SCIENTIFIC RELEASE

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KIBBLE COATING: BACK TO BASICS

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KIBBLE COATING: BACK TO BASICS

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Palatability enhancers are widely used in the dry pet food industry. Available in liquid and powder form, they are traditionally applied in top coating to improve the aroma and taste of kibbles, providing a sensorial experience that attracts pets to the bowl and ensures that they enjoy their meals.

If the nature and dosage of palatants are crucial, the way they are applied on the kibbles is critical to reach an optimal palatability performance. Based on the combined know-how of pets' palatability drivers and pet food manufacturing process, Aplicalis experts in application from DIANA Pet Food have defined several good practices to achieve an optimal coating.

WHY IS THE COATING STEP ESSENTIAL TO PALATABILITY PERFORMANCE?

Palatants accessibility

Dry kibbles available in the market generally contain from 1 to 15% fat. In addition, depending on technical and cost constraints and targeted level of performance, pet food manufacturers may apply liquid (generally 1 to 4%) and/or dry palatability enhancers (generally 0.5 to 3%) on top of the kibbles.

Liquid and dry palatants as well as most part of the fat are generally applied in top coating. Previous studies combining sensorial evaluation and physico chemical analysis of kibbles conducted by DIANA Pet Food have already established **a link between the coating procedure, the availability of the palatant on the surface of the kibble, and the way it delivers palatability performance to pets.**

The top coating step must be done in such a way to make palatants as accessible as possible to the pet's nose and tongue.

Coating homogeneity

The repartition of palatability enhancers between kibbles also plays a significant role in palatability performance. Cats are for instance particularly sensitive to heterogeneous coating: they are able to detect kibbles which are not properly coated and select those which received a superior amount of palatability enhancer. In the study below, palatability tests were conducted in order to check the effect of a heterogeneous coating in cats.

An uncoated cat kibble base and a super premium dry palatability enhancer for cat were used to simulate a homogeneous and a heterogeneous coating:

- Homogeneous coating: a first batch of the uncoated kibble base was coated with 6% poultry fat and 1% dry palatability enhancer.
- Hetereogeneous coating: a second batch of the same kibbles base was coated with 6% poultry fat. After fat coating, this batch was separated into two parts. The first half was coated with 2% dry palatability enhancer and the second half didn't receive any palatability enhancer. Kibbles coated or not with the dry palatant were then mixed together.

Palatability performance of the homogeneously coated kibbles and the heterogeneously coated kibbles was assessed using versus tests conducted on 40 cats over 2 days in Panelis, DIANA Pet Food expert center in palatability measurement.

Effect of kibbles coating heterogeneity on cat food palatability

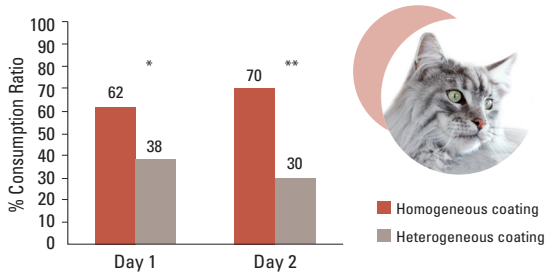


Figure 1: Comparison of palatability performance between homogenously coated and heterogeneously coated kibbles in cats

*=p≤0.05, **=p≤0.01,

Results presented in figure 1 demonstrate that **cats significantly prefer homogeneously coated kibbles to heterogeneously coated kibbles.**

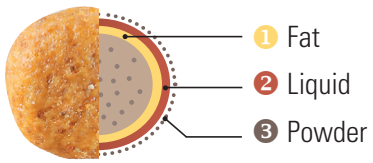
Make sure that palatability enhancers are evenly coated on all the kibbles is crucial to reach the maximal palatability performance.

HOW TO ACHIEVE THE BEST COATING

RULE N°1: Respect the sequences

The method and order of incorporation of the topical fat and palatants directly impact palatant accessibility. In order to reach the best performance, **it is essential that the fat, liquid palatant and powder palatant are applied separately**, with sufficient incorporation and mixing times between each sequence (Figure 2).

Coating ideal sequences



1 **Fat spraying** for minimum 60 seconds then mixing time for 45 to 60 seconds

2 **Liquid palatant spraying** for minimum 60 seconds then mixing time for 45 to 60 seconds

3 **Dry palatant dusting** for minimum 60 seconds then mixing time for 60 seconds

Figure 2: Coating sequences to respect for a homogeneous kibble coating

If the sequences are not respected, embedding phenomenon may occur. For instance, if some fat is sprayed after or simultaneously with a palatability enhancer, some palatant may be encapsulated in the fat which would lower its accessibility and thus the palatability performance.

Figure 3 presents palatability results obtained at Panelis when comparing different coating sequences in an expert dog panel with versus tests. In the first test, kibbles coated primarily with 6% of poultry fat, and secondly with 3% of a super premium liquid palatability enhancer were compared to kibbles coated with a homogeneous mix of 6% poultry fat and 3% of the same liquid palatant.
The second test consisted in comparing kibbles coated firstly with 6% of poultry fat and secondly with 1% of dry super premium palatant, to kibbles coated with a mixture of 1% of the same dry palatability enhancer homogeneously dispersed into 6% of poultry fat.

Impact of coating sequences on dog food palatability performance

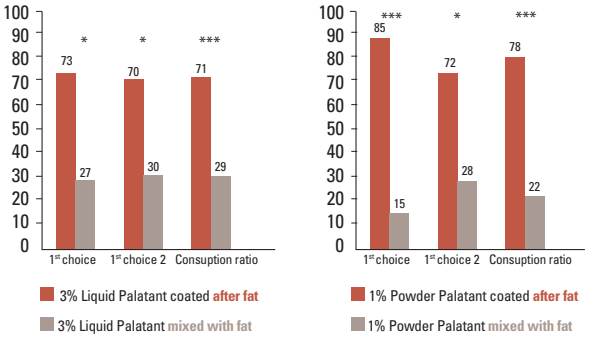


Figure 3: Comparison of palatability performance in dogs of liquid and powder palatants applied after fat or mixed with fat

*=p≤0.05, ***= p≤0.001

In both cases, the **dogs showed a significant preference for kibbles coated in sequences over kibbles coated with a mixture of fat and palatants.**

The first and most important rule to achieve effective coating is to respect a sequential application of topical fat and palatability enhancers.

RULE N°2: Take specific care with dosage, distribution and mixing

For each of the three sequences defined previously, five main coating parameters are critical to achieve an effective coating:

- **Dosage accuracy**
- **Distribution surface**
- **Incorporation duration**
- **Mixing time**
- **Mixing intensity**

In order to assess the impact of these process parameters on coating quality, it is necessary to have a reliable method to measure precisely the amount of palatability enhancers really applied on the kibbles. Aplicalis experts in petfood process and application, have developed **a unique method to measure the real amount of dry palatability enhancer applied onto individual kibbles using an internal tracer.** In that method, 50 to 100 kibbles are individually weighed and analyzed. The quantity of tracer present on the kibbles' surface is determined based on the comparison of the colorimetric results to a standard, and the real quantity of powder applied on the kibble is finally calculated.

This coating diagnosis method was used to compare the repartition of dry palatant on 2 batches of kibbles obtained with different coating parameters in a batch coater. In both cases kibbles were initially coated with 6% of poultry fat for 60 seconds followed by 60 seconds of mixing. Then, kibbles were coated with 1% of dry palatability enhancer as follows:

- For the first batch, the powder was incorporated for 5 seconds followed by a 5 second mixing step.
- For the second batch, the powder was incorporated for 60 seconds and the kibbles were then mixed for 120 seconds.

The kibbles mixing intensity was identical, and, for each batch, 50 individual kibbles were analyzed. Figure 4 shows the real dry palatant rate measured on the surface of each kibble.

Real amount of dry palatability enhancer found on kibbles coated with different coating parameters

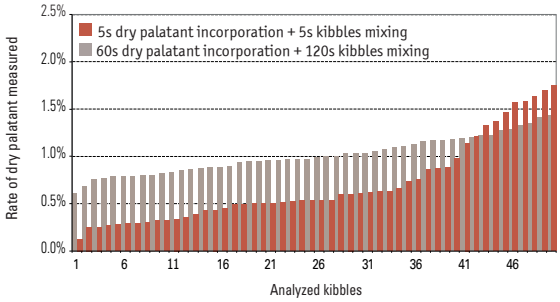


Figure 4: Impact of dry palatant incorporation length and kibbles mixing duration on coating efficiency - Each bar corresponds to one kibble

For the first batch, only an average of 0.77% of dry palatant was measured on the kibbles, with a coefficient of variation of around 16%. As for the second batch, an average of 1.01%, i.e. the totality of the dry palatant, was found on the final kibbles and the coefficient of variation was reduced to 6.8%. **Higher incorporation duration and kibble mixing time improve the efficiency of powder binding and favor a homogeneous repartition of palatant between kibbles.**

Selecting appropriate equipments and settings for the dosage, distribution and mixing steps is key to maximize the coating efficiency and thus the palatability performance.

AN ACCURATE DOSAGE FOR A CONSTANT PERFORMANCE

A precise dosage allows ensuring the application of a constant defined amount of topical ingredients. This contributes to reach the targeted palatability level while remaining within the cost constraints.

Fat and liquid palatants dosage: better with volumetric pump

To dose fat and liquid palatability enhancers precisely, positive displacement pumps - commonly called volumetric pumps - should be preferred over centrifugal pumps. Indeed, positive displacement pumps such as helical rotor, lobe pumps or gear pumps operate by alternating filling a cavity and displacing a given volume of liquid. These pumps deliver a constant volume of liquid for each cycle regardless of the pressure.

Since the volume of liquid is constant through each cycle of operation, positive displacement pumps present a good correlation between the speed of the pump and the resulting product flow. Nevertheless, **it is necessary to calibrate the pump depending on the density, temperature and viscosity of the liquid, as well as the pipe configuration between the pump and the coater**

Liquid density in particular has a significant impact on the resulting flow. It is thus highly recommended to check and set up calibration dosing curves for every pump and for each liquid applied. Figure 5 shows the calibration curves obtained for a liquid palatability enhancer (density = 1.1 kg/liter), for water (density = 1.0 kg/liter) and for a vegetable oil (density = 0.95 kg/liter) at 25°C with a helical rotor pump. In that case, if a flow of 15 kg/h is targeted, pump speed should be 57% for liquid palatant, 68% for water and 78% for vegetable oil.

Example of volumetric pump calibration

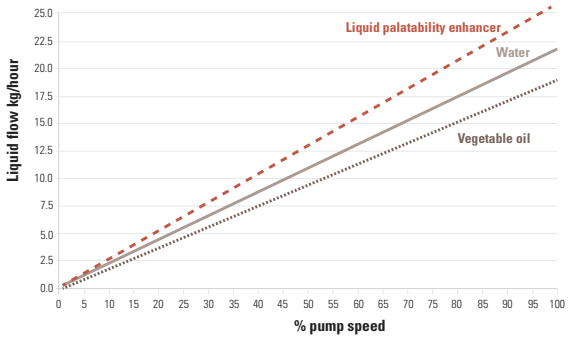


Figure 5: Helical rotor pump calibration: liquid flow with relation to working speed

Pipe configuration between the pump and the coater also impacts the flow since pressure losses may occur due to length, height, bends, filters, flow-meters... Therefore, it is important to weigh the dosed product at the end of the line and not only at the outlet of the pump when calibrating the pump.

To make sure that dosage system is efficient, an online dosage mastering tool might be set up in order to continuously verify the applied quantity and to detect potential pump malfunctions.

Powders dosage : optimal with loss-in-weight method

In the pet food industry, powder is usually dosed with either volumetric or loss in weight feeders. Even if volumetric feeders are quite reliable, some dosage disturbance may occur depending on the filling level of the hopper. Using a constant screw(s) rotation speed, the volumetric method tends to deliver higher powder flow when the hopper is fully filled than when it is almost empty. To minimize this inconsistency the hopper has to be frequently re-filled.

Loss-in-weight feeders are more accurate because the speed of screw(s) is continuously adjusted with relation to the measured weight loss.

The atmosphere in the coating area can be quite humid and powder lumps may build up in the hopper. It is recommended to equip the powder feeder with a bridge-breaker whatever the system used.

AN EFFECTIVE DISTRIBUTION FOR A MAXIMIZED HOMOGENEITY

The quality of topical ingredients distribution on the kibbles is a key factor to get a homogeneous coating. Fat and palatants have to be spread on a large surface of kibbles in movement, during a sufficient time, to be distributed equally on all the kibbles.

Fat and liquids spraying: the importance of nozzles

Fat and liquid palatants are traditionally sprayed using nozzles. In order to reach an effective distribution, it is necessary to dispense the liquids by **forming a large and homogeneous spray, during an adequate time.** A minimum spraying of 60 seconds is recommended.

Nozzles are grouped under two categories, airless and pneumatic ones:

- **Airless spray nozzles** utilize the kinetic energy of the liquid to break it up into droplets. As the liquid pressure increases, the flow through the nozzle increases, and the droplet size decreases. The nozzle has to be selected according to the flow rate, the pressure and the desired spray angle. For this type of nozzle, the working pressure for liquid palatability enhancer should be between 1 and 6 bars

- **Pneumatic nozzles** use compressed air. Shearing between high velocity compressed air and low velocity liquid disintegrates the liquid stream into droplets, producing a high velocity spray. Air and liquid pressures can be adjusted to optimize the spray shaping. For instance, finer atomization is achieved by increasing the air pressure and/or lowering the liquid pressure. The pneumatic nozzle hole is usually larger than that of the airless nozzle, which lowers the risk of clogging with particles.

To get efficient spray shaping, it is recommended to use **pneumatic nozzles when the liquid flow is lower than 2 kg/min, and airless nozzles when the liquid flow exceeds 2 kg/min**

Whatever the system chosen, it is advised to equip the coater with **several nozzles of different capacities, ideally separated with intermediate pneumatic valves** (Figure 6). This configuration brings more flexibility to the system: working nozzles can be selected according to the flow rate needed for each formula in order to get a correct shaping during a sufficient time.

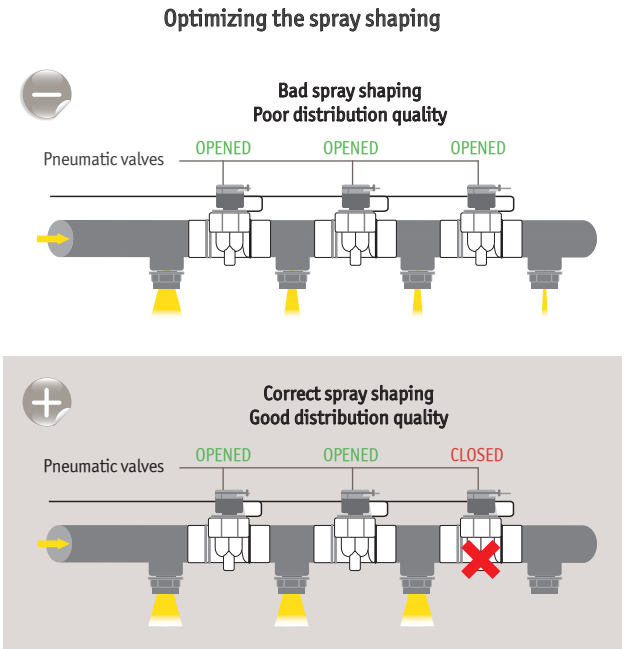


Figure 6: Working nozzles number selection according to liquid flow rate

Additionally, **the spray nozzles' position in the coater has to be carefully evaluated.** If the nozzles are too close to the kibble mixing area, the distribution is decreased. On the contrary, if the distance is too high, some droplets can be lost, creating an undesired mist. The spray should also be directed to the area where the kibbles are in movement (Figure 7).

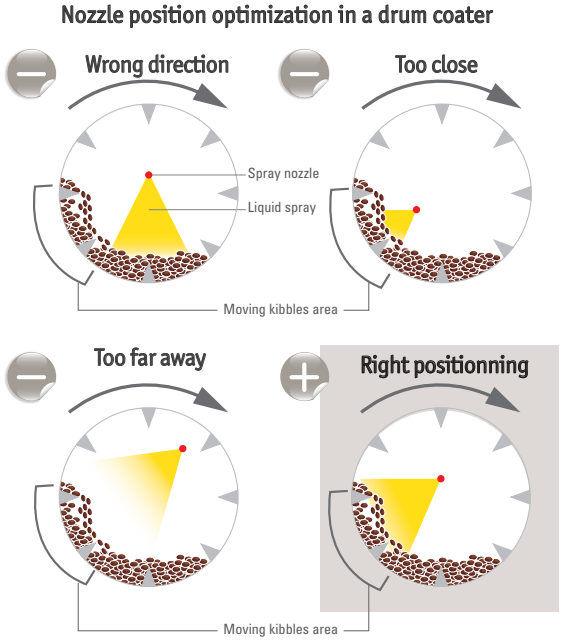


Figure 7: Impact of nozzle position in a drum coater on palatant distribution efficiency

Powder dusting: vibratory distributors and electrostatic coating

As for liquids, **palatability enhancers in powder form have to be spread on a large surface and during a sufficient time in order to be in direct contact with the maximum amount of kibbles.** Letting the powder drop directly at the outlet of the feeder is usually not sufficient. The target is to have a consistent uninterrupted flow of powder during its application, which should last around 60 seconds to be effective.

Several types of equipment can be set up for this purpose such as vibratory spreaders or electrostatic coaters:

- **Vibratory spreaders** use vibration to transport and distribute the powder on the total width of its dispenser. The dispenser width should be adapted to the kibbles flow span and the right vibration frequency has to be determined to match the desired dry palatant flow.

• **Electrostatic coating** can also be considered to improve dry palatability enhancer application. During electrostatic coating, an ionized air flow charges the dry palatant particles (positively or negatively). The resulting charged powder is then attracted by the nearest grounded kibble creating an evenly distributed cloud over the kibble (Figure 8).

Electrostatic coating principle

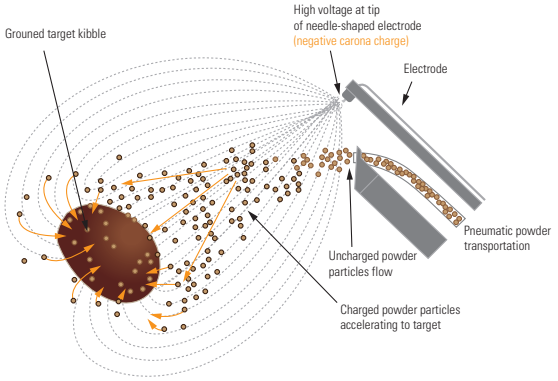


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Figure 8: Powder palatant coating using electrostatic system

A RIGHT MIXING FOR AN OPTIMIZED REPARTITION

Kibbles mixing steps conducted during the coating process are key to ensure an adequate repartition of fat and palatants on all the kibbles.

Two main mixing characteristics need to be carefully managed:

• **Mixing intensity:** the more dynamic the kibbles movement, the higher the number of kibbles in direct contact with the liquid sprays or powder distribution area... and the higher the risk of abrasion! The right mixing intensity has to be found in order to optimize fat and palatant repartition while avoiding kibble breakage and fines creation.

• **Mixing time:** kibbles residence time in the coater has also to be optimized to guarantee an efficient exchange of fat, liquid and dry palatability enhancers between over-coated and under-coated kibbles.

According to coating equipment configuration, various parameters need to be controlled to reach ideal mixing time and intensity thus optimized topical ingredients repartition.

Continuous coating

There are two main ways to put the kibbles in movement in continuous coaters:

• **With the rotation of the container** itself as for drum coaters

• **With internal shaft(s) rotation** as for paddle or ribbon mixers

For both types of continuous coaters several parameters have to be controlled to achieve the right mixing.

> For coaters using container rotation to put kibbles in movement, the key factors to manage are **the rotational speed of the drums, the kibbles filling level, and the coater angle of inclination**

> For coaters equipped with internal shaft mixers, the main elements to monitor are **the rotational shaft(s) speed, the orientation and length of the mixing elements (such as paddles or ribbons), and the kibbles filling level.**

Furthermore, other parameters linked to equipment specificities can be controlled to optimize the mixing step. For instance, for coaters using double shaft paddles, the rotational direction of the shafts plays a significant role on coating quality. In figure 9, the rotation configuration in red tends to split the kibbles into two distinct clusters leading to higher risk of coating heterogeneity. On the contrary, the rotation configuration in green contributes to create a single area where many kibbles are concentrated. Fat or palatability enhancers could then be efficiently distributed on that specific zone. This configuration also contributes to a positive kibbles mixing.

Mixing optimization in a double shaft mixer

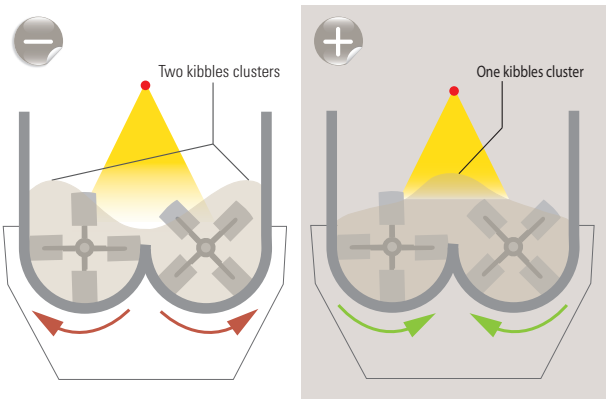
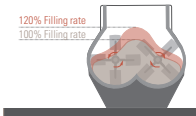


Figure 9: Double shaft mixer rotation configuration impact on kibbles concentration

Batch coating

The kibble mixing dynamic is usually well handled with batch coating. What is more complicated with this technology, is to have **a sufficient coating cycle duration to carry out mixing steps of adequate length between each distribution sequence**. If necessary, the coating cycle duration can be optimized by modifying the uncoated kibbles filling rate in the coater. Coater suppliers commonly state that increasing filling rate up to 120-130% of the nominal capacity does not significantly reduce mixing efficiency. Figure 10 presents a solution to balance the coater filling rate and the coater cycle duration in order to get an optimal application without altering the production yield.

Batch coater filling rate increase for an optimal application



	100% filling rate	120% filling rate
General settings		
Production flow	**5 Mt/h**	
Coater nominal working volume	1000 L	
Kibble density	450 g/L	
Weight per cycle	450 kg	540 kg
Coating cycles per hour	11.1	9.3
Available time per cycle	324 s	389 s
Coating cycle steps duration		
1) Uncoated kibbles loading	15 s	15 s
2) Fat spraying	60 s	60 s
3) Mixing	**39 s**	**60 s**
4) Liquid palatant spraying	60 s	60 s
5) Mixing	**38 s**	**60 s**
6) Dry palatant dusting	60 s	60 s
7) Mixing	**38 s**	**60 s**
8) Coated kibbles unloading	14 s	14 s

Figure 10: Impact of filling rate increase on coating steps duration

CONCLUSION

Using palatability enhancers is essential to ensure dry food attractiveness to pets. Due to cats and dogs high sensitivity to coating homogeneity, making sure that liquid and powder palatants are evenly coated on all the kibbles and easily accessible is crucial to reach the maximal palatability performance. Pet food manufacturers willing to make the most of palatants potential thus need to follow several recommendations.

Performing a sequential coating by applying fat, then liquid palatability enhancers, and ultimately dry palatability enhancers, is the first rule to respect. For each of these sequences, topical ingredients must be dosed accurately and distributed on a large surface, during a sufficient time. Moreover, mixing steps of adequate durations have to be set after each topical ingredient incorporation. Kibbles should be well agitated all along the coating process.

These basic guidelines allow ensuring an efficient fat and palatants coating. However, each pet food installation being unique, these advices need to be adapted to each equipment constraint. Upon request, Aplicalis experts are available to provide pet food manufacturers with personalized recommendations tailored to their problematic.

IF YOU NEED FURTHER INFORMATION, DO NOT HESITATE TO CONTACT THE AUTHOR

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