwhile, Formula 5 tablets exhibited an average friability of 0.940%.

As shown in Figure 2, all five tablet formulations met the friability requirement of not more than 1%. The equation Y = 0.799 (A) + 0.798 (B) + 0.604 (AB) represents a linear model generated using the simplex lattice design method recommended by Design-Expert 13 software. This equation indicates that the friability response is influenced by Avicel PH 101 (A), canna tuber(B), and their interaction (AB). The

positive coefficient of the interaction term suggests that the combination of Avicel PH 101 and canna tuberincreases tablet friability. This value reflects the influence on the physical quality of the tablets. It can be concluded that all tablet formulations passed the friability test (USP, 2021). The ANOVA analysis showed no significant differences among the five formulations, with a p-value of 0.9726 (> 0.05). This indicates that the concentration of the combination of Avicel PH 101 and canna tuber did not significantly affect tablet friability (Wikantyasning & Indianie, 2021). The friability test results were further evaluated using the Simplex Lattice Design approach to determine the effect of the component combination on the physical characteristics of the tablets, as shown in Figure 2. The y-axis of the graph represents the friability level of each formulation, while the x-axis represents the composition of the tablet formulation components.

The disintegration test (Table 16) showed that Formula 1 tablets disintegrated in 2 minutes 30 seconds 15 milliseconds. Formula 2 tablets had a disintegration time of 2 minutes 58 seconds 20 milliseconds. Formula 3 tablets disintegrated in 6 minutes 10 seconds 53 milliseconds, while Formula 4 tablets showed a disintegration time of 4 minutes 12 seconds 10 milliseconds. Meanwhile, Formula 5 tablets disintegrated in 2 minutes 40 seconds 10 milliseconds.

As shown in Figure 3, all five tablet formulations met the disintegration time requirement, which should not exceed 15 minutes. The equation Y = 2.30 (A) + 2.58 (B) − 0.16 (AB) represents a linear model generated using the simplex lattice design method recommended by Design-Expert 13 software. This equation indicates that the disintegration time response is influenced by Avicel PH 101 (A), canna tuber(B), and their interaction (AB). The negative coefficient of the interaction term suggests that the combination of Avicel PH 101 and canna tuberreduces the disintegration time of the tablets. Uncoated tablets are considered acceptable if their disintegration time is less than 15 minutes. A rapid and complete disintegration time is an important requirement for optimal drug availability (DepKes RI, 2014).

The ANOVA analysis of the disintegration test showed no significant differences among the five formulations, with a p-value of 0.8253 (> 0.05). This indicates that the concentration of the combination of Avicel PH 101 and canna tuberdid not significantly affect the disintegration time (Wikantyasning & Indianie, 2021). The disintegration test results were further evaluated using the Simplex Lattice Design approach to determine the effect of the component combination on the physical characteristics of the tablets, as shown in Figure 3. The y-axis of the graph represents the disintegration time of the tablet formulations, while the x-axis represents the composition of the tablet formulation components.

The dissolution test is an *in vitro* method used to determine the release of a drug from its dosage form into a dissolved state in the body. The longer the dissolution test duration, the greater the amount of active substance dissolved in the body fluids. Dissolution testing can be conducted in one, two, or three stages (S1, S2, and S3). Unless otherwise specified in individual monographs, the requirements are met if the

amount of active substance dissolved from the tested dosage form complies with the acceptance criteria table (Kemenkes RI, 2020).

The dissolution profile of ibuprofen tablets showed that each formulation exhibited a different rate of dissolution increase over time. Based on the results of the stage one (S1) dissolution test conducted on five formulations with different compositions, no unit at 60 minutes fell below the required dissolved amount (Q). Within 60 minutes, not less than 80% of $C_{13}H_{18}O_2$ of the labeled amount should be dissolved (Indonesian Ministry of Health, 2014). These results indicate that all ibuprofen tablet formulations met the dissolution requirements, as each unit produced dissolved drug levels above 80% + 5% = 85%. The obtained results for the five formulations were 94.10%, 99.02%, 96.41%, 97.03%, and 83.66%. In determining the dissolution profile, the maximum wavelength of ibuprofen in phosphate buffer solution at pH 7.2 showed a maximum absorption spectrum at 264 nm with concentrations of 120 ppm, 200 ppm, 280 ppm, 360 ppm, and 440 ppm, resulting in an absorbance of 0.458. The regression equation obtained was $y = -0.00045 + 0.00199x$ with a correlation coefficient (r) of 0.9994.

The relationship equation between the dissolution response of ibuprofen tablets and the combination of excipients (Avicel PH 101 and arrowroot starch) showed a negative value. The negative coefficient in the model indicates that the combination of Avicel PH 101 and canna tuberdecreases the dissolution response of the tablets. As shown in Figure V.4, the equation $Y = 94.10 (A) + 99.02 (B) - 5.16 (AB)$ represents a linear model generated using the simplex lattice design method recommended by Design-Expert 13 software. This equation indicates that the dissolution response is influenced by Avicel PH 101 (A), canna tuber(B), and their interaction (AB). The negative interaction term suggests that the combination reduces the dissolution rate.

All five formulations met the dissolution requirements, with not less than 85% of the labeled amount dissolved within 60 minutes (DepKes RI, 2014). The ANOVA analysis of the dissolution test showed no significant differences among the five formulations, with a p-value of 0.6571 (> 0.05). This indicates that the concentration of the combination of Avicel PH 101 and canna tuberdid not significantly affect the dissolution of the tablets (Wikantyasning & Indianie, 2021). The dissolution test results were further evaluated using the Simplex Lattice Design approach to determine the effect of the component combination on the physical characteristics of the tablets, as shown in Figure 4.

The results of the analysis of tablet physical property responses, including hardness, friability, disintegration time, and dissolution, were incorporated into the Simplex Lattice Design. The hardness, disintegration time, and dissolution tests showed negative linear coefficients for the combination term (AB), indicating an antagonistic interaction between the components. This means that when the two components are combined, the resulting response is lower than expected compared to the effect of each component when used individually. These results suggest that the interaction between

components reduces the measured response value, indicating that the combination does not produce a synergistic effect but instead weakens the overall performance for these parameters. In contrast, the friability test showed a positive coefficient for the combination term (AB), meaning that when the two components are combined, the resulting response is higher than expected compared to the individual effects of each component (Aini & Setiyadi, 2025).

In this study, the optimum formulation of ibuprofen tablets using a combination of Avicel PH 101 and canna tuberbased on the Simplex Lattice Design method (Table V.22) consisted of 50.000 mg of canna tuberand 50.000 mg of Avicel PH 101, with a desirability value of 1.000. This value indicates the program's ability to generate an optimum formula according to the established criteria. A desirability value closer to 1 indicates that the obtained optimum formulation is increasingly aligned with the desired criteria (Kusuma & Prabandari, 2020).

CONCLUSION

Based on the results, the Simplex Lattice Design optimization revealed that the combination of Avicel PH 101 and canna tuber starch positively affected tablet friability but negatively influenced hardness, disintegration time, and dissolution. The optimum formulation consisted of 50.000 mg of Avicel PH 101 and 50.000 mg of canna tuber starch, achieving a desirability value of 1.000.

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