Solubility Issues with Milk Replacer Powders—An Easy Fix

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Abstract: Wildlife rehabilitators caring for young mammals prepare and use milk replacement formulas. Most rehabilitators, over the years, have dutifully followed the mixing instructions indicated on product labeling. Instructions generally say to add water, gently stir, and the liquid formula is ready to use. This paper discusses issues related to these products' lack of complete solubility, laboratory tests performed to measure insolubility, and minor adjustments to formula preparation that easily address these issues.

Key words: milk replacement powders, milk powder solubility, reconstitution of milk replacement powder, milk powder formula preparation for wild mammals

Solubility Issues

For the past several decades, milk replacement powders have been used in the preparation of formulas fed to orphaned wild mammals in rehabilitation. The milk powders and recipes varied depending on species being fed. Mixing instructions on product labels were relatively consistent: add water to the milk powder, stir gently, and feed. The formulas were warmed before feeding. Many rehabilitators followed these instructions, with many feeding the formula immediately after preparation since the milk powders generally were considered an 'instant mix.'

In the summer of 2009, rehabilitators began reporting noticeable separation within mixed formulas using Esbilac® (PetAg®, Hampshire, IL) milk powders (WildAgain 2011). PetAg® acknowledged, in December 2008, they had changed from a multistep drying method to a single–step spray drying (SSSD) process for Esbilac®. During phone conversations, PetAg® staff suggested using warmer water would be beneficial when mixing such SSSD manufactured powder. Esbilac® labels, however, did not then and still do not reflect these 'updated' instructions.

A review of published research (Baldwin and Truong 2007; CEININ 2004; Harper et al 1963; Howat and Wright 1933; Howat and Harris 1933; Karmas, Endel, and Harris 1988; Onwulata 2005) on milk powder production provided further information about drying methods and solubility considerations. The Wisconsin Center for Dairy Research (WCDR 2010) further explained the differences of milk drying methods and their effects on preparation and use. The WCDR indicated reconstitution would benefit significantly by using hotter, but not boiling, water (about 175°F, 80°C) and allowing a longer resting time after mixing to provide more complete reconstitution of powder prior to use, especially with powders manufactured using the SSSD method.

Based on suggestions from WCDR, a series of tests were conducted to measure the effects of preparing various powdered milk replacer products (WildAgain 2012). The testing methodology used combinations of four variables: (1) warm tap water at 125°F (52°C); (2) water heated to 175°F (80°C); (3) immediate use with no resting time after mixing; and, (4) allowing mixed formula to rest four hours prior to use.

A sample of Esbilac® powder was mixed per label instructions to see if the product would be reconstituted as effectively as in the past. This first test conducted with Esbilac® manufactured by the SSSD method, however, showed considerable separation indicating a surprising degree of unwetted powder, as shown in Figure 1, when mixed according to label instructions for immediate use. The same tests then were conducted on milk powders from different manufacturers (Figure 2). The test results showed the milk powders had varying degrees of insolubility when prepared by label instructions. Often the liquid formula initially appeared smooth and fully reconstituted, as in Figure 1 at the one–minute time; however, after only a short

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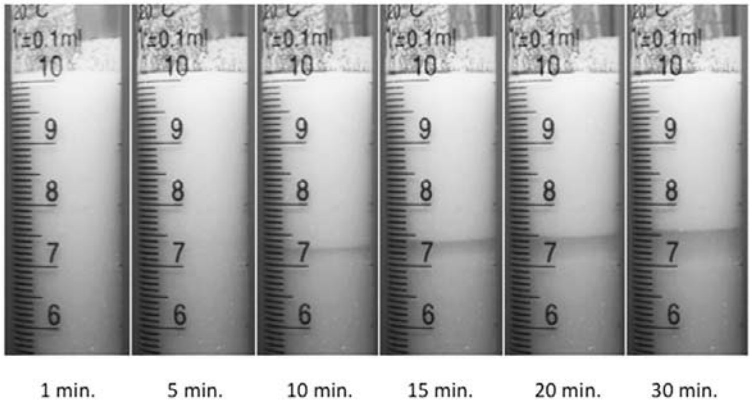


Figure 1. Esbilac® (Lot #0919E) mixed 1:2 with 125°F (52°C) water per label instructions and stirred for 30 seconds. Note the distinct three–stage separation at five–minute intervals, with unwetted powder floating to the top, a layer of translucent oil in the middle, and very dilute formula on the bottom layer.

amount of time, in this case 5 to 10 minutes, unwetted powder floated to the top.

Figure 3 shows the results of these tests and the amount of unwetted powder after 30 minutes. In all these cases, using water at a higher temperature and allowing a longer resting time decreased the amount of unwetted powder. Much of the separation, where noted, actually became very apparent after only 15 minutes rest time. A rehabilitator feeding formula from an opaque container may not realize the powder is not fully wetted or dissolved, or is beginning to separate.

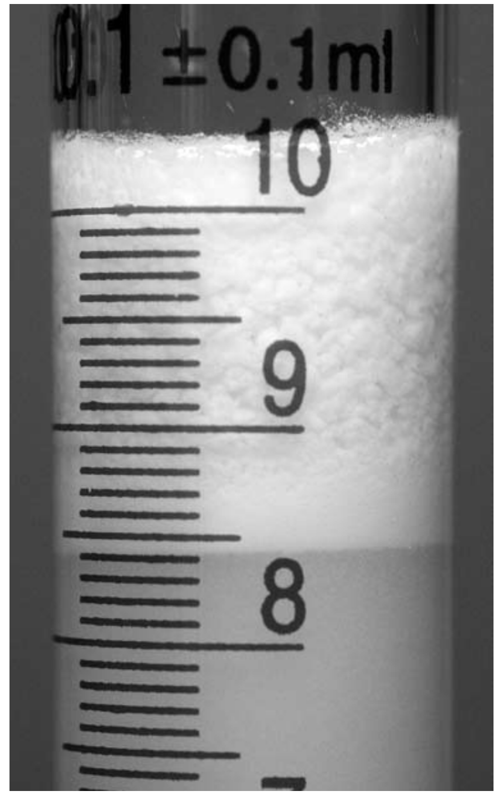


Figure 2. Example of unwetted PetAg® MultiMilk® powder (Lot#0476) that formed 30 minutes after mixing with 125°F (52°C) water per label instructions.

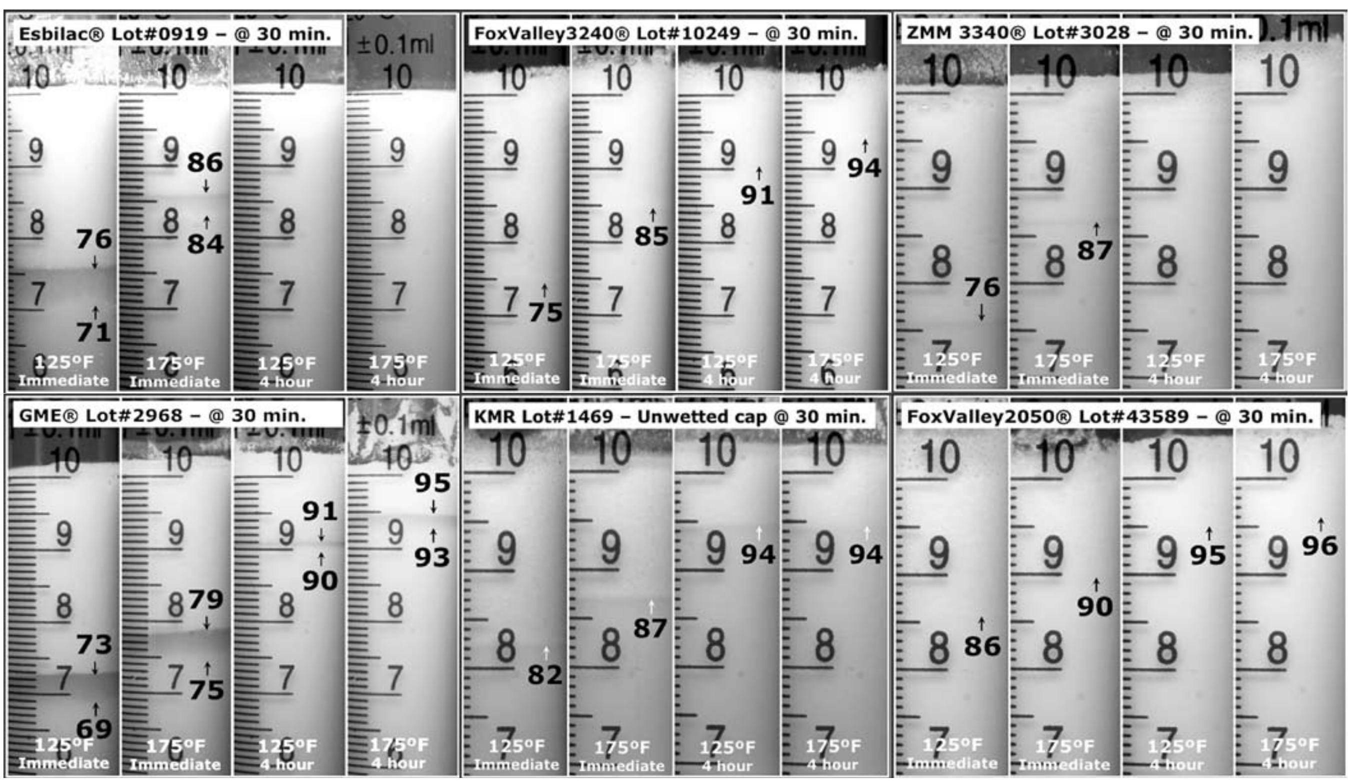


Figure 3. Level of unwetted powder in various milk replacer products after 30 minutes when product mixed at a ratio of 1:2 with warm versus hot water temperature, and when tested for immediate use versus formula resting for four hours. Legend: ZMM = PetAg® Zoologic® Milk Matrix; GME = PetAg® Goats Milk Esbilac® for Puppies.

Additionally, depending on the number of animals fed from freshly mixed formula, the rehabilitator may finish all feedings in less than 30 minutes without realizing the formula is separated or not fully wetted.

Different Water Temperature Tests

Use of hot water is essential to achieve reconstitution of most powdered milk replacers containing a relatively high fat content (approximately 40% or greater of dry matter). A minimum water temperature of about 110°F (43°C) is generally required to begin the liquefaction of the various fats contained in the powder, especially animal fats such as in the PetAg® MultiMilk® product. Many then would believe that using very warm tap water (around 125°F, 52°C) is sufficiently above this 110°F (43°C) minimum temperature. However, this is not the case.

When working with dry milk powders, the user needs to be mindful of some basic principles of chemistry and physics. Heat is a form of energy, sometimes called thermal energy, which can pass spontaneously from an object at a high temperature to an object at a lower temperature. If the two objects are in contact, given sufficient time they both reach the same temperature, achieving thermal equilibrium. In the case of mixing warm or hot water with milk powder that may be at room temperature or lower, the same thermal equilibrium reaction occurs and in effect serves to lower the water temperature and raise the powder temperature, until both are the same temperature when mixed. How much does the water temperature cool in this mixing process? Actually, it drops quite a bit, as much as 20 to 30 percent.

During the tests performed to determine the solubility of various milk replacer powders, both hot tap water (125°F, 52°C) and water from an instant hot water dispenser (175°F, 80°C) were used. As shown in Figures 4 and 5, a significant issue with using either source of water is the rapid cooling effect when mixing with a dry product (at either room temperature or refrigerated) over the 30–second mixing period.

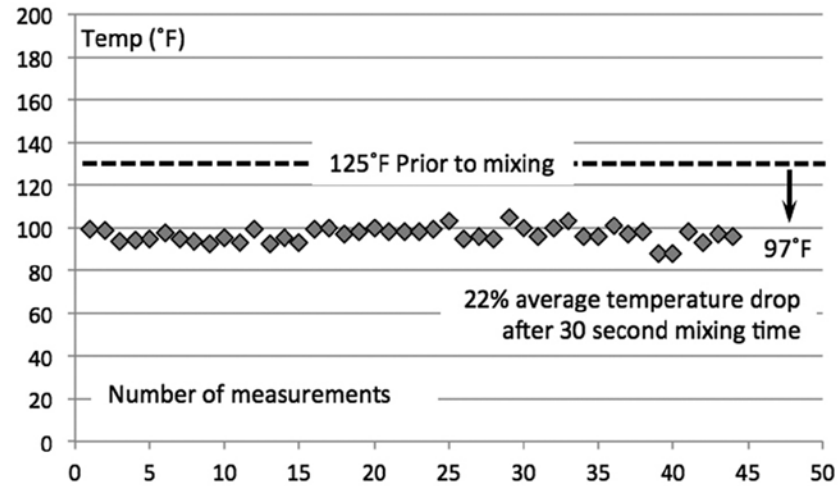


Figure 4. Temperature of formula drops almost 30°F (–1°C, 22%) on average to approximately 97°F (36°C) after mixing with 125°F (52°C) water for 30 seconds, which is below the target temperature of 110°F (43°C) to achieve optimal liquefaction of fats in the powder.

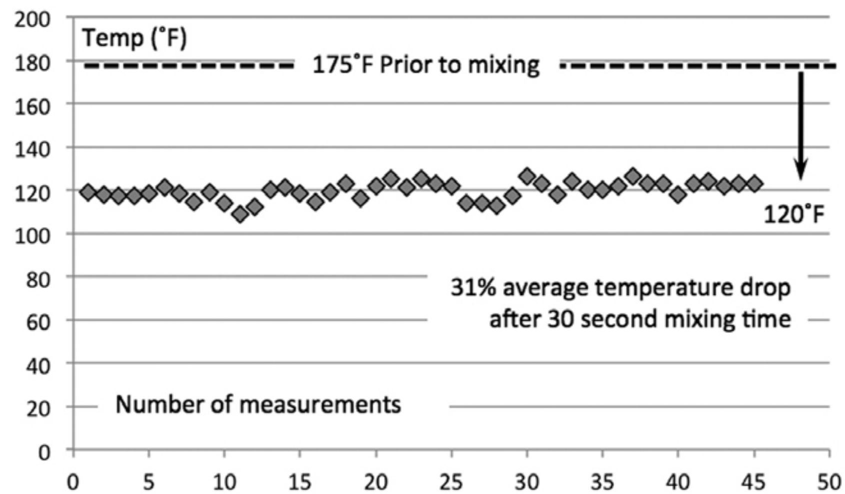
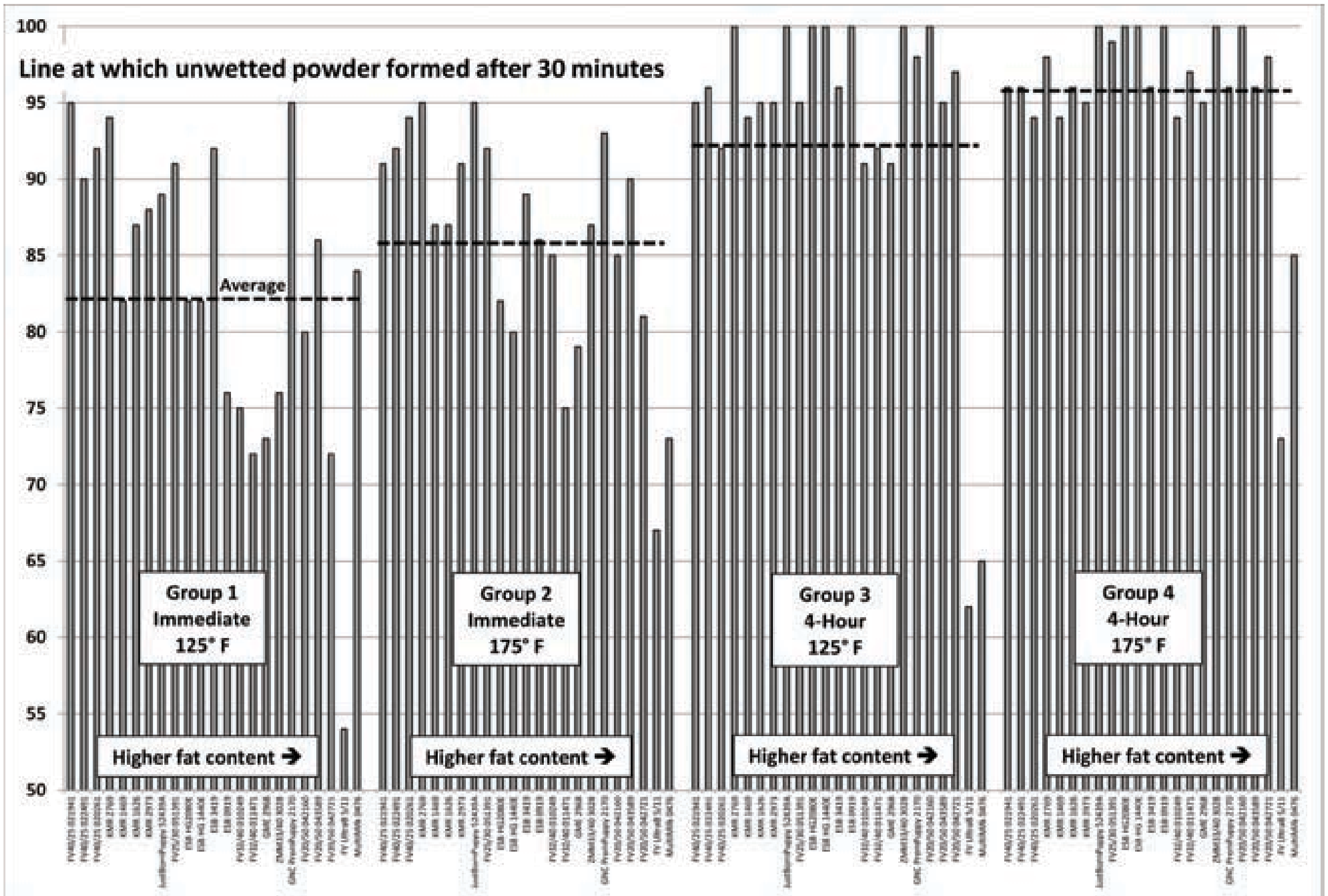


Figure 5. The mixed formula temperature dropped even farther (an average 55°F [13°C] drop or 31%) when much hotter 175°F (80°C) water is used, but resulted in an average temperature of 120°F (49°C), which is above the desired 110°F (43°C) to liquefy fats resulting in more complete reconstitution.

Hotter Water and Longer 'Resting' Time

Table 1 shows the results for 23 different product/lot combinations in these same tests using varying water temperatures and hydration times. The test results using milk powders from a variety of manufacturers, including PetAg®, Fox Valley Animal Nutrition, and others, illustrate several trends. First, the higher fat content powders demonstrated the most unwetted powder at any combination of water temperature and hydration time, indicating the fats are far more difficult to reconstitute than other solids contained in the powders. Second, in almost every test trial, use of higher water temperature yields less unwetted powder than does using tap water at around 125°F (52°C).

Table 1. Test results for 23 different product and/or lot samples. The dotted line indicates the average level at which unwetted powder appeared. Note: The average lines with higher values, such as shown in Group 4, indicate more complete reconstitution of product powders. Legend: FV = Fox Valley Animal Nutrition, Inc; KMR = PetAg® KMR® Kitten Milk Replacer; Just Born = Farnam Just Born® Milk Replacer for Puppies; ESB = PetAg® Esbilac®; GME = PetAg® Goats Milk Esbilac® for Puppies; ZMM = PetAg® Zoologic® Milk Matrix; PremPuppy = GNC Ultra Mega Premium Milk Replacer; MultiMilk = PetAg® Multi–Milk®.



Third, the most significant and beneficial influence on the solubility is to allow a longer hydration time of at least four hours in the refrigerator prior to warming and feeding, rather than simply utilizing the powders as an instant mix ready for immediate use.

Inadequately Reconstituted Formula

Inadequately reconstituted milk powders can lead to gastrointestinal disorders such as bloat, diarrhea, and gastrointestinal (GI) inflammation. Continuation of such GI problems can result in secondary infections, developmental and growth problems, and even fatalities. Young animals, especially infants, simply do not have digestive systems sufficiently developed to serve as an internal blender of sorts, attempting to process simultaneously both unwetted powder and water in the GI tract to obtain nutritional requirements and hydration needs. Ingestion of unreconstituted powder can result in incomplete digestion, utilization, and absorption. Consider an analogy of feeding a human infant powdered milk product and water simultaneously, but without prior mixing—and expecting a successful outcome.

A Simple Solution

As demonstrated by the laboratory tests and clearly shown in Table 1, an easy remedial action was developed and tested. Guided by the laboratory test results, simply using the hotter water temperature, premixing four hours prior to use, and storing in the refrigerator, the amount of unwetted powder is reduced by 76 percent, on average, between the 23 products/lots tested, as shown comparing Group 1 and Group 4 in Table 1. Some products resulted in zero percent unwetted powder using this preparation method.

Rehabilitator Reports

WildAgain makes this information available about the improved solubility using warmer water (about 175°F, 80°C) and allowing the formula to 'rest' in the refrigerator to hundreds of rehabilitators via training, publications, and websites. Many rehabilitators reported the more fully reconstituted formulas seemed more easily digested and showed less indication of gastrointestinal upset, such as bloat, diarrhea, and constipation, when fed a formula recipe that meets the animal's nutritional needs. Additionally, more complete digestion seems to allow better utilization of nutrition in the formula, which appears especially important for very young mammals for which formula is the sole source of food and nutrition.

Rehabilitators report some planning is required for formula preparation a minimum of four hours in advance of use. For new admissions, this four–hour wait period generally has not been an issue, as most new admissions require some level of hydration therapy prior to beginning formula. In other cases, the rehabilitator must estimate the amount of formula generally needed in the next day or two, and then simply prepare that amount in advance—which actually reduces the number of times formula is made each day and helps save time.

Conclusion

Just as rehabilitators must be alert to changes in wildlife practices, medicine, and so forth, it becomes necessary that they also monitor changes in manufacturing processes in the array of products used. As shown, the effects of manufacturing changes can be significant and potentially life threatening for wild animals in rehabilitation. With the wildlife rehabilitation community viewed as a relatively small market by milk replacer manufacturers, the research described above almost always falls to the rehabilitation community to perform and fund. It is critical that as a community, rehabilitators recognize there are a wide variety of challenges involved with rehabilitating wildlife, identifying and communicating potential concerns in a timely and complete manner, and using a collaborative problem–solving approach. Sometimes, such as in this case, factors changed that were beyond our control—but not beyond our ability to create a workable solution.

Test Methodology

The complete laboratory solubility test methodology is available at <Ewildagain.org>, along with independent laboratory component analysis of 45 different product and/or lot combinations. More products are being tested and added to the site on a regular basis.

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