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Specialized Meat Processing: Measuring pH and Water Activity In-house or Third Party

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Bottom line:
The breakeven of in-house and third party testing for pH and water activity (a_w) is about 28 samples.

Why is pH and water activity important? Product safety and shelf stability are impacted by product pH and a_w. Testing is required for shelf stable processed meat products under the Michigan Department of Agriculture and Rural Development Specialized Retail Meat Processing Variance (Variance).

How often is testing needed with the Variance? Products that are fully shelf stable require a_w and pH testing for every batch, whereas products labeled “shelf stable, keep refrigerated upon opening” need two consecutive production batches tested initially and then quarterly testing.

What instruments were used?
pH Meter A was a portable meter (Foodcare Portable pH meter, Model 99161, Hannah Instruments, Woonsocket, RI).
pH Meter B was a handheld pen style pH probe (Model 8689, Thermoworks, American Fork, UT).
Handheld a_w meter (range from 0.00 - 1.00 ± 0.02; Aqualab Pawkit handheld water activity meter, Decagon Devices, Pullman, WA).
All instruments were calibrated/verified according to manufacturer instructions at the beginning of each testing session. Results were not different among probes or testing laboratories (Table 3).

How long does it take to test samples for pH and a_w? It took approximately 34 minutes 35 seconds to measure pH and a_w for one sample and 14 minutes 10 seconds for subsequent samples (Table 2). It is important to note that sample preparation and operation efficiency improved over time.

How was pH and a_w measured? Sample preparation and protocol: Sebranek and others, 2001. Available from Michigan State University Extension: *Processed Meat Quick Guide: pH and water activity protocol.*

What is the cost and time involved in third-party testing?
One set of samples was shipped to an accredited third party laboratory packaged in a foam box and kept cold using two frozen reusable gel packs. The package was shipped overnight and results emailed the next day (Tables 4 and 6).

Table 1: Prices used when calculating breakeven pricing

Labor/hour		**$12.00**
Laboratory Equipment	Graduated cylinder	$45.54
	Magic Bullet	$39.99
	Wash bottle	$6.08
		$91.61
Laboratory Supplies	Gallon of deionized water	$43.12
	Filter paper	$12.40
	Kim wipes	$8.65
	pH 4.0	$11.75
	pH 7.0	$5.90
	pH 10	$12.50
	Sample cups (500 count)	$196.00
	0.76 a_w calibration solution	$96.00
	0.92 a_w calibration solution	$96.00
		$482.32
Maintenance/Calibration		**$100.00**
Sample Prep per sample		**$11.00**
Aw testing per sample		**$13.00**
pH testing per sample		**$44.00**
Water activity (a_w) meter		**$2,000.00**
pH meter		**$445.00**
Shipping		**$16.90**
Packaging to ship		**$24.00**

How many samples have to be run in-house before breaking even? Breakeven prices were calculated using set costs for each scenario (Table 1). The breakeven point was calculated by taking the sum of costs to be incurred doing in-house testing and dividing that by the total cost incurred sending samples to an accredited third party laboratory. It would take approximately 28 samples to breakeven (Table 5).

How is shelf stability determined? The pH and a_w criteria that must be met for shelf stability is displayed on the Specialized Retail Meat Processor (SRMP) process criteria chart (Figure 1; MDARD, 2014a). This chart displays the relationship of pH and a_w and the points that may support the growth of potentially harmful organisms.

What other factors need to be considered? Meter precision should be taken into account when using results to determine product safety. Factors such as temperature can affect pH readings and it is important to have a meter with automatic temperature compensation.

Does meter costs affect accuracy? Despite the price difference in the pH meters, both gave acceptable results. All meters regardless of price should be properly calibrated and maintained to help reduce variability. Proper meter care and maintenance and spot checking against an accredited third party laboratory is encouraged.

Tables taken from Theisen and Schweihofer (2016).

Table 2: Time for in-house testing of pH and a_w

	Time (min:sec)		
Step of Testing	**Average**	**Low**	**High**
Gather equipment and supplies	03:49	02:29	05:57
Calibrate a_w meter	12:25	12:04	12:47
Calibrate pH Meter A	02:46	01:03	04:09
Calibrate pH Meter B	05:06	02:50	07:25
A_w preparation time	01:46	01:12	03:01
A_w test time	05:20	05:05	05:32
pH Meter A preparation time	03:22	01:43	04:26
pH Meter A test time	00:39	00:16	01:47
pH Meter B preparation time	03:22	01:43	04:26
pH Meter B test time	01:28	00:33	02:35
Clean-up between samples	02:06	01:31	02:45
Overall Cleanup	05:15	02:41	07:35
Estimated time for pH Meter A	37:27	28:04	47:59
Estimated time for pH Meter B	40:37	30:08	52:03
Estimated average time using a single pH meter[a]	34:35	29:06	50:01

[a] Estimated time using only one pH meter was calculate using an average calibration and testing time between pH meter A and B.

Table 3: Trial 2: pH and water activity (a_w) of different flavored snack sticks from in-house or third party laboratories

Sample	Laboratory	pH	Standard Error	a_w	Standard Error	SMP Chart[a]
Black Pepper Garlic	In-House A[b,f]	4.25[i]	0.015	0.94[j]	0.000	A
	In-House B[c,f]	4.41[i]	0.015			A
	MSU Food Science and Human Nutrition[d,g]	4.39[i]	0.015	0.93[j]	0.008	A
	Third Party Lab[e,h]	4.40[i]		0.96[j]		A
Devil's Kiss	In-House A	4.05[k]	0.050	0.95[l]	0.005	B
	In-House B	4.49[k]	0.060			A
	MSU Food Science and Human Nutrition	4.31[k]	0.005	0.94[l]	0.000	A
	Third Party Lab	4.30[k]		0.96[l]		A
Jalapeno	In-House A	4.53[m]	0.025	0.94[n]	0.010	A
	In-House B	4.55[m]	0.050			A
	MSU Food Science and Human Nutrition	4.62[m]	0.005	0.94[n]	0.002	A
	Third Party Lab	4.60[m]		0.95[n]		A
Shelf Stable	In-House A	4.36[o]	0.010	0.91[p]	0.000	B
	In-House B	4.51[o]	0.005			B
	MSU Food Science and Human Nutrition	4.41[o]	0.005	0.92[p]	0.001	B
	Third Party Lab	4.50[o]		0.94[p]		A

[a] Michigan Department of Agriculture and Rural Development Specialized Meat Processing Variance Chart (2014a)
[b] ± 0.01 units for In-House pH Meter A (Foodcare Portable pH meter, Model 99161, Hannah Instruments, Woonsocket, RI)
[c] ± 0.05 units for In-House pH Meter B (Model 8689, Thermoworks, American Fork, UT)
[d] ± 0.002 units for MSU Food Science and Human Nutrition pH meter (Accumet Basic AB15 meter Fisher Scientific, Pittsburgh, PA)
[e] ± 0.002 units for Third Party pH meter
[f] ± 0.02 units for In-House a_w meter (Aqualab Pawkit handheld water activity meter, Decagon Devices, Pullman, WA)
[g] ± 0.003 units for MSU Food Science and Human Nutrition a_w meter (Aqualab bench top model 3TE Decagon Devices, Pullman ,WA)
[h] unknown precision for Third Party a_w meter
[i] pH values not different ($P = 0.245$)
[j] a_w values not different ($P = 0.368$)
[k] pH values not different ($P = 0.142$)
[l] a_w values not different ($P = 0.308$)
[m] pH values not different ($P = 0.151$)
[n] a_w values not different ($P = 0.368$)
[o] pH values not different ($P = 0.207$)
[p] a_w values not different ($P = 0.165$)

Table 4: Approximated shipping costs[a] for overnight and 2-day shipping for up to 10 lbs. package.

Carrier	Delivery Time	Max Cost 1-5 lbs	Max Cost 6-10 lbs
UPS Next Day Air Early A.M.	8 am next business day	$61.25	$66.95
UPS Next Day Air	10:30 am next business day	$31.25	$36.95
UPS Next Day Air Saver	3 pm next business day	$28.05	$33.55
UPS Second Day Air A.M.	2 business days by 10:30 am	$18.20	$22.75
UPS Second Day Air	End of business day	$15.85	$19.75
USPS Priority Mail Flat Rate Boxes (Large, Medium, and Small with a 70 lb max)	1-3 days	$18.75	
		$13.45	
		$6.80	
FedEx First Overnight	Next day by 8am	$60.60	$66.52
FedEx Priority Overnight	Next day by 10:30 am	$32.60	$38.52
FedEx Standard Overnight	Next day by 3 pm	$30.03	$35.97
FedEx 2Day A.M.	2nd day by 10:30 am	$19.79	$24.69
FedEx 2Day	2nd Day by 4:30 pm	$17.21	$21.47

[a] Prices as of 6-19-16; subject to change

Table 5: Breakeven cost for in-house compared to third party testing on a per sample basis

	In-house	Third Party
Labor at $12/hr (35 min for testing, 30 min to ship)	$7.20	$6.00
Laboratory equipment	$90.00	
Laboratory supplies	$480.00	
Aw meter	$2,000.00	
pH meter	$445.00	
Maintenance/Calibration[a]	$100.00	
Sample prep fee		$11.00
Aw testing		$44.00
pH testing		$13.00
Shipping		$16.90
Packaging to ship		$24.00
Total	**$3,222.20**	**$114.90**
Total pH only	**$734.20**	**$70.90**
Breakeven pH and a_w	**28 samples**	
Breakeven pH only	**10 samples**	

[a] Estimated maintenance and calibration as needed

Table 6: Third party testing costs on a quarterly testing basis based on 2 samples tested per quarter.

Quarterly Testing	
Labor x 4	$24.00
Sample Prep x16 (n=2)	$176.00
Snack Sticks pH x 4	$52.00
Snack Sticks Aw x 4	$176.00
Jerky pH x 4	$52.00
Jerky Aw x 4	$176.00
Shipping x 4	$67.60
Packaging x 4	$96.00
Total Annual Cost for 2 Samples Quarterly	**$723.60**

Figure 1: SMP Process Criteria Chart[a]

Michigan Modified Tables A & B*

pH \ Aw	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98
6.0	B	B	B	A	A	A	A	A						
5.9	B	B	B	A	A	A	A	A						
5.8	B	B	B	A	A	A	A	A						
5.7	B	B	B	A	A	A	A	A						
5.6	B	B	B	A	A	A	A	A						
5.5	B	B	B	A	A	A	A	A						
5.4	B	B	B	A	A	A	A	A	A					
5.3	B	B	B	A	A	A	A	A	A	A	A			
5.2	B	B	B	A	A	A	A	A	A	A	A			
5.1	B	B	B	A	A	A	A	A	A	A	A			
5.0	B	B	B	B	B	B	A	A	A	A	A			
4.9	B	B	B	B	B	B	A	A	A	A	A			
4.8	B	B	B	B	B	B	A	A	A	A	A			
4.7	B	B	B	B	B	B	A	A	A	A	A			
4.6	B	B	B	B	B	B	B	B	A	A	A	A	A	A
4.5	B	B	B	B	B	B	B	B	A	A	A	A	A	A
4.4	B	B	B	B	B	B	B	B	A	A	A	A	A	A
4.3	B	B	B	B	B	B	B	B	A	A	A	A	A	A
4.2	B	B	B	B	B	B	B	B	A	A	A	A	A	A
4.1	B	B	B	B	B	B	B	B	B	B	B	B	B	B

A	Products meeting the criteria for A are cured meat products that are considered shelf stable when packaged and labeled "Refrigerate for safety upon opening" as they will support the growth of vegetative organisms.
B	Products meeting the criteria for B are cured meat products that are considered shelf stable and do not support the growth of vegetative organisms.
	Products not meeting A or B are considered Product Assessment Required, therefore are treated as Temperature Control for Safety/ Potentially Hazardous Foods and must be labeled "Keep Refrigerated" or Refrigerate for Safety".

[a]Michigan Department of Agriculture and Rural Development, 2014a

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