

Technological benefits of adding glycerine to animal feeds at pilot level

Glycerine, a liquid co-product of the biofuel (diester) industry, is becoming more accessible due to the development of this business activity. Now available for use in animal feeds, industrials using glycerine find themselves facing certain technological issues. This study addresses the concerns of industrials by evaluating the technological pros and cons of adding glycerine to animal feeds. This study is co-funded by two partners: ONIDOL (now Terres Univia) and Tecaliman.

The study was performed in two phases:

- Phase 1 assessed how glycerine affects feed flows and determines glycerine temperatures and incorporation rates for the Phase 2 tests (5 levels / 3 temperatures / 2 feedstuffs). Two tests on interactions with other liquids were performed in parallel.
- Phase 2 studied the mix behaviour, and possibly the particle size, of 8 animal feed formulations. Three feed formats were employed: coarse meal, pellets and crumbs. Two glycerine incorporation rates were studied for each feed type and compared against a glycerine-free control batch.

1. Equipment and apparatus

1.1. Liquids

The glycerine used in all the tests has a 90% glycerol content. Provided by the Venette plant, it matches that used at French plants. Its viscosity decreases depending on the incorporation temperature: 600 cP at 20°C, 200 cP at 40°C, close to water at 60°C.

Other liquids used include: Methionine, Lysine, Blend of 2 organic acids, Molasses.

1.2. Feedstuffs

	Pig	Supplement ary nitrogen
Median diameter D50 (µm)	407	332
Angle of repose ATE (°)	59	49
Bulk density (g/l)	615	663
Hausner Index (HI)	1.2	1.1

In Phase 1, only supplementary nitrogen (SN) and a finishing pig formulation (containing other liquids) were used (see table above).

Phase 2 tested 8 meals of varying particle sizes (see characteristics below):

- Fine, for pelletization (< 700 µm): Pig, pre-starter piglet, supplementary nitrogen, beef cattle, rabbit, broiler and turkey.
- Coarse, for tests with meal (between 850 and 1065 µm): pig, laying hen and broiler.

Feedstuffs	D 50 (µm)	Part. < 125 µm (%)	Angle of repose (°)	Bulk density (g/l)
Pig	372	19	65	579
Piglet	433	25	56	591
Suppl. nitrog.	441	16	52	626
Beef cattle	436	22	56	629
Rabbit	603	14	66	527
Broiler	501	13	59	623
Turkey	651	2	61	575
Pig	852	10	54	629
Laying hens	1065	7	54	735
Broiler	1005	4	52	709

Beef cattle and rabbit feeds have an initial molasses percentage of 6%, broiler and turkey are enriched with 3% soybean oil and the laying hen feed contains 8% calcium carbonate in microgranulated format.

1.3. Main equipment

The feed-glycerine mixes were prepared using a 100-litre Théaudin-brand blade mixer on which was attached a spraying system comprising a five-litre heated, insulated tank and a flat-angle nozzle. This tank was pressurised with air to ensure spraying. It was weighed before and after injection to provide an accurate measurement of the amount of liquid incorporated.

Once mixing was complete, certain feedstuffs were pelleted, at a constant rate, using a 3 kW KAHL press with a flat die fitted with various sensors connected to a data acquisition board. The pig feed was then crumbled on a roller mill.

2. Method

2.1. Phase 1

During Phase 1, up to 10% of glycerine, maintained at a temperature of 20, 40 or 60°C, was sprayed in 2% increments during mixing onto the 2 feedstuffs in question. Samples were taken after each increment and measurements taken of density, flow rates, percentage of clods of meal (Fraction > 1.6 mm) and mixer power demand. In tests using other liquids, the liquids were added before or after spraying the tests with 10% glycerine in the pig feed. The same measurements were taken.

2.2. Phase 2

The following table shows the test methods used during this phase. For beef cattle and rabbit feeds, the molasses were incorporated during mixing, and can replace some or all of the glycerine.

	Feedstuffs	% Glycerine (G) or Molasses (M)		
Pellets	Pig	0 G	4 G	8 G
	Pre-starter piglet	0 G	3 G	6 G
	Supplementary nitrogen	0 G	3 G	6 G
	Broiler	0 G	3 G	6 G
	Turkey	0 G	3 G	6 G
	Beef cattle	0 G / 6 M	3 G / 3 M	6 G / 0 M
	Rabbit	0 G / 6 M	3 G / 3 M	6 G / 0 M
	Meal	Pig	0	2.5 G
Laying hens		0	2 G	4 G
Broiler		0	2 G	4 G

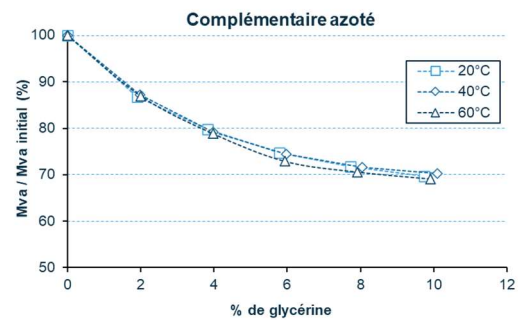
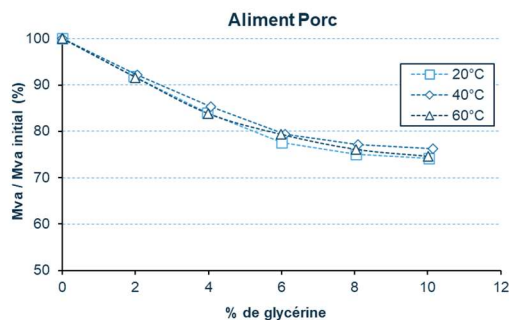
The same physical characteristics are measured on the meals during both phases: Flow rate, particle size, moisture content, Aw, hardness and durability for pellets (Phase 2), ...

In Phase 2, while the 7 feedstuffs are pelleted on different dies, the same die and same packaging temperature are used for each feed irrespective of its glycerine content.

3. Results

3.1. Phase 1

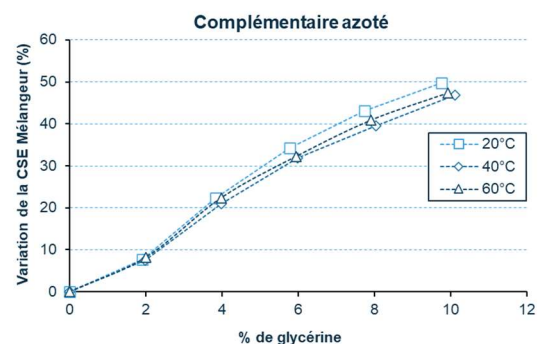
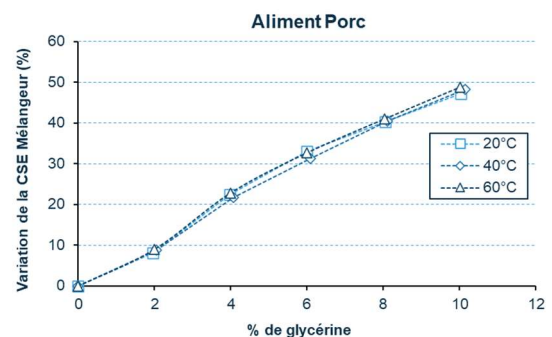
The addition of glycerine **lowered the density** of the tested feedstuffs (BD) irrespective of the glycerine temperature (see figures below).



This can be understood as a 25% increase in the volume of the pig feed, and 31% for the SN with 10% glycerine. This change is not linearly proportional to the glycerine content, as a threshold effect is observed at 6%.

Spraying the meals also causes the **particles to clump together**, evidenced by a decrease in the amount of fine particulate matter and the appearance of clods. **There was no observable interaction between the other liquids and the glycerine.** However, these tests demonstrate the benefit of **spraying the glycerine on last**, in order to limit the risk of the feed forming clods.

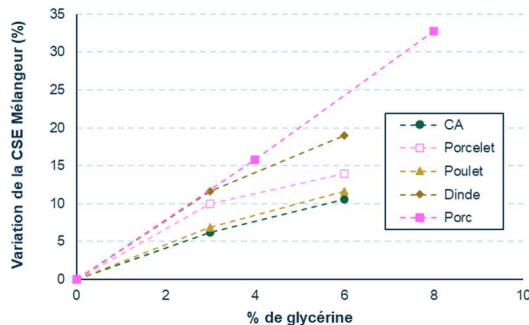
Considering the mix in energetic terms, spraying with glycerine **increases specific energy consumption (SEC)** by about 50% for both feedstuffs containing 10% glycerine (see figure below). Also, as glycerine content gradually increases, the **power demand** also fluctuates **with a larger amplitude** (increase in the power population CV from 16.5 to 34% of 0 to 10% glycerine).



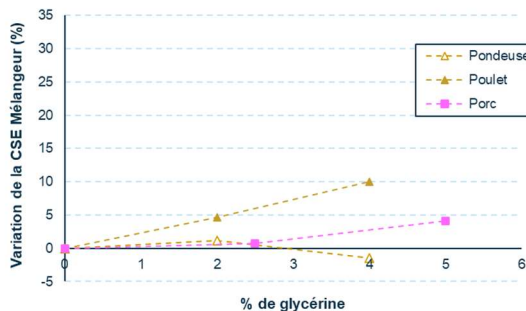
Lastly, it proved more difficult to incorporate the glycerine at 20°C than at 60°C due to viscosity issues. Despite this, temperature does not appear to have any major impact on the endpoint physical characteristics of the finished meals or on mix energy criteria.

3.2. Phase 2

These new tests confirmed the Phase 1 results, even if, in this case, maximum glycerine contents were 6 and 8%. The tests showed that the mixer's **specific energy consumption (SEC) demand increases** further during incorporation of the glycerine, but that the amplitude of the demand is lower for certain feedstuffs (see figure below).



The friction generated during the mixing of coarse meals masks this effect slightly (see figure below). However, as this is a low energy consuming station (in this case, 0.028 kWh/t), the ultimate increase remains 0.006 kWh/t at worst.



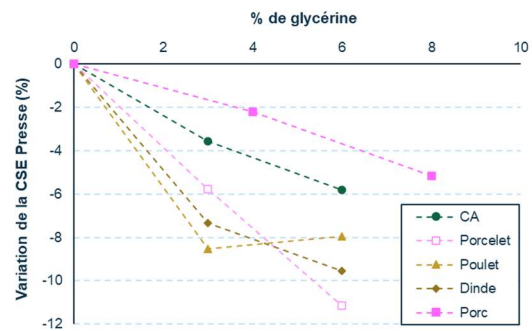
The **density of the meals decreases** even further in the presence of glycerine, but by a variable amount depending on the feed formulation: density decreases significantly for pig (-15% with 8% glycerine), piglet (-14%) and SN (-11%) feeds, but shows no decrease where fatty feedstuffs are concerned (broiler and turkey).

Note also that spraying with molasses causes swelling (and therefore a decrease in density) similar to that observed with glycerine.

The quantity of clods depends on the feedstuffs: High for pig feed, average for poultry feeds and low for piglet and SN feeds. This phenomenon increases slightly with molasses. Clogging of the mixer can decrease as meal particle size increases (-35% between the two broiler feeds - fine and coarse).

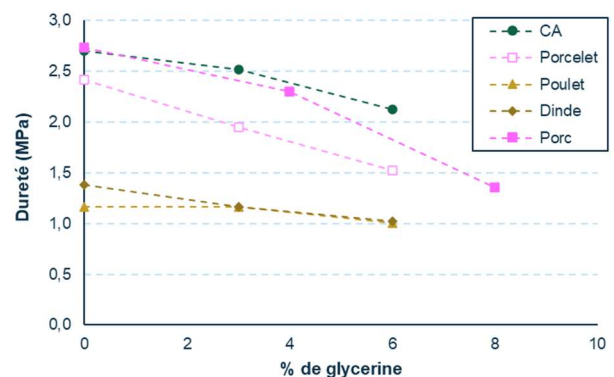
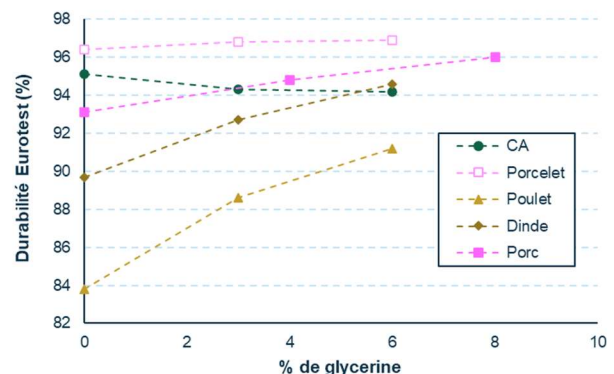
These changes in the feedstuffs' initial physical characteristics affect pelleting conditions. Following the addition of glycerine, the **flow rate** of less dense feedstuffs (pig, piglet and SN) should theoretically **decrease** for a given feeder setting. Increasing feed volumes could limit pelleting rates if the feeder is close to its maximum capacity.

The glycerine appears to act as a lubricant for most feedstuffs, as both the **heating of the die and the specific energy consumption of the pelleting process decreases** as glycerine content increases, largely offsetting the increase in power demand observed with the mix (see figure below).



This impact on energy consumption during pelleting is greater for fine or fatty feedstuffs such as piglet, broiler and turkey feeds: nearly -3% of the SEC / % glycerine for certain feedstuffs.

In the presence of glycerine, **pellets** all present a **softer, more elastic texture**. This change is characterised by an **increase in durability** and a **decrease in hardness** (see figures below).



In terms of durability, the feedstuffs with the highest fat content gain the most: +1.2% durability / % glycerine for broiler feed and +0.8% durability / % glycerine for turkey feed. Hardness decreases for all feedstuffs; when expressed as a % of the initial hardness with no glycerine this decrease presents as: -2.3% / % glycerine for broiler feed, up to -8.4% / % of glycerine

for pig feed. This indicates that adding glycerine makes it possible to produce a feed that is both more resistant to mechanical stress, while being softer for teeth or beaks.

This softer texture leads to a **risk of crushing during the crumbling process**.

Lastly, incorporating glycerine into feedstuffs can **increase the moisture content** (from 0.3 to 0.6%) **while decreasing the Aw** (from 3 to 6% of the initial value). Glycerine has the ability to capture and retain water.

Following compression tests, this study also

highlighted the **increased risks of rapid caking** of feedstuffs in the presence of glycerine, which suggests that glycerine should be added as late as possible prior to pelleting, and recommends **not storing feeds that contain glycerine for long periods**, such as in silo bins upstream of the press.

Lastly, bacteriological analyses have **not demonstrated any effect on feed preservation**, whether in terms of total flora, fungal flora or enterobacteria flora. A summary of observed effects is given in the summary table below.

	Feedstuffs	Mix power demand	Bulk density	% of clods	Moisture content	Aw	Press flow rate	Press power demand	Durability	Hardness
Pellets	Pig	↗↗	↘↘↘	↗	↘↘↘	↗↗↗	↘↘↘	↘↘	↗↗	↘↘↘
	Pre-starter piglet	↗↗	↘↘↘	↗↗↗	↘↘↘	↗	↘↘	↘↘↘	≈	↘↘↘
	Supplementary nitrogen	↗	↘↘↘	↗↗	↘↘	↗	↘↘	↘↘	↗↗	↘↘↘
	Broiler	↗	≈	↗↗	↘↘	↗↗	≈	↘↘↘	↗↗↗	↘
	Turkey	↗↗	≈	↗↗	↘↘	↗	≈	↘↘↘	↗↗	↘↘↘
	Beef cattle	↘↘	≈	↘	↘↘↘	↘	≈	↘↘	≈	↘↘
	Rabbit	↗	≈	≈	↘↘↘	↘	≈	↘↘	≈	↘↘
Coarse meal	Pig	↗	↘↘↘	↗↗	↘↘	↗↗↗				
	Laying hen	≈	↘↘↘	↗↗	↘↘	↗				
	Broiler	↗	≈	↗↗	↘↘↘	≈				

4. Conclusions

This study assessed the impact of adding glycerine to a range of feed formulations and feed formats, at varying rates of incorporation, in order to compare this co-product against others already in use. This datasheet summarises the most marked effects:

- **Risk of feeds in meal format caking in silos** and a recommendation not to store meals containing glycerine for long periods
- **Possibility of producing feedstuffs** that are both **softer** and more **durable** (pellets with greater resistance to mechanical stress)
- No particular benefit in reheating glycerine prior to incorporation
- **Decrease in the density of feeds** in meal format
- Slight increase in mixer power demand, leading to a slight increase in specific energy consumption at this station
- Decrease in specific energy consumption and, therefore, press energy costs due to a significant lubricant effect: nearly -3% of SEC / % glycerine for certain feedstuffs.
- Reduction in heating of the die, often the main factor in the destruction of heat-sensitive nutritional compounds

- No interaction with other liquids
- The quantity of clods increases when high glycerine contents are involved
- Possibility of decreasing available water and increasing Aw, but with no directly visible impact on certain bacterial flora

Lastly, this extensive study has also highlighted the **general lack of available data on the use of various liquids** in animal feeds and the value of furthering our insight in this area.