Model for determination of the interacting water quantity in the leathers

Abstract

For the calculation of the water contained in the leather, a model was built that allows us to simulate the distribution of the water within the same according to the amount of absorbed water. The purposes of the model are to define the fraction of water available to interact with the processing bath and which we call *interacting water*. We can define this water as the fraction of absorbed water which has the opportunity to interact with the solutes dissolved in the processing bath. Knowing the amount can be useful in the study of all those phenomena that employ the reference model that of the semi-permeable membrane, including the study of the efficiency of the washing phases. According to what we hypothesize, the quantity of interactive water does not depend on the bath ratio used but depends more reasonably, on processing times. When the times are long enough, as in common operations, we can think that even the water posed deeper in the protein structure has greater possibility of being achieved by the solutes of the processing bath. When the times are restricted, as in washes, the possibilities of interaction of the water in depth are lower. Another factor that influences the wetting of the leathers is the temperature because at high temperatures the ability to spread solvents and solutes are higher.

The data collected in the previous paragraph show us the quantities of water that the leatherss retain and the data refer to the amount of collagen present. But leather and collagen are not the same because the leather, as semi-finished or finished material, is a set of collagen, reticular and elastic fibers inside which there are quantities of water or humidity. Water and humidity content are, in fact, the same thing, but it is preferred to use the term humidity when the water content is modest. When it comes to humidity, this must always be understood as absolute because the relative one varies continuously with the processing.

If, in the previous paragraph (http://www.danielepistorio.com/water-adsorption-of-collagen-and-leather/), the water content has been referred to the weight of collagen (g_{AQ}/g_C), in this we will refer to the measurable weight of the leather (Kg_{AQ}/Kg_L) which is easy to reference. The measurable weight is what can be easily measured during the productive phases: raw, desalted, pelt, tanning, crust.

Interacting water in the retanning operations

The calculations for the reconstruction phases are simpler than the beamhouse phases. Firstly because, in these phases, the material is homogeneous. Secondly, because the tanned material allows us a more correct initial investigation than the raw.

Tanned leather

To illustrate the proposed model, imagine to have to retaning 100 kg of tanned leathers (Wet Blue – Wet White – Full Veg). The percentage of water contained in these materials is on average equal to approximately 55%. The starting conditions of the belt are summarized in Table 3.

Weight of collagen and water are obtained starting from the water content present in the tanning (UA). As reported by Table 3, the tanning holds a good amount of water, equal to about 1,22 gr_{AQ}/gr_C.

Once the initial data has been defined, it is possible to obtain the distribution of the water. To do this we use the data shown in the paragraph Absorption of water by collagen and leathers. In the tanning, these data are not important but are reported for knowledge:

TANNED LEATHERS - CRUST PELLE CONCIATA - CRUST	$[gr_{AQ}gr_{COLL}]$	[Kg]
PESO PELLI CONCIATE - TANNED LEATHERS WEIGHT	-	100
CONTENUTO ACQUA [%] - WATER CONTENT [%]	-	55,0%
COLLAGENE - COLLAGEN - [Kg]	1,00	45,00
CONTENUTO ACQUA - WATER CONTENT - [Kg]	1,22	55,00
ACQUA NON REMOVIBILE - NOT REMOVIBLE WATER - [Kg]	0,32	14,22
ACQUA SCAMBIABILE - EXCHANGEABLE WATER - [Kg]	0,91	40,78

Table 1: Determination of interacting water quantity in the leathers – Conditions of the tanned leather

ACQUA - REGIMI WATER - REGIMES		THEORETICAL QUANTITY $[gr_{AQ}gr_{COLL}]$	PRESENT QUANTITY [Kg]	PRESENT QUANTITY $[Kg_{AQ}/Kg_P]$	PARTIALS [Kg]	PARTIALS $[Kg_{AQ}/Kg_P]$	INTERACTING WATER $SOLV_{CAP}$ [%]	INTERACTING WATER QUANTITY [Kg]
STRUCTURAL	I	0,07	3,15	0,032	3,15	0,03	0,0%	0,00
LINKED	II	0,18	8,10	0,081	TOT_{LINKED}		20,0%	1,62
LINKED	II'	0,17	7,65	0,077	15,75	0,16	40,0%	3,06
FREE	II'	0,03	1,35	0,014	TOT_{FREE}		100,0%	1,35
FREE	III	0,77	34,75	0,348	36,10	0,36	100,0%	34,75
AMOUNT	I-II-II'-III	1,22	55,00	0,550	55,00	0,55		

Table 2: Determination of interacting water quantity in the leathers – Subdivision of the water present inside the tanned leather

In the tables the reference weight (KGP) is that of the shaved.

The structural water is equal to 0,032 Kg_{AQ}/Kg_L, the tied (tied) one is 0,16 Kg_{AQ}/Kg_L while the total free one is 0,36 Kg_{AQ}/Kg_L.

In the tables it is preferred to compare the weights in Kg, which are the unit of measurement of the beaten weight (expressed by the term Kg_L or Kg_P).

We can go to determine the conditions of the skin once they are placed in the box. To do this, we distinguish between:

Real operations, which have enough durability to make the water of the processing bath in a way has the opportunity to arrive very deeply. By depth we do not mean the fibrous structure of the leathers but refers to the structural levels previously described;

Very short operations or washing (5-10 minutes), in which it is reasonable to hypothesize that the bathroom does not have time to spread in depth and that the involvement of the fractions of humidity present is lower.

By involvement we mean the possibilities of exchange of solutes between the processing bath and water held by the leathers.

Operations (long phases)

As we have seen, not all the water absorbed by the skins can be considered as an interactive water because it is part of it is structural and part of it is bound to collagen with strong limitations in the freedom of interaction.

Since it is not possible to know exactly the interaction capabilities of each fraction of water in the skins, we will try to estimate them, attributing to the different categories of water a hypothetical percentage interaction power with respect to the ability to interaction free water, whose ability to interaction is maximum (100%):

- 0% for structural water (Type I water);
- 50% for the fraction of bound water present in Type II water;
- 75% for the fraction of bound water present in Type II water;
- 100% for the fraction of free water present in Type II water and Type III water.

The results are summarized in Table 3 and Table 4:

LEATHERS IN PROCESSING - PELLI IN LAVORAZIONE OPERATIONS - OPERAZIONI	[gr$_{AQ}$gr$_{COLL}$]	[Kg]
ACQUA NON REMOVIBILE - NOT REMOVIBLE WATER - [Kg]	0,20	9,11
ACQUA DI SATURAZIONE - SATURATION WATER - [Kg]	**2,70**	**121,67**
ACQUA ASSORBITA PRIMO RINVERDIMENTO - ABSORBED WATER FIRST SOAKING - [Kg]	1,48	66,67
ACQUA INTERAGENTE - INTERACTING WATER - [Kg]	**2,50**	**112,55**
COLLAGENE - COLLAGEN - [Kg]	1,00	45,00
PESO TOTALE PELLI IN BOTTE - TOTAL WEIGHT LEATHERS IN DRUM - [Kg]	3,70	166,67

Table 3: Determination of interacting water quantity in the leathers – Subdivision of water into the leathers – Generic operation

ACQUA - REGIMI WATER - REGIMES		THEORETICAL QUANTITY [gr$_{AQ}$gr$_{COLL}$]	PRESENT QUANTITY		PARTIALS		INTERACTING WATER	
			[Kg]	[Kg$_{AQ}$/Kg$_P$]	[Kg]	[Kg$_{AQ}$/Kg$_P$]	SOLV$_{CAP}$ [%]	QUANTITY [Kg]
STRUCTURAL	I	0,07	3,15	0,070	3,15	0,07	0,0%	0,00
LINKED	II	0,18	8,10	0,180	TOT$_{LINKED}$		50,0%	4,05
LINKED	II'	0,17	7,65	0,170	15,75	0,35	75,0%	5,74
FREE	II'	0,03	1,35	0,030	TOT$_{FREE}$		100,0%	1,35
FREE	III	2,25	101,42	2,254	102,77	2,28	100,0%	101,42
AMOUNT	**I-II-II'-III**	**2,70**	**121,67**	**2,704**	**121,67**	**2,70**	-	**112,55**

Table 4: Determination of interacting water quantity in the leathers – Conditions of water into the leathers – Generic operation

With Table 3 we obtain Table 4 that provides us with interesting additional information.

The first concerns the amount of water absorbed by the tanned leathers at the beginning of the processes (surviving or disarray phase) which is equal to about 0,65 Kg$_{AQ}$/Kg$_L$. The weight of the material placed in the box increases by a factor equal to about 1,65 and, consequently, the amount of water downloaded is lower than the one loaded. Knowledge of this data is important in the calculation of pollutants downloaded after the soaking phases.

The second information concerns the total amount of water absorbed by the leather which is very high and equal to 2,7 gr$_{AQ}$/gr$_C$, or equal to almost three times the weight of the present protein.

The third information is that not all the absorbed saturation water, which is equal to 1,22 Kg_{AQ}/Kg_L, is available to interact with the processing bathroom because this quantity is lower and is equal to 1,12 Kg_{AQ}/Kg_L.

Short operations and washings

Post operation washes have lasted lower than those of real operations and it is plausible to hypothesize that the water added during these phases has lower diffusion capacity compared to those previously seen:

- 0% for structural water (Type I water);
- 25% for the fraction of bound water present in Type II water;
- 50% for the hamlet of bound water present in Type II water;
- 100% for the fraction of free water present in Type II water and Type III water.

Results are shown in Table 5 and allow us to build Table 6:

LEATHERS IN PROCESSING - PELLI IN LAVORAZIONE WASHINGS - LAVAGGI	$[gr_{AQ}gr_{COLL}]$	[Kg]
ACQUA NON REMOVIBILE - NOT REMOVABLE WATER - [Kg]	0,29	13,05
ACQUA DI SATURAZIONE - SATURATION WATER - [Kg]	2,70	121,67
ACQUA ASSORBITA PRIMO RINVERDIMENTO - ABSORBED WATER FIRST SOAKING - [Kg]	1,48	66,67
ACQUA INTERAGENTE - INTERACTING WATER - [Kg]	2,41	108,62
COLLAGENE - COLLAGEN - [Kg]	1,00	45,00
PESO TOTALE PELLI IN BOTTE - TOTAL WEIGHT LEATHERS IN DRUM - [Kg]	3,70	166,67

Table 5: Determination of interacting water quantity in the leathers – Subdivision of water into the leathers – Short operations and washings

ACQUA - REGIMI WATER - REGIMES		THEORETICAL QUANTITY $[gr_{AQ}gr_{COLL}]$	PRESENT QUANTITY [Kg]	PRESENT QUANTITY $[Kg_{AQ}/Kg_P]$	PARTIALS [Kg]	PARTIALS $[Kg_{AQ}/Kg_P]$	INTERACTING WATER $SOLV_{CAP}$ [%]	INTERACTING WATER QUANTITY [Kg]
STRUCTURAL	I	0,07	3,15	0,070	3,15	0,07	0,0%	0,00
LINKED	II	0,18	8,10	0,180	TOT_{LINKED}		25,0%	2,03
LINKED	II'	0,17	7,65	0,170	15,75	0,35	50,0%	3,83
FREE	II'	0,03	1,35	0,030	TOT_{FREE}		100,0%	1,35
FREE	III	2,25	101,42	2,254	102,77	2,28	100,0%	101,42
AMOUNT	I-II-II'-III	2,70	121,67	2,704	121,67	2,70	-	108,62

Table 6: Determination of interacting water quantity in the leathers – Conditions of water into the leathers – Short operations and washings

The quantity of interacting water in washing is lower than what we can have in ordinary operations, and goes from 1,12 to 1,08 Kg_{AQ}/Kg_L. This data will be useful in the calculation of the extraction efficiency of the washes themselves because the volumes of water involved are not those introduced but the exchangeable ones, which are lower and can be those that we have just calculated.

Thanks for reading! If the article was useful to you or if you need information, please contact me at +39.349.37.61.002 or at my email daniele.pistorio@gmail.com