Jurnal Global Ilmiah
Vol. 3, No. 11, August 2026
ISSN: 3026-5207

Analysis of the Addition of Pumpkin Additive on Filtration Loss, Mud Cake, and Drilling Mud Rheology

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Keywords:
Filtration Loss, Mud Cake, Pellow Pumkin, Drilling Mud, Rheology, API

ABSTRACT

Drilling is one of the most crucial processes in the oil and gas industry. Among the various types of drilling fluids used in field operations, Water-Based Mud (WBM) remains one of the most widely applied systems. However, this type of drilling fluid still commonly faces challenges related to rheological instability and excessive filtration loss. The extensive use of synthetic additives as filtration control agents has raised environmental concerns, highlighting the need to explore sustainable alternatives. This study aims to analyze the effect of yellow pumpkin addition on filtration loss, drilling mud rheological properties, and mud cake characteristics in water-based mud systems. The study employed a laboratory-scale experimental approach involving four sample variations: 0 g, 6 g, 8 g, and 10 g of yellow pumpkin additive. Testing parameters included mud weight, filtration loss, mud cake thickness, plastic viscosity, yield point, gel strength, and pH in accordance with API 13A standards. The results demonstrated that pumpkin addition significantly affected drilling mud properties, particularly by reducing filtration loss from 8.3 mL to 5.4 mL with the addition of 10 g of pumpkin additive, representing a 34.94% reduction. In addition, mud cake thickness decreased from 0.33 mm to 0.23 mm at the same concentration. Among the 6 g, 8 g, and 10 g samples, the rheological parameter most significantly affected was yield point, which increased from 15 lb/100 ft² to 44 lb/100 ft², while pH values shifted from 10.7 (alkaline) to 7.05 (neutral). These findings indicate that yellow pumpkin starch, due to its high amylopectin content, has potential as an effective biodegradable filtration control agent for water-based drilling fluids.

INTRODUCTION

The drilling process represents a critical stage in the oil and gas industry, serving as the primary mechanism for accessing hydrocarbon-bearing formations and establishing flow paths from subsurface reservoirs to the surface. Beyond enabling reservoir access, drilling operations must maintain borehole stability, facilitate cuttings transport, and control formation pressure to prevent blowouts and uncontrolled fluid influxes (Shehab et al., 2023). The success of these operations largely depends on drilling fluids, which play essential roles in cuttings removal, wellbore stabilization, and drill string lubrication and cooling. Therefore, the selection and formulation of appropriate drilling fluids are fundamental factors determining operational efficiency and safety (Lavrentiadi & Leusheva, 2023).

Drilling fluid systems are primarily categorized into Water-Based Drilling Fluids (WBDFs), Oil-Based Drilling Fluids (OBDFs), and Synthetic-Based Drilling Fluids (SBDFs). Among these systems, Water-Based Mud (WBM) is one of the most widely used due to its

economic advantages and relatively lower environmental impact. Although OBDFs and SBDFs generally provide superior wellbore stability and lubricating performance, their higher costs and environmental considerations create challenges for large-scale implementation. In comparison, WBDFs offer reduced environmental impacts while meeting regulatory requirements and providing advantages in terms of cost efficiency, handling, and maintenance. However, WBM systems still face challenges related to rheological instability and excessive filtration loss, which may result in formation damage, wellbore instability, and increased operational costs if not properly controlled (Akbar et al., 2023; Muzzakar et al., 2025).

Filtrate invasion into the formation through the borehole wall results in the formation of a filter cake layer, which may cause operational problems if its properties are not properly controlled. Although filter cake formation contributes to wellbore stabilization, excessive filter cake thickness or poor-quality filter cake structures may create drilling complications (Tost et al., 2020). During the use of WBDFs, filtrate invasion into subsurface formations may lead to shale hydration, wellbore instability, and formation damage. Excessive filter cake thickness can increase the risk of differential sticking, restricting drill string movement and rotation, while excessive filtrate invasion may negatively affect reservoir properties. Therefore, the application of effective fluid loss control additives is essential for minimizing filtrate volume and forming a thin, low-permeability filter cake (Mansah et al., 2024).

The performance of drilling fluids strongly depends on the selection and application of appropriate additives in the drilling mud formulation. Chemical additives, such as Carboxymethyl Cellulose (CMC), are commonly used as fluid loss control agents because they can increase viscosity and improve water retention within drilling fluids (Olamigoke & James, 2023; Youssef et al., 2025; Zhou et al., 2024). Currently, commonly used filtration control additives for WBDFs include synthetic resins, alkene monomer copolymers, nanomaterials, and natural polymers. Water-soluble resin materials, such as sulfonated phenolic and lignite-based resins, provide effective filtration control under high-temperature conditions, including temperatures above 180 °C; however, their environmental limitations restrict their application. Common polymer-based fluid loss reducers include acrylamide-based copolymers containing acrylic acid (AA) and 2-acrylamido-2-methylpropanesulfonic acid (AMPS) monomers. Nevertheless, CMC and other synthetic polymer additives may present economic and environmental challenges due to hydrolysis susceptibility, significant effects on rheological properties, and limited biodegradability (Peng et al., 2024; Yang et al., 2022; Zhang et al., 2023).

Based on these challenges, this study utilized starch-based additives as a more economical and environmentally sustainable alternative. The application of organic polymers has been widely investigated as a method for controlling filtration loss and improving drilling fluid viscosity (Wastu et al., 2023). Natural polymer materials are commonly considered promising fluid loss reducers because they can adsorb onto clay mineral surfaces and promote hydration processes. Starch, a biological carbohydrate polymer widely found in plants, has been applied in various industries, including biomedicine, food processing, and petroleum engineering, due to its abundance, low cost, and biodegradability. Starch consists of two glucose polymers, amylose and amylopectin, with proportions varying depending on plant sources. Native starches from different sources exhibit variations in morphology, particle size

distribution, gelatinization temperature, and amylopectin content, which influence filtration loss, rheological properties, and pH behavior in water-based drilling fluids.

Yellow pumpkin (Cucurbita moschata Duch.) is an organic polymer source that may be utilized as a drilling fluid additive to address filtration loss and rheological challenges. This material has potential as an environmentally friendly fluid loss control additive due to its availability, economic value, and renewable characteristics. Starch-based materials have commonly been used as fluid loss control additives in water-based drilling mud systems (WBMs) (Mahto, 2013). With global production reaching approximately 27 million metric tons, pumpkin represents a significant agricultural commodity, although considerable quantities are discarded as waste annually. For example, approximately 18,000 tons of pumpkins are wasted during Halloween in the United Kingdom alone, while approximately 453,000 tons are wasted in the United States. In Indonesia, yellow pumpkin production is distributed across various regions. Based on data published by the Central Statistics Agency (BPS), yellow pumpkin production in Indonesia remains relatively high and shows an increasing trend. Indonesia ranks among the world's major producers of yellow pumpkin, with reported production of 603,325 tons, per capita production of 2,277 kg, agricultural land area of 8,828 hectares, and productivity reaching 68,342.2 kg/ha (Institute, 2020). This abundant availability makes yellow pumpkin a promising candidate for developing sustainable, locally sourced drilling fluid additives.

Yellow pumpkin is a source of starch and protein with significant potential for industrial applications. In 100 g of yellow pumpkin starch, components include carbohydrates (amylose and amylopectin), protein, fat, ash, fiber, and water. The primary components contributing to its suitability as a drilling fluid additive are amylose and amylopectin. These glucose-based polymers form the structural framework of starch and contribute to polymer functionality in drilling fluid formulations. Therefore, the development of yellow pumpkin-based starch products has considerable potential (Issa et al., 2023). Recent studies have demonstrated that pumpkin-derived additives can reduce fluid loss and improve rheological parameters, including plastic viscosity, apparent viscosity, yield point, and gel strength. Additionally, food waste materials, including pumpkin, zucchini, and butternut squash peels, have been investigated as additives in WBDF formulations, demonstrating potential improvements in filtration and rheological properties. Therefore, this study investigated yellow pumpkin starch as an additive to evaluate its feasibility as a fluid loss control agent.

Laboratory experiments were conducted to evaluate the ability of yellow pumpkin additives to reduce filtration loss. The initial stage of the research involved incorporating different concentrations of yellow pumpkin additives to assess their effectiveness as fluid loss control agents. Native starches with higher amylopectin content generally demonstrate improved filtration control and thermal stability. The gelatinization and thickening characteristics of starch granules, along with their ability to form hydrogen-bond networks, contribute to viscosity regulation and filtration loss reduction. This research was motivated by the importance of drilling fluid performance in controlling fluid loss, maintaining hydrostatic pressure, and ensuring borehole stability. The limitations associated with synthetic fluid loss control additives have encouraged the development of more sustainable alternatives. Increasing environmental concerns in drilling operations have accelerated the transition toward environmentally responsible and high-performance drilling fluids (Nazemi et al., 2024).

Yellow pumpkin, as a biodegradable natural polymer derived from renewable resources, has potential applications as a drilling fluid additive. However, the effects of yellow pumpkin addition on filtration loss, filter cake characteristics, and drilling fluid rheological properties require validation through experimental investigation. Therefore, this study focused on analyzing the influence of yellow pumpkin flour addition on these parameters in water-based drilling mud. The research gap identified was the limited investigation of yellow pumpkin starch specifically as a drilling fluid additive, despite its abundance in Indonesia and potential as a sustainable alternative. Although previous studies have examined various starch-based materials and food waste products as drilling fluid additives, comprehensive evaluations of yellow pumpkin's effects on filtration loss, filter cake thickness, and rheological properties under API standard conditions remain limited.

This study was limited to the application of yellow pumpkin flour as an additive with concentration variations of 6 g, 8 g, and g. The purpose of this study was to analyze the effect of yellow pumpkin addition on filtration loss, filter cake thickness, and drilling fluid rheological properties. The novelty of this research lies in the systematic evaluation of yellow pumpkin starch as a locally available, biodegradable alternative to synthetic filtration control agents, with testing conducted according to API 13A standards. The results are expected to provide scientific insights into the potential application of yellow pumpkin as an environmentally friendly natural additive, support the development of improved drilling fluid formulations, and serve as a reference for future research in drilling fluid technology. This research contributes to the broader objective of developing more sustainable drilling technologies aligned with global environmental goals.

METHOD

The research employed a quantitative experimental design conducted at a laboratory scale to analyze the effect of yellow pumpkin additive concentration variations on the physical and rheological properties of water-based drilling mud (WBM). This experimental approach enabled controlled variable manipulation, systematic data collection, and reproducible testing under standardized conditions. The research was conducted at the STT Migas Laboratory in Balikpapan, Indonesia, from May 24–25, 2026. The research samples consisted of WBM formulations containing yellow pumpkin flour as an additive. A purposive sampling technique was applied, with sample formulations prepared using predetermined additive concentrations based on the research objectives. The drilling mud samples were prepared with yellow pumpkin flour concentrations of 6 g, 8 g, and 10 g, along with a control sample containing 0 g of additive.

Data collection instruments included calibrated equipment in accordance with API standards, consisting of a mud balance for density measurement, an API filter press for filtration loss and filter cake thickness measurements, a Fann VG meter rheometer for rheological properties including plastic viscosity, yield point, and gel strength, and a pH meter for pH measurement. Supporting equipment included digital scales, mixers, filter papers, calipers, and measuring cups. The materials used included fresh water as the base fluid, caustic soda as a pH controller, bentonite as a viscosifier and filtration control agent, PAC-LV as a fluid loss control additive, yellow pumpkin flour as the experimental additive, barite as a weighting agent, KCl as a shale stabilizer, and XCD polymer as a viscosifier. All

instruments were calibrated before testing, and each test was conducted in triplicate to ensure measurement reliability.

The research procedure began with the preparation of yellow pumpkin flour through processing stages involving cleaning, drying, grinding, and sieving to obtain a uniform particle size. The drilling mud samples were then prepared by mixing the required materials according to predetermined formulations and mixing procedures. The prepared samples were tested for physical and rheological properties, including density using a mud balance, filtration loss and filter cake thickness using an API filter press at 100 psi for 30 minutes based on API RP 13B-1 procedures, rheological properties and gel strength using a Fann VG meter at 120°F, and pH values using a pH meter. The collected data were tabulated and analyzed descriptively by comparing parameter values among samples and evaluating the results against API standards and previous studies. Microsoft Excel was used for data organization and graphical presentation. All tests were performed following standardized laboratory procedures to evaluate the effect of yellow pumpkin addition on water-based drilling mud characteristics.

RESULTS AND DISCUSSION

In this section, we present the results and discussion of the effect of adding yellow pumpkin on filtration loss and drilling mud rheology. The sludge that has been formulated is then tested to obtain parameter values including Mud Weight, Rheology (Plastic Viscosity, Yield Point, and Gel Strength), Filtration Loss, pH, and Mud Cake. This study uses a number of additives in the process of making sludge samples that function to maintain the physical properties of the sludge according to the specifications that have been set, including caustic soda (as a pH CONTROLLER), PAC-LV (as a filtrate reducer), bentonite (as a thickener), yellow flask (to reduce the filtration of drilling mud), barite (as a ballast), KCL (as a shale stabilizer), and XCD polymer (as a viscosifier).

Results of Data Sample Analysis

The following are the specifications and composition of the sludge used as well as the test results of each sample.

Table 1. API 13B Specification Standard

Mud Properties	Specification	Units
Mud Weight	8,5-9,6	gr/cm³
Plastic Viscosity	Minimal 7	cp
Yield Point	Maximum 50	lb/100ft²
Gel Strength	Minimal 0,48	lb/100ft²
Filtrate API, ml/30min	Maximum 15	ml/30min
pH	Minimal 7	-
Mud Cake	Maximum 2	mm

Source: *American Petroleum Institute (API). (2020). API Specification 13A: Specification for Drilling Fluids Materials.*

Sampel Original

From the test results in sample 1 (original sample), the results were obtained as shown in table 4.3. It can be seen that the mud weight value is 9.1 ppg, Plastic Viscosity is 21 cps, Yield Point is 15 lbs/100ft2, Gel strength 10 seconds 10 lbs/100ft2, Gel strength 10 minutes is 13 lbs/100ft2, API Filtration loss is 8.3 ml/30 minutes, pH is 10.7, and mud cake is 0.33 mm.

Table 2. Composition of Sludge

Composition	Volume (ml)	SG	Weight (gr)	Time Minutes	Speed
Fresh Water	305,05	1,00	305,05	1	Low
Caustic Soda	0,12	2,13	0,25	1	Low
Bertonite	1,20	2,50	3,00	5	Low
PAC-LV	0,83	1,50	1,25	5	Low
Starch	0	1,50	0,00	5	Low
Barite	28,57	4,20	120,00	3	Low
Kcl	13,38	1,98	26,50	3	Low
XCD Polymer	0,84	1,60	1,35	8	Low

Source: *Prepared by the authors based on laboratory formulation at STT Migas Balikpapan (2026).*

Sample test results:

Table 3. Sample Test Results 1

MUD PROPERTIES	UNIT	RESULT
Mud Weight	SG	9.1
Reading @ 120°F	RPM 600	57
-	300	36
-	200	30
-	100	22
-	6	12
-	3	10
PV	Cps	21
YP	lbs/100ft²	15
Gel Strength 10 seconds	lbs/100ft²	10
Gel Strength 10 Minutes	lbs/100ft²	13
API Filtration loss	Cc/30 min	8,3
pH	-	10,7
Mud Cake	Mm	0,33

Source: *Prepared by the authors based on laboratory testing at STT Migas Bal*

Addition of Yellow Pumpkin 6 g

From the test results in sample 2 (sample of adding 6 gr of yellow pumpkin) the results were obtained as shown in table 4.5. It can be seen that *the mud weight* value is 9.4 ppg, *Plastic Viscosity* is 22 cps, *Yield Point* is 36 lbs/100ft2, *Gel strenght* 10 seconds 15 lbs/100ft2, *Gel strenght* 10 minutes is 17 lbs/100ft2, *API Filtration loss* is 7.4 ml/30 minutes, pH is 8.30 and *mud cake* is 0.29 mm.

So it can be concluded that the addition of 6 grams of yellow pumpkin in sample 2 can affect the value of *filtration loss* and *rheology* in the mud. API filtrate was initially 8.3 and decreased to 7.4 (included in the specifications). This happens because the *polysaccharide* content in yellow pumpkin starch can affect *the filtrate* in the mud so that API filtrate decreases.

Table 4. Composition of Sludge

Composition	Volume (ml)	SG	Weight (gr)	Time Minutes	Speed
Fresh Water	299,18	1,00	299,18	1	Low
Caustic Soda	0,12	2,13	0,25	1	Low
Bertonite	1,20	2,50	3,00	5	Low
PAC-LV	0,83	1,50	1,25	5	Low
Yellow Pumpkin	5,88	1,02	6,00	5	Low
Barite	28,57	4,20	120,00	3	Low
Kcl	13,38	1,98	26,50	3	Low
XCD Polymer	0,84	1,60	1,35	8	Low

Source: *Prepared by the authors based on laboratory formulation at STT Migas Balikpapan (2026).*

Sample test results 2:

Table 5. Sample Test Results 2 (6 g Yellow Pumpkin)

MUD PROPERTIES	UNIT	RESULT
Table 4. 5 Sample Test Results 2*Mud Weight*	SG	9.4
Reading @ 120°F	RPM 600	80
-	300	58
-	200	55
-	100	43
-	6	16
-	3	15
PV	Cps	22
YP	lbs/100ft²	36

MUD PROPERTIES	UNIT	RESULT
Gel Strength 10 seconds	lbs/100ft²	15
Gel Strength 10 Minutes	lbs/100ft²	17
API Filtration loss	Cc/30 min	7,4
pH	-	8,30
Mud Cake	Mm	0,29

Source: *Prepared by the authors based on laboratory testing at STT Migas Balikpapan (2026).*

Addition of Yellow Pumpkin 8 gr

From the test results in sample 3 (sample of adding 8 gr of yellow pumpkin) the results were obtained as in table 4.7. It can be seen that the *mud weight* value is 9.5 ppg, *Plastic Viscosity* is 23 cps, *Yield Point* is 38 lbs/100ft2, *Gel strenght* 10 seconds 17 lbs/100ft2, *Gel strenght* 10 minutes is 19 lbs/100ft2, *API Filtration loss* is 6.3 ml/30 minutes, pH is 7.21 and *mud cake* is 0.26 mm.

So it can be concluded that the addition of 8 grams of yellow pumpkin in sample 3 can affect the value of *filtration loss* and *rheology* in the mud. API filtrate was initially 8.3 and has been reduced to 6.3 (included in the specifications). This happens because the *polysaccharide* content in yellow squash can affect *the filtrate* in the mud so that the API filtrate decreases (Khalaf et al., 2021).

Table 6. Sludge Composition

Composition	Volume (ml)	SG	Weight (gr)	Time Minutes	Speed
Fresh Water	297,22	1,00	297,22	1	Low
Caustic Soda	0,12	2,13	0,25	1	Low
Bertonite	1,20	2,50	3,00	5	Low
PAC-LV	0,83	1,50	1,25	5	Low
Yellow Pumpkin	7,84	1,02	8,00	5	Low
Barite	28,57	4,20	120,00	3	Low
Kcl	13,38	1,98	26,50	3	Low
XCD Polymer	0,84	1,60	1,35	8	Low

Source: *Prepared by the authors based on laboratory formulation a*

Sample test results 3:

Table 7. Sample Test Results 3

MUD PROPERTIES	UNIT	RESULT
Mud Weight	SG	9.5
***Reading* @ 120°F**	RPM 600	84
-	300	61
-	200	58
-	100	45
-	6	18
-	3	16
PV	cps	23
YP	lbs/100ft²	38
***Gel Strength* 10 seconds**	lbs/100ft²	17
***Gel Strength* 10 Minutes**	lbs/100ft²	19
API Filtration loss	Cc/30 min	6,3
pH	-	7,21
Mud Cake	mm	0,26

Source: *Prepared by the authors based on laboratory testing at STT Migas Balikpapan (2026).*

Addition of Yellow Pumpkin 10 gr

From the test results in sample 2 (sample of adding 10 gr of yellow pumpkin) the results were obtained as shown in table 4.9. It can be seen that the *mud weight* value is 9.6 ppg, *Plastic Viscosity* is 30 cps, *Yield Point* is 44 lbs/100ft2, *Gel strenght* 10 seconds 19 lbs/100ft2, *Gel strenght* 10 minutes is 20 lbs/100ft2, *API Filtration loss* is 5.4 ml/30 minutes, pH is 6.75 and *mud cake* is 0.23 mm.

So it can be concluded that the addition of 10 grams of yellow pumpkin in sample 4 can affect the value of *filtration loss* and *rheology* in the mud. API filtrate was initially 8.3 and has been reduced to 5.4 (included in the specifications). This happens because the *polysaccharide* content in yellow squash can affect *the filtrate* in the mud so that the API filtrate decreases (Alkalbani et al., 2023).

Table 8. Sludge Composition

Composition	Volume (ml)	SG	Weight (gr)	Time Minutes	Speed
Fresh Water	295,26	1,00	295,26	1	Low
Caustic Soda	0,12	2,13	0,25	1	Low
Bertonite	1,20	2,50	3,00	5	Low
PAC-LV	0,83	1,50	1,25	5	Low

Composition	Volume (ml)	SG	Weight (gr)	Time Minutes	Speed
Yellow Pumpkin	9,80	1,02	10,00	5	Low
Barite	28,57	4,20	120,00	3	Low
Kcl	13,38	1,98	26,50	3	Low
XCD Polymer	0,84	1,60	1,35	8	Low

Source: *Prepared by the authors based on laboratory formulation at STT Migas Balikpapan (2026).*

Sample test results:

Table 9. Sample Test Results 4

MUD PROPERTIES	UNIT	RESULT
Mud Weight	SG	9.6
***Reading* @ 120°F**	RPM 600	104
-	300	74
-	200	67
-	100	54
-	6	21
-	3	19
PV	cps	30
YP	lbs/100ft²	44
***Gel Strength* 10 seconds**	lbs/100ft²	19
***Gel Strength* 10 Minutes**	lbs/100ft²	20
API Filtration loss	Cc/30 min	5,4
pH	-	7,10
Mud Cake	mm	0,23

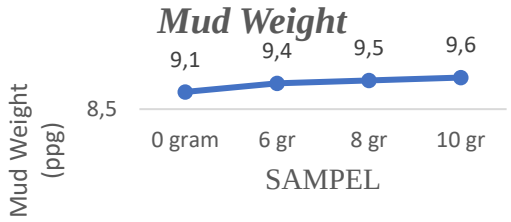
Source: *Prepared by the authors based on laboratory testing at STT Migas Balikpapan (2026).*

Comparison of Physical Properties of Mud

Mud Weight

Mud *weight* testing on drilling mud (WBM) using *mud balance* is useful for calculating the density of each sample of drilling mud to obtain results that comply with API standards. The test was carried out in static conditions using sludge samples whose composition consisted of *fresh water, caustic soda*, bentonite, PAC-L, Barite, KCL, Xcd Polymer and added yellow pumpkin additives with 4 mass variations, namely, 0 grams, 6 grams, 8 grams and 10 grams.

Figure 1. *Mud Weight* of Yellow Pumpkin



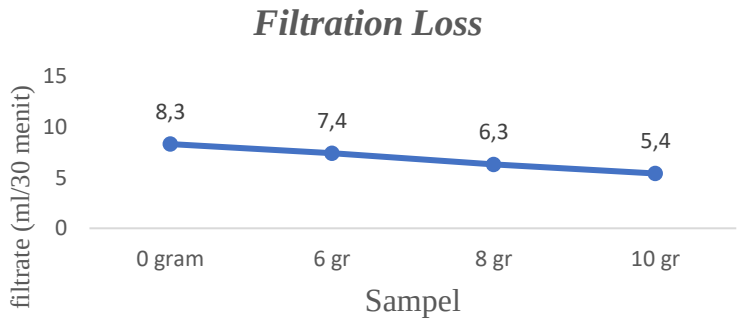
Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

Based on the results of *mud weight testing* on the addition of yellow pumpkin additives sample 6 gr, 8 gr, 10 gr in sample 1 (original sample) mud weight 9.1 ppg, sample 2 (addition of yellow pumpkin 6 gr) mud weight 9.4, sample 3 (addition of yellow pumpkin 8 gr) mud weight 9.5 ppg and sample 4 (addition of yellow pumpkin 10 gr) mud weight 9.6 ppg. As shown in figure 4.1, the *mud weight* value of yellow pumpkin has increased along with the addition of *additives*. According to the API Spec 13B standard, the reference value range for mud weight is 8.5 to 9.6 ppg. If the mud weight is excessive (exceeding the upper limit), it can result in lost circulation, which causes a decrease in hydrostatic pressure and disturbances in the circulatory system. On the other hand, if the mud weight is deficient, it can trigger the entry of formation fluid into the borehole (kick), which has the potential to result in blowout if not controlled properly.

API Filtration Loss

In *filtration lose and mud cake* on drilling mud (WBM) using a filtrate press, it is useful to calculate the number of filtrate and mud cake thickness at a pressure of 100 psi in each drilling mud sample to get results in accordance with API standards. The test was carried out in static conditions using sludge samples whose composition consisted of fresh water, caustic soda, bentonite, PAC-L, Barite, KCL, Xcd Polymer and added yellow pumpkin additives with 5 mass variations, namely, 0 grams, 6 grams, 8 grams and 10 grams.

Figure 2. API Filtration Loss of Yellow Pumpkin



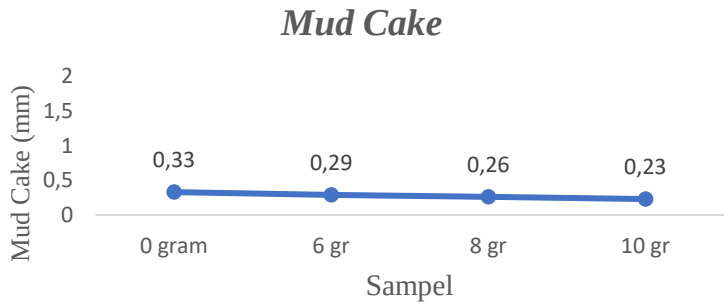
Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

Based on the results of the filtration loss test with the addition of yellow gourd to the 6 gr, 8 gr, and 10 gr samples in the drilling mud system, it showed a decrease in the value of the filtrate.

As can be seen in the graph, there is a decrease in the value of filtration loss along with the addition of yellow flask, this is due to the polysaccharide content which can increase the viscosity of the mud and strengthen the bonds in the drilling fluid. The results of the filtration loss test with the addition of yellow pumpkin are as follows: sample 1 produces a value of 8.3 ml/30 minutes, sample 2 produces a value of 7.4 ml/30 minutes, sample 3 produces a value of 6.3 ml/30 minutes, and sample 4 produces a value of 5.4 ml/30 minutes. Based on the API Spec 13B standard, the allowable filterate loss value is a maximum of 15 ml/30 minutes. All samples tested still meet these specifications. Where low filtrate shows that the sludge is able to form a tight *filter cake,* so it is good to prevent fluid loss and maintain formation permeability.

Mud Cake

Figure 3. *Mud Cake* from Yellow Pumpkin



Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

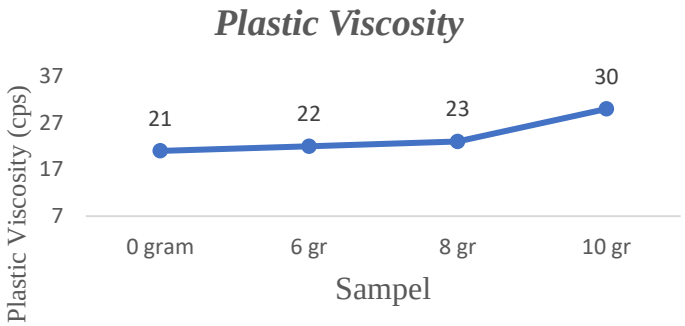
The results of mud cake testing with variations of adding yellow pumpkin additives at concentrations of 6 grams, 8 grams, and 10 grams, obtained the following values: sample 1 produced mud cake of 0.33 mm, sample 2 of 0.29 mm, sample 3 of 0.26 mm, and sample 4 of 0.23 mm. As shown in Figure 4.3, the thickness of the mud cake decreases proportionally to the increase in the concentration of yellow pumpkin additives. According to the API Spec 13A standard, the maximum mud cake thickness value is 2 mm. All specimens tested still meet these specifications. The thin mud cake provides optimal cushioning to the drill pipe and borehole surface. However, if the mud cake is too thick, it can cause problems such as kicks that cause difficulties in the process of turning and enforcing the drill pipe.

Rheology

The test results on drilling mud *rheology* including *Plastic Viscosity* (PV), *Yield Point* (YP), and *Gel Strength* at each concentration of yellow pumpkin additives will be discussed in detail in this section. The discussion was carried out with the aim of finding out how the addition of yellow gourd affects the rheology of drilling mud. The graphs will show the concentration of yellow pumpkin in each sample.

1. *Plastic Viscosity*

Figure 4. *Plastic Viscosity* of Yellow Pumpkin

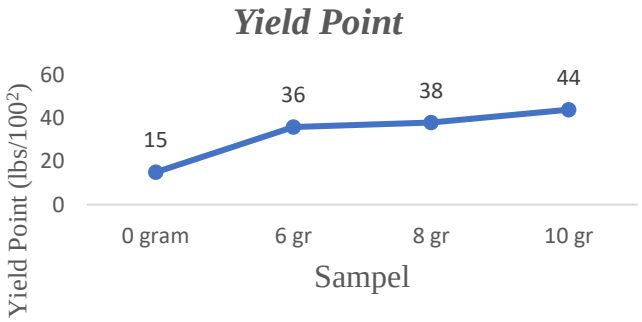


Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

Based on the graphic data displayed, the addition of yellow pumpkin pulp additives resulted in the following plastic viscosity values: sample 1 (original specimen) of 21 cp, sample 2 (yellow pumpkin 6 grams) of 22 cp, sample 3 (yellow pumpkin 8 grams) of 23 cp, and sample 4 (yellow pumpkin 10 grams) of 30 cp. As can be seen in Figure 4.4, yellow pumpkin additives can increase the plastic viscosity value of drilling mud. This phenomenon occurs because plastic viscosity is affected by the concentration of solids in the sludge; The higher the concentration of solids, the higher the viscosity value of the mud. According to the API Spec 13B standard, the minimum plastic viscosity value is 7 cp. A plastic viscosity value that is too low can reduce the ability of the sludge to carry cutting, but if the value is too high, it can cause operational problems such as increased pump pressure and circulation barrier.

2. *Yield Point*

Figure 5. *Yield Point* of Yellow Pumpkin



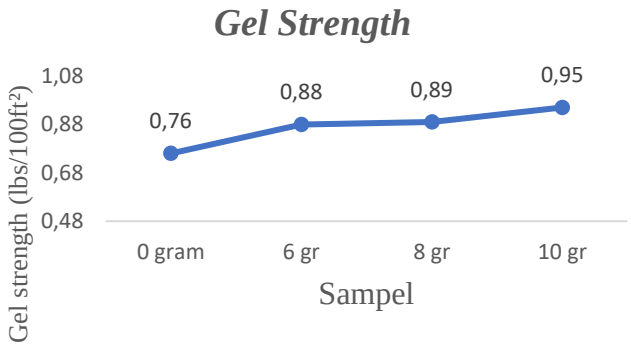
Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

Based on the graph data above, the yield point (YP) value of the addition of yellow pumpkin additives is directly proportional to the concentration of additives added. The addition of yellow squash additives resulted in the following yield point values: sample 1 (0 gr sample) of 15 lb/100 ft², sample 2 (addition of 6 grams of yellow squash) of 36 lb/100 ft², sample 3 (addition of 8 grams of yellow squash) of 38 lb/100 ft², sample 4 (addition of 10 grams of

yellow squash) of 44 lb/100 ft². As seen in Figure 4.5, there is an increase in yield point value as there is an increase in the mass of yellow pumpkin additives. Based on API Spec 13B standards, the maximum allowable yield point value is 50 lb/100 ft². A high yield point value can cause the sludge to become too thick, complicate fluid flow and force the pump which can potentially cause overheating. On the other hand, if the YP value is too low, it causes problems such as solids deposition and blockage. Diluted mud allows heavy particles or drill debris to settle at the bottom of the well. This can clog the drill bit, annulus, or circulation system, slowing down drilling and increasing the risk of *stuck pipes*.

3. *Gel Strength*

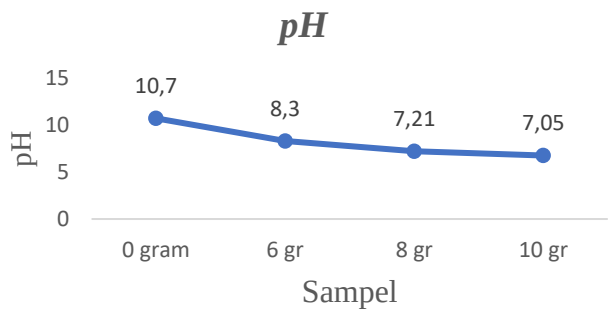
Figure 6. *Gel Strength* of Yellow Pumpkin



Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

The results of the gel strength test with the addition of yellow pumpkin additives of 6 gr, 8 gr, and 10 gr to the drilling mud, showed a consistent increase in gel strength value. As seen in the graph, the increase in *gel strength* values occurs after the addition of yellow pumpkin additives. The results of the gel strength test with the addition of yellow squash are as follows: sample 1 yields gel strength of 0.76 lb/100 ft², sample 2 of 0.88 lb/100 ft², sample 3 of 0.89 lb/100 ft², and sample 4 of 0.95 lb/100 ft². Based on API Spec 13B standards, the *Gel Strength* value is at least 0.48 lb/100 ft². All samples meet these specifications. Too low a GS value can cause less stability of the drilling mud when circulation stops.

Figure 7. pH of Yellow Pumpkin



Source: *Prepared by the authors based on laboratory testing results at STT Migas Balikpapan (2026).*

The pH test results were with the addition of yellow pumpkin additives of 6 gr, 8 gr, and 10 gr to the drilling mud. As seen in Figure 4.7, there is a decrease in pH value due to the content of yellow pumpkin, but as the addition increases, the pH value tends to become more neutral. The pH test results are as follows: sample 1 (original sludge) produces a pH of 10.7, sample 2 (the addition of 6 grams of yellow pumpkin) produces a pH of 8.30, sample 3 (the addition of 8 grams of yellow pumpkin) produces a pH of 7.21, and sample 4 (weighing 10 grams of yellow pumpkin) produces a pH of 7.05. Based on the API Spec 13B standard, the required pH value is at least 7. All samples meet these specifications. A low pH value can cause erosion or corrosion of the drilling tool, while if the value exceeds the limit it can trigger an excessive chemical reaction.

Calculation Results

The rhelogy calculation on all samples is as follows:

1. Sample 1 (Original Sample) calculation results

   To calculate PV using equation (1),

   PV = C600 – C300

   = 57 – 36

   = 21 cp

   To calculate YP using equation (2)

   YP = C300 – YP

   = 36 – 21

   = 15 lb/100ft2

   To calculate GS using equation (3)

   GS = $\frac{Simpangan\ maksimum\ 10\ detik}{Simpangan\ maksimum\ 10\ menit}$

   =$\frac{10\ lb/100ft^2}{13\ lb/100ft^2}$

   =0,76 lb/100ft2

2. Sample 2 calculation results (Addition of 6 grams of Yellow Pumpkin)

   To calculate PV using equation (1),

   PV = C600 – C300

   = 80 – 58

   = 22 cp

   To calculate YP using equation (2)

   YP = C300 – YP

   = 58 – 22

   = 36 lb/100ft2

   To calculate GS using equation (3)

   GS = $\frac{Simpangan\ maksimum\ 10\ detik}{Simpangan\ maksimum\ 10\ menit}$

   =$\frac{15\ lb/100ft^2}{17\ lb/100ft^2}$

   = 0,88 lb/100ft2

3. Results of Sample 3 calculation (Addition of 8 grams of Yellow Pumpkin)

   To calculate PV using equation (1),

   PV = C600 – C300

= 84 – 61

= 23 cp

To calculate YP using equation (2)

YP = C300 – YP

= 61 – 23

= 38 lb/100ft2

To calculate GS using equation (3)

GS = $\frac{Simpangan\ maksimum\ 10\ detik}{Simpangan\ maksimum\ 10\ menit}$

= $\frac{17\ lb/100ft^2}{19\ lb/100ft^2}$

= 0,89 lb/100ft2

4. Results of Sample 4 calculation (Addition of 10 grams of Yellow Pumpkin)

To calculate PV using equation (1),

PV = C600 – C300

= 104 – 74

= 30 cp

To calculate YP using equation (2)

YP = C300 – YP

= 74 – 30

= 44 lb/100ft2

To calculate GS using equation (3)

GS = $\frac{Simpangan\ maksimum\ 10\ detik}{Simpangan\ maksimum\ 10\ menit}$

= $\frac{19\ lb/100ft^2}{20\ lb/100ft^2}$

= 0,95 lb/100ft2

CONCLUSION

Based on the research results and the addition of yellow pumpkin additive, the following conclusions were obtained. Increasing the concentration of yellow pumpkin additive reduced filtration loss values from 8.3 mL, 7.4 mL, 6.3 mL, and 5.4 mL, representing a maximum reduction of 34.94%. These findings indicate that yellow pumpkin additive has potential as an effective fluid loss control agent for reducing filtration loss in water-based drilling mud. Furthermore, increasing yellow pumpkin additive concentration reduced filter cake thickness from 0.33 mm in the control sample to 0.23 mm in the sample containing 10 g of additive. This reduction indicates that yellow pumpkin additive may contribute to the formation of a thinner and more stable filter cake, which is beneficial for maintaining wellbore stability during drilling operations.

The addition of yellow pumpkin additive at concentrations of 6 g, 8 g, and 10 g influenced the rheological properties and pH characteristics of the drilling mud, particularly the yield point and pH values. The test results showed that increasing the amount of yellow pumpkin additive gradually increased the yield point value from 15 lb/100 ft², with the highest value recorded in the sample containing 10 g of yellow pumpkin additive at 44 lb/100 ft².

Conversely, increasing yellow pumpkin additive concentration resulted in a decrease in pH from an alkaline condition (10.7) to a near-neutral condition (7.05).

Based on the research findings regarding the use of yellow pumpkin as a drilling mud additive, further investigations are recommended. Future studies should evaluate the performance of yellow pumpkin additive under high-temperature conditions to determine its suitability for more challenging formation environments. Additional research should investigate the optimal additive concentration using a wider concentration range to identify the most effective formulation. Furthermore, future studies should examine the long-term stability, biodegradability, and compatibility of yellow pumpkin-based drilling fluids with other drilling fluid components under field conditions. Evaluations of aging effects on rheological properties and economic feasibility compared with commercial synthetic additives are also recommended before potential field-scale application.

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