Ingredient Receiving and Sampling

Determining ingredient quality prior to diet formulation or feed manufacturing is an important tool for precision feeding in swine production. Visual appearance, microbiological and chemical analysis tests are commonly used to determine quality of ingredients. Inspecting grains at receiving gives opportunity to file deficiency claims. Supplier relationships and monitoring procedures are critical for ensuring quality ingredients. Evaluating the receiving procedures and collecting samples for testing will provide information for adjustments needed to provide quality feed (Figure 1).

Sampling

Equipment

To determine the best sampling equipment, the length of the tool should reach the bottom of the container being sampled (Table 1). Larger diameters should be used for whole grain ingredients and smaller diameters used for ground ingredients. Equipment used to provide a representative sample include grain probes and sampling triers (Figure 2). When using a grain probe, the probe should be closed when inserted into the product and then twisted to reveal holes, allowing grain to flow in. Equipment used for cut-stream sampling includes pelican samplers or PVC pipe samplers.

Representative sample

Results from ingredient analysis can only be as good as the sample taken. Therefore, a sample must be representative of the entire lot to be meaningful. Sample timing and location must be considered. A representative sample for free-flowing and static material can be obtained by either timed collection every 1 to 5 minutes during the unloading process or strategically sampling at predetermined locations of bags or bulk containers. For automatic sampling, proper installation where a representative sample of material can be obtained and specific timing of when the sample is taken will determine the quality of the sample. Another option is cut stream sampling during unloading, depending on safety and accessibility. The sample should be taken in the middle of the load and stream flow may need to be reduced while collecting to prevent overflow of the sampler equipment. Collection should be a side-to-side sweep of the sampler, collecting the entire stream. A pre-unloading sample used for visual inspection is another option where the receiving pit cover remains in place and a small amount of ingredient is let out onto the cover to be used for visual inspection or analysis prior to unloading. Approximately 1-lb samples should be collected to be used for analysis and sample retention. For sample preparation please refer to the "*Ingredient analysis*" section below.

Sample frequency

Determining when official analysis via commercial laboratory is necessary will depend on the concern. However, when evaluating a new supplier, proximate analysis should be used to assure ingredient quality with a commercial laboratory or on-site QA laboratory. Testing should be more frequent for byproduct and alternative ingredients (Table 2).

Sample labeling and storage

Labeling should be done to ensure proper sample identification and include a minimum of sampling date, ingredient name, lot ID, and sampler identification (Table 3). Containers used for sample storage should be cleaned prior to use. Plastic bags or sterile plastic bags are best used for dry ingredient storage. Liquid samples should be stored in plastic or glass containers. Samples are best stored in a refrigerator or freezer, however, if

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storage space is limited, sample priority for freezers should be highest to lowest moisture content and lowest to highest frequency of use. Storage outside of a freezer or refrigerator should still be in a cool, dry place with low humidity. Samples should not be retained past ingredient shelf life when stored outside of freezer. Retained samples should be kept at minimum while the ingredient is being used and depending on the associated risk of spoilage or biological hazards thereafter.

Figure 1: Flow chart for quality control of raw materials and the feed manufacturing flow. (Adapted from PHILSAN, 2010)

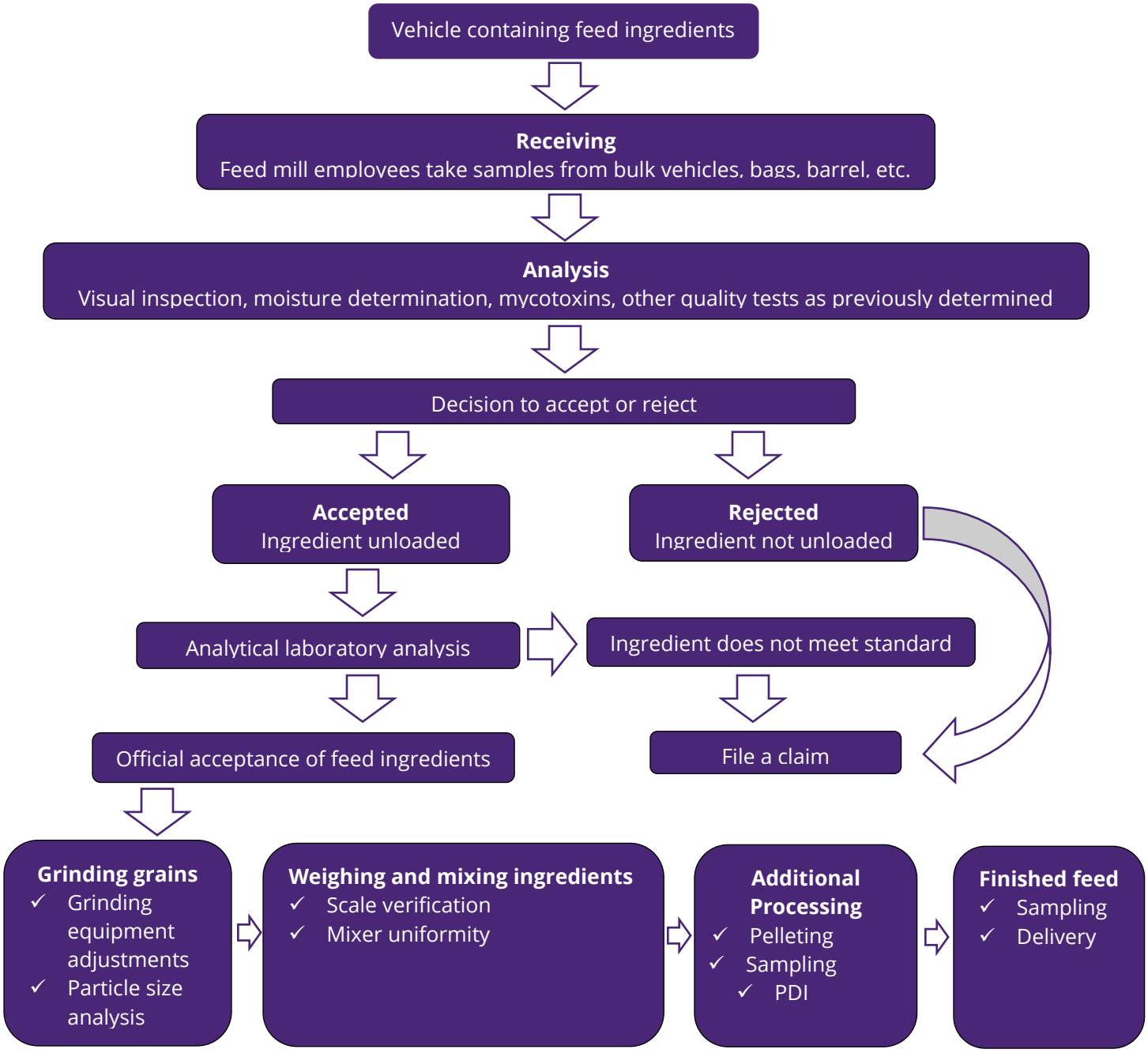

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Table 1. Sampling tools based on container size (adapted from Lissolo 2005)				
	Manual		Automated	
Container Size	**Dry Material[1]**	**Liquid Material[2]**	**Dry Material**	**Liquid Material**
Bag/Drum	a probe, 1-in diameter, double tube, without compartments	Glass/stainless tube 3/8 to ½-in diameter	---	---
Bulk Truck	a probe, stainless, aluminum, brass, 1 3/8-in diameter 40 to 50-in long	Bomb/zone sampler	Diversion[3] Gravity flow[4] Tube and Screw[5] Slide Gate[6] Retractable-Tube[7] Mechanical Probe[8]	Continuous flow[9] Pressure-Pipeline[10] Cylinder-Probe[11] Vacuum[12]
Rail Car	a probe, stainless, aluminum, brass, 1 3/8-in diameter 72 to 120-in long	10 ft core sampler, aluminum, 2-in diameter		

[1] Dry materials in motion can be sampled with a pelican sampler approximately 18 × 2 × 6-in to crosscut the entire stream of flowing material.
[2] Liquid materials should be stirred or agitated before sampling. If drip sampling, allow material to flow prior to taking the sample to prime the line.
[3] Diversion sampling – cross cuts the entire stream of material, similar to pelican sampling.
[4] Gravity flow – rotating, slotted tube projected through or into the flow line for dry, free flowing material
[5] Tube and screw – rotating, slotted tube projected through or into the flow line that uses a screw to move sample material, typically used for auger sampling.
[6] Slide gate – places inside a screw/drag conveyor, slide gate opens to allow material to be sampled.
[7] Retractable tube – extends a sampling tube for a predetermined period and then retracts
[8] Mechanical probe – pneumatic probe sampler.
[9] Continuous flow – bleeder line of 3/8 standard pipe, located at the vertical section of pumping line where material is being pumped continuous. Sample should be taken by opening and closing for 1 minute (fats and oils).
[10] Pressure-Pipeline – valve controlled by signal and mounted to flow line or bypass (molasses)
[11] Cylinder probe – similar to retractable tube for dry ingredients
[12] Vacuum – use of a vacuum controlled by timer or flow meter signal

Figure 1: Example of a double tube grain probe (top) and bag trier (bottom; Gibson Company).

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Receiving procedures

Documentation

Prior to accepting an ingredient, trucks and documentation need to be inspected. Feed mills must be registered and in compliance with the Bioterrorism Act for record keeping and traceability. Transporters and non-transporters (feed mills) must maintain records that identify both transporter and non-transporter supplier and recipient. Transporters must maintain records of origin, date received/delivered, quantity, product description, route, transfer points. Non-transported must have previous source, date of receipt/outbound shipment, product, quantity, transporter, supplier/lot code number. Records must be kept for 2 years.

Unloading

Bulk trucks should be free of external material buildup such as mud, slush, and dirt. Bagged ingredients should be evaluated for damaged bags. Ingredient weight of bulk and bagged ingredients should be compared with delivery tickets. All shipping documents and delivery tickets should be reviewed and retained. During unloading the receiving pit should be visually inspected and cleaned as needed prior to receiving of the next bulk ingredient to minimize cross-contamination. Pit covers should be in place as trucks drive over receiving grate to keep debris from trucks and potential pathogens from entering the facility. If there is ingredient spillage during unloading, ingredients that have touched the floor should be disposed. Spillage can be minimized by use of guards around receiving pits and slowing down unloading speed. Under no circumstance should spilled ingredients be swept into the pit to minimize risk for pathogen cross contamination. For micro ingredients bulk and bags should be visually inspected and used on a first in, first out rotation. For liquid ingredients, all lines should be properly labeled, and line caps locked to secure against improper unloading. For drug receiving, the documentation should be recorded.

Visual Inspection

The samples' odor and visual appearance can help decide quality and basis of rejection of some products. Therefore, it is encouraged to take a sample prior to unloading if possible. Whole grain ingredients such as corn can be visually inspected for excessive broken corn foreign material (BCFM) and indication of toxins and should be tested to evaluate moisture and mycotoxins. Bagged ingredients must be sampled for visual inspection. Visual inspection by personnel of byproduct ingredients or processed ingredients such as dried distillers' grains with solubles (DDGS), soybean meal, fat sources, etc. is helpful in determining when to run further tests. Some examples include soybean meal or DDGS samples that appear dark and have a burnt smell can be an indication overprocessing. Lipid oxidation can be indicative of a compromised fat source with samples being dark and rancid smelling. Visual inspection becomes more challenging when considering minor and micro ingredients which is where supplier verification is important. However, inspecting for water damage, clumping and bag tears, or anything that may be unusual to the product should be taken into consideration. The basis for rejection needs to be predetermined for each ingredient and monitored (AAFCO Official Publication). Using a reference sample with known characteristics to compare to ingredient sample at receiving is helpful in deciding if further analysis is necessary, based on product color, texture, and odor. If ingredients have visual deviation from reference sample, nutrient analysis via near infrared reflectance spectroscopy (NIRS) or laboratory testing should be conducted. Poor visual inspection does not always mean poor ingredients. Operators should consult mill managers or nutritionists for further instruction.

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Rejection or deficiency

If rejection of an ingredient is necessary, the supplier should be notified within the same business day and provided necessary documentation. Additionally, filing a deficiency claim when ingredients do not meet established specifications will decrease added cost from ingredient compensation and demonstrates commitment to quality for employees and supplier. Guidelines for basis of rejection can be found in current AAFCO Official publication.

Ingredient analysis

Once a sample is taken, required testing should be determined (Table 3). Type of testing is determined by variability of ingredient, frequency of use, and/or degree of problem. Byproduct and coproduct ingredients are most likely to be highly variable. Options for testing include visual and physical inspection, use of quick tests (if applicable), or use of a commercial laboratory.

On-site Testing

To alleviate the risk of segregation in a sample bag, samples should be subdivided or subsampled by a sample divider (riffle) prior to analysis. The sample should be divided until the amount needed for analysis is obtained. Rapid testing methods help nutritionists and production systems react quicker to changes in processes. Keep records of ingredient testing to evaluate supplier compliance and find historical data trends.

- **Grading and test weight (bulk density) of grains:** Grain grading is done to maintain grain quality that can be affected by growing and storage conditions. Links to grading standards for grains are included in "Additional Resources".

  Bulk density of an ingredient should be determined according to ASABE Standard S269.4 (2007). The ingredient is poured into a cylindrical container from a certain height to facilitate free flowing of the samples until the container overflowed. The excess material is removed by striking a straight edge across the top of the container. Net weight of the ingredient is obtained by subtracting the weight of the empty container from the combined weight of the ingredient and container. Bulk density is calculated by dividing the mass by the container volume.

- **Moisture content:** Determining the moisture content of an ingredient is important for making decisions pertaining to storage, shrink, and other feed milling processes. Moisture analysis of whole grain ingredients should be done for every incoming load due to the effects that added moisture can have throughout the feed manufacturing process. Options for rapid analysis of moisture include using a Dickey-John moisture analyzer or NIRS.

- **NIRS:** The NIRS device can also be used to analyze other components such as protein, fat, fiber and starch. Establishing accurate NIRS calibrations is imperative for predictability. This technology can determine nutrient content of ingredients which is helpful in determining ingredient quality. Samples should be ground prior to placement in the chamber for analysis. Advancements have been made with NIRS technology in feed mills to include in-line analyzers. In-line analyzers can provide results as ingredients pass along a sensor allowing for continuous monitoring and segregation based on nutrient value (Stark, 2013).

- **Fat:** Fat quality can be evaluated by a combination of oxidative and hydrolytic rancidity. Oxidative rancidity can be measured by lipid peroxidation using a combination of primary and secondary

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oxidative products from peroxide value or thiobarbituric acid reactive substances (TBARS) tests, respectively. Additionally, hydrolytic rancidity tests include free fatty acid tests. Fat sources should be used as quickly as possible therefore only receiving the amount needed monthly can reduce risk of fat rancidity. Additionally, use of an antioxidant can prevent the risk of fat rancidity.

- **Mycotoxins:** Mycotoxins can be produced in the field or in storage. Field toxins include, deoxynivalenol (vomitoxin), zearalenone and fumonisin and storage toxins include aflatoxin and ochratoxin (Table 4). To determine the risk of mycotoxin contamination from grains, weekly reports (link in "Additional Resources") are available to assess the risk of mycotoxin contamination in grains from a specific area which can help determine how many loads to sample. Lateral flow test strips or enzyme-linked immunoassay (ELISA) kits can be used as a single mycotoxin test to determine toxin level present in ingredient. However, it is important to note that each type of mycotoxin requires a specific test. Official laboratory testing should be done if pigs show signs of mycotoxin contamination, and the quick test does not show positive results. More on FDA mycotoxin levels can be founded under "Additional Resources".

Summary

Determining the quality of ingredients at receiving is critical for accurate formulation and strategic feeding. A representative ingredient sample is important to establish accurate nutrient profiles for each ingredient. There are numerous factors that influence the quality of sample including ingredient characteristics, sample technique, sample tools, and the point in time the sample was taken. Use of quick tests allows for fast, informed decision making and eventually can lead to decreased commercial laboratory evaluation cost. In addition to topics covered in this guide, FSMA Regulations and questions from the CGMP Checklist should be reviewed. This guide is not intended to replace regulatory procedures but enhance ingredient quality procedures. Quality ingredients are necessary to manufacture quality feed.

Additional Resources

AAFCO Official Publication
- https://www.aafco.org/Publications

AAFCO Feed Inspectors Manual
- https://www.aafco.org/Portals/0/SiteContent/Publications/AAFCO_Feed_Inspectors_Manual_5th_ed.pdf

AFIA Quality Manual Template
- https://www.afia.org/site-search/?Keywords=quality+manual+template

AFIA Resource Center
- https://www.afia.org/resources/search/

FDA mycotoxin levels
- http://feed.ngfa.org/images/uploads/NGFAComplianceGuide-FDARegulatoryGuidanceforMycotoxins8-2011.pdf

Feed Additive Compendium
- https://www.feedadditivecompendium.com/

USDA Grain Grading Standards
- https://www.ams.usda.gov/grades-standards/grain-standards

Weekly Mycotoxin reports
- https://www.feedandgrain.com/blog/category/monday-mycotoxin-and-crop-report

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Table 2. Example analytical schedule for ingredients and finished feed based on 1000 Ton/week.[1]															
			Number of Tests[2,3]												
Ingredients	Estimated usage per week (Tons)	Loads per week[4]	Moisture	Protein	Fat	Amino acids	Ca	P	NaCl	Mg	Aflatoxin	DON	Zea	Fum	PV
Corn	600	24	X	X	X	X	X	X			*[5]	*	*	*	
Soybean meal	250	10	X	X		X									
DDGS	200	8	X	X											
Wheat middling	200	8	X	X											
Fish meals	200	8		X	X		X	X	X	X					
Bakery meal	100	4		X	X				X						
Wheat bran	50	2	X	X											
Rice bran	50	2	X	X	X										
Fat	20	1													Q
Limestone	10	0.5					Q			Q					
Mono/Di-calcium phosphate	10	0.5					Q			Q					
Finished feed[6]	1000	40	3W	3W	3W		4M	4M	4M						

[1] Adapted from National Grain and Feed QA.
[2] Composite sample based on supplier.
[3] If ingredients are from a new supplier, testing may need to be more frequent.
[4] Based on 25T truck capacity.
[5] * = Evaluate weekly grain reports to determine risk and establish testing schedule.
[6] It is recommended to collect 3 samples each week from each feed type to evaluate moisture, crude protein, and fat, Then, 4 to 6 samples of each feed type should be evaluated monthly for calcium, phosphorus, and sodium.
M = Monthly; W = Weekly; Q = Quarterly

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Table 3. Mycotoxin infected grains, tolerated levels, conditions in swine production[1]					
Mycotoxin	**Type**	**Growth Conditions**	**Commodity**	**Levels**	**Symptoms in swine**
Aflatoxin (B1. B2, G1, G2)	Field and storage	• Consistently high temperature and humidity • 75 to 95°F • 80 to 85% RH 17% moisture content	Corn, sorghum, cotton seed, peanuts	**FDA Action Level** • breeding swine: < 100 ppb • finishing swine greater than 100 lb BW: < 200 ppb • Cotton seed meal: < 300 ppb	• Low feed intake, low growth rate, immunosuppression • Sever liver dysfunction, hemorrhages, jaundice, and sudden death
Deoxynivalenol (vomitoxin)	Field	• Alternating warm and cool temperatures in growing season, high humidity • 79 to 72°F • 88% RH 22% moisture content	Corn, wheat, barley, sorghum, rye, others	**FDA Action Level** • < 5 ppm for ingredients • < 1 ppm in complete feed • Included in < 20% of diet	• Sharp decrease in feed intake, low growth rate • Complete feed refusal, vomit, diarrhea, sever digestive lesions, sudden death
Fumonisin	Field	• Drought during growing season followed by cool, wet conditions. • Likely < 77°F > 20% moisture content	Corn	**FDA Action Level** • < 20 ppm for ingredients • < 10 ppm in complete feed • Included in < 50% of diet	• Low feed intake and growth rate, immunosuppression • Severe lung lesions, labored breathing, cyanosis, and death
Ochratoxin A	Storage	• Low temperature • 54 to 77°F • 85% RH 19 to 22% moisture content	Corn wheat, barley, rye	**Advisory Level** • Grower/finisher: < 200 ppb in complete feed	• Low growth rate, poor feed efficiency, kidney lesions at slaughter • Sever kidney dysfunction
Zearalenone	Field	• Alternating warm and cool temperatures in growing season, high humidity • 45 to 70°F 24% moisture content	Corn, wheat barley, sorghum	**Advisory Level** • young growing pigs: < 1 ppm in complete feed • breeding herd: < 2 ppm in complete feed • finishing and boars: < 3 ppm in complete feed	• Vulvar swelling/redness, prolapse of rectum and vagina. • Anestrus, false pregnancy • Early embryo loss • Low libido

[1]Testing can be done through a certified lab or with quick testing. Quick tests for each mycotoxin type can be purchased through a distributor and used with little training. Common quick test manufacturers include Neogen, Europhins and others. Adapted from Osweller and Ensley (2012) and Menegat et al. (2019)

Table 5: Example Label for Incoming Ingredients (Avery 8163)

Receiving Date: ____________________ Ingredient Name: ____________________ Supplier: ____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________	Receiving Date: ____________________ Ingredient Name: ____________________ Supplier:____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________
Receiving Date: ____________________ Ingredient Name: ____________________ Supplier: ____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________	Receiving Date: ____________________ Ingredient Name: ____________________ Supplier:____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________
Receiving Date: ____________________ Ingredient Name: ____________________ Supplier: ____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________	Receiving Date: ____________________ Ingredient Name: ____________________ Supplier:____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________
Receiving Date: ____________________ Ingredient Name: ____________________ Supplier: ____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________	Receiving Date: ____________________ Ingredient Name: ____________________ Supplier:____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________
Receiving Date: ____________________ Ingredient Name: ____________________ Supplier: ____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________	Receiving Date: ____________________ Ingredient Name: ____________________ Supplier:____________________ Lot Number: ____________________ Sampler I.D.:____________________ Other : ____________________