PE4.71 WHCtrend, a Dinamic Parameter Based on the Filter Paper Press Method to Measure Water Holding Capacity in Meat 254.00

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Abstract*— To simplify the measurement of the water-holding capacity (WHC) of meat, a modification to the Grau-Hamm method is proposed. VIA represents sure the best system because it is associated with high repeatability, few variation due to operators and short time. The solution adopted by the BT WHCi instrument was to put a camera on the compression system. In this way the simplification of process is due to immediately application of total load and freezing of image at time=0s and measurement. Every 15s image is frozen and measured until 10min are past. The compression force is always 500N as a scale is connected to the system. In this way is always measured the total area, which is easily distinguishable from the white background. The classical measurement at 10min is obtained subtracting the first total area, which is the meat area, to the last total area, to obtain the Liquid Area. Moreover it is obtained a dynamic measurement of water release in time that was called WHCtrend and the repeatability has a coefficient of variability of 5.6%. This is the residual variability due to the three repetitions for the same sample, comprehensive of the sample preparation and meat variability. The Pearson Correlation Coefficients among Meat Cooking Shrinkage, Cooking Loss and the Cooling Water Loss measured with the MCS protocol, Thawing Loss, Cooking Loss, Dripp Loss, tenderness measured by the Peak and Break with the Warner-Bratzler Shear Force Procedure gave interesting correlations with WHCtrend parameters. It could be possible to replace some classical parameters (CL and DL) to save time and money. The application was tested on different animal types but the solution adopted shows that BT-WHCi also works under very difficult light conditions with very clear meats. Many methods and different operating conditions of Filter Paper Press Method have been published in literature causing confusion to interpret data. Now it will be possible to reassess the Filter Paper Press Method and use it for rapid screening to measure the meat Water Holding Capacity and improve meat quality control.

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***Index Terms*— meat, whc, trend, instrument**

I. INTRODUCTION

Water Holding Capacity (WHC) is the ability of meat to hold fully or in part its own water [1] and it is influenced by the change in volume of myofibril [2]. This qualitative parameter is of primary importance for the meat industry and the consumers. It affects technological traits, sensory attributes and nutritional constituents and it is important to know its relationship with breeding traits and postmortem events to obtain meat of good quality. It is known that meat WHC is a result of metabolic events prior to harvest and slaughter and following the immediate postmortem conversion of the muscle to meat in relation to different factors.

Present methods available to measure the WHC of meat and its products [3, 4] despite many efforts over the year, do not have a sufficient standardization, essential for comparison [5]. It has been particularly observed that the application of Filter Paper Press Method [6] - which requires the compression of a little amount of meat on filter paper, the subsequent determination of the surfaces formed by meat and juice and the estimation of the difference between the areas - has been suffering a lot of interpretations and adaptations. Some Authors [7, 8, 9] utilized different filter paper types and amounts of meat; when considering the load, they put it under different pressures and compression times; sometimes they measured surfaces with the aid of a planimeter, at times outlining areas on the original by pencil, or by the use of an optical electronic system (Video Image Analyzer). Finally, Authors even applied different formulae to measure WHC [10, 11, 12].

To improve the application of this parameter was developed a machine to standardize the operation of measurement of the Filter Paper Press Method. The solution adopted has solved the problem to measure the meat area and the liquid area and it has produced a dynamic measurement on time of water release that was called WHCtrend, a new parameter giving traditional data and trend in water release.

II. MATERIALS AND METHODS

Numbers of experiments were carried out. The WHCtrend parameter was tested on 243 samples of meat, different for specie and commercial category (pig: 30; calf: 72; young bull: 87). The tested muscles were *Longissimus thoracis* and *lumborum* (LG) and

Semitendinosus (ST) (pig: 30 LG; calf: 72 LD and 32 ST; young bull: 87 LG and 22 ST).

24 calf and 29 beef samples were submitted to the WBS analysis to test correlation with WHCtrend (calf: 24 LD and 24 ST; young bull: 29 LG and 5 ST).

The employed materials were: a mincing machine (600 rpm for 20s), filter paper (Whatman cat n° 1001 125; 125 mm∅), translucent plastic plates, scale and the patented BT-WHCi instrument (Figure 1) produced by the author. The system was composed of a video camera, a video light source, a press with incorporated a scale to control the compression force. The procedure to control or measure load, time and surface was automated by using the BT-WHCi instrument that applies Video Image Analysis (VIA) to area measurement [13]. The instrument and the scale to weight homogenized sample where connected to a pC with a self-developed software to get sample weight, frame and to process image in an automatic way.

The tested samples where obtained from experimental trials or bought on market. Each meat sample was measured three times. The meat was obtained from the Meat Cooking Shrinkage parameter [14], an experimental procedure to measure cooking meat shrinkage.

A quantity of 80-100g meat, chilled at 4°C and freed from external fat and connective tissue, was rapidly homogenized at 600rpm for 20 seconds. A sample of 250 mg of homogenized meat was placed on a filter paper and put between two plexiglas sheets in the BT WHCi instrument for compression at a constant force of 500N. Filter paper was dried in the oven at 105°C and maintained in a dryer until the analysis started. The meat and the liquid areas (mm2) were measured by BT WHCi instrument automatically every 15s for ten minutes. The 10min length was chosen according the Grau and Hamm Method [x] to compare the last measurement with other researches.

The elaborations of WHC data were done by the SAS software version 9.3.1. The procedures PROC CORR and PROC GLM were employed. Tukey test for multiple Lsmean comparisons was performed. For each curve, a quadratic model was performed and coefficients were estimated. A selection of possible measured variables were elaborated:

Meat Area (mm2) when t=0; Total area (mm2) after 10 min; Weight sample; quadratic model coefficients (k1whc and k2whc); Liquid Area (%) = (Total Area - Meat Area)/Total Area; Total Area and Meat Area were also expressed for Weight sample unit to verify a possible effect of sample weight variability.

These dependent variables are an example of a few different ways to express the Water Holding Capacity found in the quoted bibliography.

III. RESULTS AND DISCUSSION

Prior applications of video image analysis tried to measure meat area and liquid area at the end of the compression period but this is very difficulty as meat colour and liquid area are very similarly. Some times the meat area were outlined by pencil on the original to separated from the liquid area to apply a VIA system. To bad, the filter paper was measured with a planimeter. All these solutions together with different force and time compression introduce a great source of variability to keep useless the parameter.

The solution adopted by the BT WHCi instrument was to put a camera on the compression system. In this way the simplification of process is due to immediately application of total load and freezing of image at time=0s and measurement. Every 15s image is frozen and measured until 10min are past. The compression force is always 500N as a scale is connected to the system. In this way is always measured the total area, which is easily distinguishable from the white background. The classical measurement at 10min is obtained subtracting the first total area, which is the meat area, to the last total area, or Liquid Area. Moreover it is obtained a dynamic measurement of water release in time as shown in graph 1 that was called WHCtrend. The protocol to prepare the sample and the image-processing technique shows a very interesting repeatability with a coefficient of variability 5.6%. This is the residual variability due to the three repetitions for the same sample, comprehensive of the sample preparation and meat variability.

In table 1 are reported an application of the WHCtrend parameters to discriminate among commercial species, categories and muscles. No difference for compression force (Load=501.0±7.65 N) and weight sample (253.6±16.68 mg) to indicate the correct preparation of samples. There is an interesting difference in meat area due to an interaction between muscle and category. It is strange that the same quantity of homogenized meat gives a significant difference, with pork LG response similar to the cattle ST meat area. This is also a constant for the other parameters. The Total Area is always significant and higher in the cattle ST muscle with the highest value in ST calf muscle.

The beef and calf Liquid Area are significant higher than pork LA as expected with the highest value in calf LG.

The two parameters describing the WHC trend are also significant as shown in graph 1. The trends are similar but this is the average trend. A specific analysis has shown different shapes of different curves according treatments that will be elaborated.

As other parameters were measured the Pearson Correlation Coefficient (table 2) was calculated among

Meat Cooking Shrinkage (MCS), Cooking Loss (CL_MCS) and the Cooling Water Loss measured with the MCS protocol, Thawing Loss, Cooking Loss, Drip Loss, tenderness measured by the Peak and Break with the Warner-Bratzler Shear Force Procedure. An interesting negative correlation is between Meat Area and Peak, and Break force. It seems that tough meat has enlarged less. Could be the meat area an indicator of tenderness? The positive correlation among Total and Liquid Area and MCS, CL_MCS, CL and DL could be useful to substitute parameters (CL and DL) expensive in time and cost.

The WHCtrend is an automatized analysis and once started it needs 10min to the end and three replications are done in 40min total time of analysis, including sample preparation. The BT WHCi instrument does not need the continue operator's presence to work, just to give the start.

IV. CONCLUSION

The Filter Paper Press Method has the advantage to be rapid and simple but a proper standardization is necessary. The BT WHCi instrument has solved this aspect and also it permits to measure in a dynamic way the water release. The protocol adopted is clearly defined as WHC values depend on: applied load, filter paper type, compression time, area measurement method and the dependent variable used to express it.

In this research all these factors have been kept under control so that it was possible to define and standardize working conditions and to automate it in a reliable way.

The application was tested on different animal types but the solution adopted shows that BT-WHCi also works under very difficult light conditions with very clear meats, and last but not least, results can be directly comparable.

Many methods and different operating conditions of Filter Paper Press Method have been published in literature causing confusion to interpret data in this field. Now it will be possible to reassess the Filter Paper Press Method and use it for rapid screening to measure the meat Water Holding Capacity and improve meat quality control.

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Table 1 – WHC parameter Lsmeans of categories and muscle meat samples (DFE=238).

		PORK	CALF		YOUNG BULL		MSE
		LG	LG	ST	LG	ST	
Meat Area	mm^2	836.0^{A}	785.5^{B}	836.4^{A}	790.4^{B}	813.1^{AB}	4164.21
Meat Area/ weight sample	$mm^2\ mg^{-1}$	330.9^{A}	310.7^{B}	331.3^{A}	312.3^{B}	323.2^{AB}	678.83
Total Area after 10'	mm^2	1271.2^{A}	1392.4^{aB}	1443.4^{bC}	1332.2^{D}	1408.3^{BC}	6654.12
Total Area after 10' / weight sample	$mm^2\ mg^{-1}$	503.1^{A}	550.4^{aB}	571.7^{B}	526.5^{bB}	559.8^{BC}	1089.63
Liquid area after 10'	%	33.68^{A}	43.31^{aB}	41.83^{B}	40.38^{bC}	42.00^{BC}	37.10
k1whc*	$mm^2\ s^{-1}$	1.31^{A}	1.72^{B}	1.87^{BC}	1.64^{BD}	1.86^{BC}	0.071
k2whc*	$mm^2\ s^{-1}$ x1000	-1.14^{A}	-1.70^{B}	-1.88^{BC}	-1.54^{BD}	-1.84^{BC}	0.0000
Load	N	500.6	501.9	500.6	500.8	500.5	59.16
Sample weight	mg	252.1	253.0	252.5	255.4	251.7	281.00

* First and second coefficient describe the WHC trend quadratic curve.

Table 2 – Pearson correlation Coefficients and probability among WHC parameters with other quality parameters

	Meat Area	Meat Area/ weight sample	Total Area after 10'	Total Area after 10' / weight sample	Liquid area	k1whc*	k2whc**
MCS	NS	NS	0.33 <.0001	0.35 <.0001	0.17 0.0099	0.34 <.0001	-0.29 <.0001
CL_MCS	NS	NS	0.36 <.0001	0.37 <.0001	0.26 <.0001	0.34 <.0001	-0.33 <.0001
Thawing Loss	NS	NS	-0.13 0.0600	-012 0.0929	-0.12 0.0923	NS	NS
Cooking Loss	NS	NS	0.25 0.0238	0.31 0.0043	NS	0.22 0.0552	-0.20 0.0665
Drip Loss	-0.20 0.0059	-0.18 0.0129	0.26 0.0004	0.27 0.0003	0.34 <.0001	0.26 0.0004	-0.32 <.0001
Peak WB	-0.25 0.02	-0.24 0.03	NS	NS	0.25 0.0229	NS	NS
Break WB	-0.30 0.0064	-0.29 0.0075	NS	NS	0.27 0.0141	NS	NS
Cooling Water Loss	NS	NS	NS	NS	NS	NS	NS

* First and second coefficient describe the WHC trend quadratic curve.

Graph 1. WHCtrend for different species and categories